

THE RISE IN DISABILITY ROLLS AND THE DECLINE IN UNEMPLOYMENT*

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Abstract

Between 1984 and 2001, the share of non-elderly adults receiving Social Security Disability Insurance income (DI) rose by 60 percent to 5.3 million beneficiaries. Rapid program growth despite improving aggregate health appears explained by reduced screening stringency, declining demand for less skilled workers, and an unforeseen increase in the earnings replacement rate. We estimate that the sum of these forces doubled the labor force exit propensity of displaced high school dropouts after 1984, lowering measured U.S. unemployment by more than half a percentage point. Steady state calculations augur a further 40 percent increase in the rate of DI receipt.

JEL: H53, H55, I12, J21, J64, and J68

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The federal Disability Insurance (DI) program is the largest income replacement program in the United States directed towards non-elderly adults, with annual cash transfers exceeding \$54 billion in 2001. Once benefits are awarded, recipients receive income replacement and medical benefits until return to work, medical recovery, death, or retirement at age 65, at which point they obtain equivalent benefits from the Social Security Administration's Old Age and Survivors Insurance program. Over the past two decades, two important changes have impacted eligibility and generosity for this program. The first, occurring in 1984, liberalized the disability determination process, reversing a dramatic reduction in disability rolls underway. The second occurred more gradually. Because the DI benefits formula is progressive and indexed to the mean wage in the economy, the widening dispersion of earnings during the 1980s and 1990s substantially raised the ratio of disability income to prior earnings (the 'replacement rate') for low skilled workers, a trend augmented by the rising real value of medical benefits provided. Contemporaneously, the share of non-elderly adults receiving DI income rose by more than sixty percent from its 1984 trough to 3.7 percent of the adult population ages 25 to 64 (5.3 million beneficiaries). Relative to prior DI cohorts, new entrants were younger and substantially more likely to suffer from low mortality impairments, particularly pain and mental disorders.

The objective of this paper is to assess how these programmatic changes – reduced screening stringency and a rising replacement rate – interacted with declining demand for less skilled workers to impact labor force participation of low skilled during the period of 1978 to 1998. The question is intrinsically difficult. DI is for the most part a uniformly administered federal program, making for limited treatment-control comparisons. Additionally, while aggregate health improved during the past two decades, reduced DI screening stringency coincided with a period of declining labor market opportunities for less skilled workers, making it likely that *demand* for benefits (as a form of income replacement) rose while benefits *supply* was shifting outward.¹ Finally, the administrative definition of disability – the

¹ See Juhn, Murphy and Topel [1991], Juhn [1992] and Katz and Autor [1999] on adverse demand shifts faced by low skilled workers in recent decades.

inability to “engage in a substantial gainful activity” – ensures that holding health constant, disability benefits are easier to obtain when job opportunities are scarcer. Given these confounds, distinguishing the impacts of increasing supply from increasing demand for benefits is a major theme of our paper.

To (attempt to) surmount these issues, we develop two sets of instrumental variables to proxy demand and supply conditions. To identify exogenous variation in the supply of disability benefits, we exploit the progressivity of the DI benefits formula. Because this formula does not account for variation in regional wage levels, potential replacement rates are substantially higher in low wage states. Using labor force data matched to individual Social Security earnings histories, we show that national shifts in disability policy yield substantially larger impacts on disability rolls in high replacement rate states, indicating that the potential replacement rate is a plausible instrument for benefits supply. To identify exogenous variation in the demand for benefits, we follow Bartik [1991] in constructing a measure of state level labor demand shifts at low and medium frequency. This measure, a weighted sum of national industry employment changes (excluding own state employment) projected onto state industry composition, performs well in predicting the flow of DI applications by state, indicating that adverse demand shocks raise demand for disability benefits. Exploiting this combination of instruments, we study the impact of the supply and demand for DI benefits on the labor force behavior of low skilled workers during the period of 1978 – 1998.

Our contribution builds on an influential literature exploring the impacts of disability benefits on the level of labor force participation in the United States and abroad.² Distinct from this literature, our paper analyzes the impact of the supply of disability benefits on the responses of low-skilled workers to adverse labor market shocks. The rationale for this focus is that non-employment is a de facto pre-condition for

² Key papers in this literature include Parsons [1981], Bound [1989], Haveman, De Jong and Wolfe [1991], Bound and Waidman [1992], Gruber and Kubik [1995], Aarts, Burkhauser, and De Jong [1996] and Gruber [2000], who study the impact of disability benefits on labor supply in Canada, the Netherlands, and the United States. Lewin-VHI, Inc. [1995], Rupp and Stapleton [1995], and Stapleton et al. [1998] analyze the importance of the economic climate to disability application and receipt. Bound and Burkhauser [1999] provide a comprehensive overview of the labor market impacts of disability programs. The paper closest in spirit to the approach taken here is Black, Daniel and Sanders [1998], who study the impact of shocks to coal prices on SSI income in mining intensive counties.

disability application, making the opportunity cost of seeking DI benefits higher for employed workers than for job losers and non-participants. Many potential beneficiaries will therefore seek benefits in the event of job loss but not otherwise. We call these potential beneficiaries ‘conditional applicants.’ As our conceptual model demonstrates, the size of this conditional group is likely to be relatively elastic to program and labor market conditions. By contrast, direct employment to disability transitions will be relatively inelastic. Our framework therefore implies that reduced DI screening stringency, rising replacement rates, and slackening demand for low skilled workers should have raised the propensity of workers facing an adverse demand shock to exit the labor force to seek disability benefits.

This prediction structures our empirical analysis. After establishing that cross-state shifts in the supply of benefits raised the labor force participation of less-skilled workers during the 1979 – 1984 disability retrenchment and lowered them thereafter, we turn to an examination of the interaction of the disability program with adverse demand shocks. We find that DI application rates for given demand shocks rose secularly after the disability reforms of 1984, reaching two to three times their pre-reform levels by the late 1990s. Paralleling this change, we estimate a sixty percent increase in the propensity of displaced high school dropouts to exit the labor force. Simple calculations suggest that increased disability application propensity can account for this behavioral change. As alternative explanations for the observed labor force exit of less skilled workers, we explore the importance of changing mortality rates, rising immigration and incarceration rates, fluctuations in UI benefits and, logically, falling wages. Though many of these factors appear relevant to cross-state patterns of low-skilled labor force participation, none substantially alters the finding that the increasing supply of DI benefits induced substantial labor force exit of low skilled workers during 1984 – 1998.

To gauge the importance of changes in the DI program for the aggregate labor market, we calculate the demand contraction experienced by high school dropouts over the post-disability-reform years to form a counterfactual labor force participation figure net of disability. A limitation of our approach is that it does not allow us to disaggregate the separate labor market impacts of reduced screening and rising replacement rates – the latter a partial function of declining relative wages for low-skilled workers.

Summing over these structural components, our ‘reduced form’ counterfactual suggests that changes in labor force behavior of less skilled workers induced by the disability system lowered the measured U.S. unemployment rate by more than half a percentage point since 1984. Notably, the impact of disability on the aggregate labor market is yet to be fully felt. Steady state calculations augur a further forty percent increase in DI reciprocity rates over the next decade, which is likely to be concentrated among less skilled workers.

I. POST-1984 CHANGES TO THE FEDERAL DISABILITY SYSTEM: SCREENING, BENEFITS, AND BENEFICIARIES.

The federal government provides cash and medical benefits to the disabled through the Social Security Disability Insurance (DI) and Supplemental Security Income (SSI) programs.³ The health eligibility criteria for the two programs are identical, requiring a medically determinable impairment that prevents the applicant from engaging in any “substantial gainful activity.” SSI benefits are means-tested and do not require prior work history. DI benefits, which are not means tested, are set according to a recipient’s prior earnings history. To obtain benefits, applicants provide detailed medical, income, and asset information to a federal Social Security Administration (SSA) office, which makes the disability determination. Individuals currently in the labor force are not normally considered eligible for disability benefits.⁴

A. Clampdown and Liberalization

During the late 1970s, concern over swelling disability rolls spurred the Social Security Administration to tighten medical eligibility criteria and exercise greater control over the state boards that interpret SSA’s eligibility standards. The fraction of applicants awarded benefits (the ‘award rate’) fell from 45 percent in 1976 to 32 percent in 1980. Augmenting this administrative action, Congress passed

³ Approximately one-fourth of DI recipients also receive funds from Supplemental Security Insurance (SSI), which is an entitlement program rather than a labor income insurance system. Though the two programs have many overlaps, we focus on DI because by design, it has far more interaction with labor force participants. Bound, Burkhauser and Nichols [2001] report that approximately 85 percent of DI applicants were employed 36 months prior to application while the comparable figure for SSI applicants was below 30 percent.

⁴ For example, earnings exceeding \$500 per month in 1999 would have automatically disqualified a DI applicant.

legislation in 1980 mandating that SSA perform more frequent beneficiary health reassessments known as Continuing Disability Reviews. In the subsequent three years, SSA determined that more than 380,000 DI beneficiaries – 40 percent of those whose cases were reviewed – no longer met medical standards and terminated their benefits [Rupp and Scott 1998]. Congress also required the Social Security Administration to further tighten medical criteria, accelerating the decline in award rates. This large-scale curtailment of benefits, occurring during the deepest post-war U.S. recession, was met with intense public criticism. Citing violations of due process, seventeen states refused to comply with the DI review effort during 1983 and 1984.

Responding to the backlash, Congress passed legislation in 1984 that profoundly altered the disability determination system, yielding a broader definition of disability and providing applicants and medical providers with greater opportunity to influence the decision process.⁵ Despite improving economic conditions, the number of DI awards increased by one third from its 1982 trough to a 1986 peak (the highest level reached during the 1980s). Contemporaneously, Continuing Disability Reviews came to a near halt. In the five years from 1985 through 1989, SSA terminated fewer individuals for failing to meet medical eligibility standards than it had terminated in the first five months of 1982.

B. Rising Replacement Rates

While we have stressed the role of the liberalization of screening in expanding the supply of DI benefits, potentially as significant was an unforeseen rise in the earnings replacement rate. This rise was caused by the interaction between the DI benefits indexation schedule and the growth of earnings

⁵ SSA was required to: 1) relax its strict screening of mental illness by placing less weight on diagnostic and medical factors and relatively more on functional factors; 2) give highest weight to the source evidence provided by the applicant's own health care provider above the SSA's own consultative exam; 3) give more consideration to pain and related factors; 4) consider multiple non-severe impairments as constituting a disability (whereas prior to 1984 only listed severe impairments were considered); 5) desist from terminating benefits for any individual for whom SSA could not demonstrate compelling evidence of health improvement; 6) provide benefits for those former recipients whose terminations were under appeal; and 7) suspend Continuing Disability Reviews for mental impairments and pain until appropriate guidelines could be developed. See Stapleton, et al. [1998] for a detailed discussion. In the post-1984 period, Congress made two additional changes that expanded the number of beneficiaries. In 1989, Congress directed SSA to conduct outreach to potentially eligible low-income individuals to inform them about SSI benefits. In 1991, Congress required SSA to place still greater weight on the information provided by an SSI or DI applicant's own medical provider.

inequality in the United States economy.⁶

Determination of an individual's DI benefit proceeds in two steps. First, the beneficiary's Average Indexed Monthly Earnings (AIME) is computed as

$$(1) \quad AIME = \frac{1}{T} \sum_{t=1}^T Y_{it} \cdot \max \left[\frac{\bar{Y}_{T-1}}{\bar{Y}_t}, 1 \right],$$

where Y_{it} is equal to an individual's average monthly earnings (conditional on employment) in each year t , inflated to current dollars by the ratio of the average wage in the United States economy in the prior year (\bar{Y}_{T-1}) to the average wage in the year of earnings.⁷

Second, the benefit awarded, the 'Primary Insurance Amount' (PIA), is computed from the AIME using the piecewise linear formula

$$(2) \quad PIA = \begin{cases} 0.9 * AIME & \text{if } AIME \in [0, b1] \\ 0.9 * b1 + 0.32 * (AIME - b1) & \text{if } AIME \in (b1, b2], \\ 0.9 * b1 + 0.32 * (b2 - b1) + 0.15 * (AIME - b2) & \text{if } AIME > b2 \end{cases}$$

where the 'bend points' ($b1, b2$) are also rescaled each year by average wage growth in the economy. As visible in (2), the DI benefits formula is progressive (i.e., concave), ensuring that low wage workers replace a greater share of income.⁸ Indexation of the benefit formula to the mean wage in the economy further ensures that benefit levels keep pace with aggregate earnings growth.

In an era of stable earnings inequality, this formula has little impact on the evolution of replacement rates. Between 1979 and 1995, however, real weekly earnings of full time, full year workers with less than a high school degree fell by 19.1 percentage points while the Social Security Administration's mean

⁶ To our knowledge, this increase has been overlooked by the economics and DI policy literatures.

⁷ In addition, approximately the lowest five years of earnings are discarded and quarters with earnings in excess of that period's taxable Social Security maximum are truncated at the cap. Once the DI benefit is awarded, annual cost of living increases are tied to the Consumer Price Index.

⁸ For example, a worker with an AIME that did not exceed $b1$ would receive 90 percent earnings replacement. Because a 7.25 percent Social Security payroll tax is assessed on wage but not DI income, the effective replacement rate would be closer to 100 percent.

real series increased by 21.6 percentage points in real terms.⁹ This increase in the proportional difference between mean wages and below-mean wages caused the DI replacement rate for low-wage workers to rise substantially.

To illustrate the mechanism underlying this rise, it is useful to consider a worker whose earnings growth over her career lagged contemporaneous average nominal wage growth (as would be true for many low-skilled workers in this era). Because the wage index applied in (1) and (2) inflates prior earnings to current dollars using the growth rate of average nominal wages, the indexed monthly earnings (AIME) computed in step one of the benefits calculation for this low earnings-growth individual would exceed current earnings. Additionally, because the bend points in (2) follow the same wage index, these would also have risen relative to individual earnings. A greater share of the worker's AIME would therefore be replaced on the steeper sections of the curve (i.e., in the 90 and 32 percent ranges rather than the 15 percent range). These two impacts – a rising AIME and rising bend points – are additive: indexation of earnings to the mean wage raises the ratio of AIME to prior earnings while indexation of the bend points raises the share of the AIME replaced on the more generous sections of the benefits formula.

The distributional impacts of indexation are seen in Table I. Currently employed male workers ages 55 – 61 at the 10th percentile of the (age-specific) earnings distribution who applied for and received DI benefits in 1979 would have replaced 52 percent of their current earnings with DI cash transfers. By 1999, this number had risen to 74 percent. Accounting for the rising value of in-kind Medicare benefits provided, the potential DI replacement rate for a 10th percentile male age 55 – 61 rose still further from 67 to 104 percent. Nor was this rise limited to the older workers. For males at the 10th percentile of earnings, the rise in the replacement rate exceeded 18 percentage points in all age brackets. At higher positions in the earnings distribution, however, the growth was far less pronounced. For workers at the 75th and 90th percentiles of earnings, potential replacement rates rose a comparatively modest 4 to 8

⁹ Real wages are calculated from CPS March Annual Demographic files as annual earnings of full-time male high school dropouts ages 25 – 64 for earnings years 1979 and 1998.

percentage points.¹⁰

C. *Changing Characteristics of DI Beneficiaries*

As documented in Tables II and III, several marked demographic shifts in the DI population accompanied these benefit supply shifts. One was a rapid increase in the share of younger recipients. Among males ages 25 – 39 and 40 – 54, DI receipt rose by 50 percent between 1984 and 1999. The proportional increase for males above age 54 was only one-quarter as large. Among women, growth in DI receipt was even more rapid but also skewed towards younger recipients. In net, the share of DI recipients between the ages of 40 and 54 rose by more than 50 percent following the 1984 liberalization while the share of male beneficiaries declined by 15 percent [U.S. Social Security Administration, *Social Security Bulletin: Annual Statistical Supplement*, various years].

The DI population has always been substantially less educated than average, and as the program grew post-1984, it encompassed a substantially larger share of this population. Using data from the Survey of Income and Program Participation (SIPP), we estimate that the share of high school dropouts receiving disability benefits rose by over 60 percent after 1984, and more than doubled for high school dropout males ages 40 – 54.¹¹ In 1999, a 40 – 54 year old high school dropout was four to five times as likely to receive DI benefits as a male in the same age range with at least a high school degree.

The rapid growth in DI receipt among male high school dropouts mirrored a substantial decline in their labor force participation (panel C). Between 1984 and 1999, the labor force participation rate of high school dropout males declined by 8.7 percentage points among those 40 – 54, and 7 percentage points among those 55 – 64. Simultaneously, the share of male high school dropouts in these age brackets

¹⁰ Further information on all data sources and variable construction is provided in the Data Appendix. We find that cash replacement rates increased for workers at all percentiles of the wage distribution (though less for high wage individuals) because earnings used for the SSA indexation formula increased approximately 20 percentage points more during 1979 to 1999 than did average wages for males ages 25 – 61 in the March CPS files used for our replacement rate series.

¹¹ Since SSA does not report the educational distribution of DI recipients, we use the SIPP to estimate these numbers for 1984 and 1999. SIPP data are unfortunately not available for earlier years. Relative to high school dropouts, proportionate growth in DI receipt for those with at least a high school degree was substantially smaller among males and slightly larger among females. In all cases, growth among better educated workers was from a low base.

receiving DI rose by 5.3 and 6.3 percentage points. Hence, despite the steep decline in male high school dropout participation, the share of male high school dropout *non-participants* receiving DI benefits in these age categories rose to slightly above 40 percent.¹²

Finally, as younger beneficiaries entered the DI rolls, the fraction suffering from comparatively low mortality impairments grew (Table III). The share of DI awardees with a primary diagnosis of a mental disorder or a disease of the musculo-skeletal system (typically back pain) – the two disorders with the lowest mortality among SSA’s fourteen major diagnostic categories – increased by 60 percent between 1983 and 1999. The corresponding award shares for neoplasms (cancers) and circulatory system diseases (primarily heart disease), both of which have mortality far in excess of average, declined by 40 percent.

Several consequences of these demographic shifts are seen in Figure I, which plots the annual rate of DI benefit termination by cause from 1978 – 2000: death, retirement, and medical disqualification. Following the 1984 liberalization, DI rolls increased at an average annual rate of 4.2 percent (*excluding* dependents of DI recipients). As younger cohorts with lower mortality impairments entered, the annual mortality rate of DI recipients fell by 35 percent and the exit rate into the retirement system declined by 40 percent. Accordingly, the expected benefit duration of newer cohorts now substantially exceeds 1984 levels [Rupp and Scott 1998].¹³

Because most objective evidence suggests that the prevalence of disabling illness fell during this time [Cutler and Richardson 1997], it is likely that the growth in DI rolls is primarily explained by non-health factors that shifted the supply and demand for disability benefits. These include a more expansive definition of disability, changes in the DI award process, rising replacement rates and, closely related, declining labor market opportunities for less skilled workers.¹⁴

¹² Unemployment per population rates of high school dropouts also fell steeply during these years (panel D). We discuss these trends further in Section V.

¹³ An exception to this expansionary trend was Congress’ 1996 discontinuation of benefits for individuals who qualified for disability on the basis of alcohol and drug addiction, resulting in the termination of approximately 130,000 beneficiaries, visible in Figure I [cf., Lewin Group 1998].

¹⁴ This set of facts does not imply that more recent disability beneficiaries are ‘shirking.’ As Bound and Waidmann

II. WHEN DO SHIFTS IN BENEFITS SUPPLY IMPACT LABOR SUPPLY: DEMAND SHOCKS OR DIRECT QUILTS?

Before analyzing the impact of changing DI benefits supply and demand on the labor market, we offer a brief model to motivate our empirical approach. In a market setting where all job separations were involuntary, workers would apply for DI benefits only at the onset of illness or job loss. An analysis of the impact of shifts in the supply of benefits on labor force participation would therefore focus on the labor supply decisions of displaced workers, specifically whether they chose to seek new employment or apply for DI benefits instead. Since in reality workers can endogenously quit jobs to obtain DI benefits, shifts in benefits supply might instead largely impact labor supply by inducing endogenous quits even absent adverse shocks. Below, we write a simple dynamic programming model to explore how elastic these responses – exit after shocks or direct quits – are likely to be to shifts in the supply of benefits.

We compare steady states of a discrete time Markov model in which individuals may be in one of three states in each period: employed; unemployed and seeking work; and seeking or receiving DI benefits (not participating). Employed workers receive per-period utility of employment $\mathbf{n}(w, h)$ where the utility of work is increasing in wages and health: $\mathbf{n}_1(\cdot), \mathbf{n}_2(\cdot) > 0$.¹⁵

Employed workers face a per-period hazard s of job loss and unemployed job seekers face a per-period hazard q of re-employment. As an alternative to employment, individuals may seek DI benefits. Applicants with health h qualify for benefits after one period with probability $p = p(h)$, and rejected applicants may reapply. Consistent with DI program rules, labor force participants are rejected with

stress [1992 and 2000], disability is a continuous rather than a dichotomous medical state. A more expansive definition of disability will accommodate a greater range of illness. Bound and Waidmann [2000] provide evidence that the incidence of self-reported disability among males responds markedly to changes in the generosity of the disability program. Similarly, Baker, Stabile and Deri [2001] find using matched medical records and health self-reports from Canada that individuals who are out of the labor force are more likely to report major medical ailments that are not reflected in objective health records. Notably, despite large increases in disability receipt, Burkhauser, Daly, Houtenville, and Nargis [2001] find that prevalence of self-reported disability by income decile has changed little over the past two decades.

¹⁵ In modeling the disability application decision as a function of both health and the disutility of work, we follow the approach of Diamond and Sheshinski [1995]. See also Hausman and Halpern [1986], Butler, Burkhauser and Weathers [1999], Kreider [1999] and Benitez-Silva et al. [2000] for theoretical and empirical models of the DI

probability one.¹⁶ Accepted applicants receive per-period income of d in perpetuity.

We assume a discount factor of $\mathbf{b} < 1$ and set per-period utility of unemployment to zero.¹⁷ To (further) simplify the analysis, we restrict attention to the case in which neither w nor h is time varying, and we consider a set of individuals who face a common probability of DI award conditional on application: $p(h_i) = p \forall_i$.

Using these parameters, the asset value of employment reduces (after some algebra) to the following expression:

$$(3) \quad V_E = \max \left[\frac{\mathbf{b}pV_D}{1 - \mathbf{b}(1-p)}, \frac{\mathbf{n}_i(1 - \mathbf{b}(1-p)) + \mathbf{b}^2psV_D}{(1 - \mathbf{b}(1-s))(1 - \mathbf{b}(1-p))}, \frac{\mathbf{n}_i(1 - \mathbf{b}(1-q))}{(1 - \mathbf{b})(1 - \mathbf{b}(1-q-s))} \right].$$

Each of the three terms inside of the brackets in (3) corresponds to one of three decision rules ('policies') that a worker may pursue: apply for DI benefits immediately (I), apply conditional on job loss (C), or remain in the labor market after job loss (R).

The first bracketed term in (3) is the value of quitting employment directly to seek disability benefits. Note that if a worker selects this policy, she will find it optimal to quit employment immediately, to reapply for benefits if rejected, and to remain a beneficiary in perpetuity once accepted. The asset value of policy V_I is therefore the present discounted value of permanent benefits receipt $V_D = u(d)/(1 - \mathbf{b})$ discounted by the expected time from quit to award.

The second term is the value of remaining employed until exogenous job loss and then seeking disability benefits thereafter. We refer to this policy as 'conditional application' and its value V_C incorporates the asset value of applying for and ultimately receiving DI benefits and the expected flow

application decision.

¹⁶ Although it is possible that some DI applicants collect unemployment insurance benefits during the application process, this is technically illegal and likely rare since UI beneficiaries must demonstrate that they are active job seekers. UI recipients may of course seek DI benefits when UI is exhausted.

¹⁷ Setting per-period unemployment utility to zero is an assumption rather than a normalization. Provided that the flow utility of unemployment is less than the flow utility of receiving DI benefits, explicitly parameterizing the level of unemployment benefits adds complexity but does not change the core results.

value of employment prior to DI application.

The third policy in brackets is the value of remaining in the labor market in perpetuity, V_R . Because workers pursuing this policy seek reemployment (not DI benefits) after job loss, the reemployment hazard q appears in this expression while the benefits award hazard p does not.

The three components of (3) are linked by the $\max[\cdot]$ operator because the value of employment for a given individual corresponds to the policy $\{I, C, R\}$ that yields the highest expected utility. For market participants arrayed along the distribution of \mathbf{n} , the value of employment is the upper envelope of these three policies. Figure II depicts a simulation of the asset value of each policy as a function of \mathbf{n} .¹⁸ As is visible in the figure, these three slopes give rise to two thresholds labeled $\tilde{\mathbf{n}}_{IC}$ and $\tilde{\mathbf{n}}_{CR}$, in which the optimal policy shifts from (I) to (C) to (R) as a function of \mathbf{n} . Solving for these thresholds yields

$$(4) \quad \tilde{\mathbf{n}}_{IC} = \left(\frac{\mathbf{b}p}{1 - \mathbf{b}(1-p)} \right) u(d), \quad \tilde{\mathbf{n}}_{CR} = \left(\frac{pu(d)}{q} \right) \left(\frac{1 - \mathbf{b}(1-q-s)}{1 - \mathbf{b}(1-p)} \right).$$

Equation (4) permits exploration of the question that motivates the model: how do changes in program parameters d and p (the ‘supply’ of benefits) and labor market parameters q and s (the ‘demand’ for benefits) affect the share of workers pursuing each policy, in particular quitting work immediately to apply for benefits versus applying for benefits conditional on job loss?

Consider first the impact of demand conditions on labor force exit. An individual who is indifferent between immediate and conditional disability application is by definition indifferent to a change in the job loss hazard that hastens or retards the moment of application. Hence, $\tilde{\mathbf{n}}_{IC}$ is independent of s . Because workers pursuing (I) and (C) do not reenter the labor market after exit, $\tilde{\mathbf{n}}_{IC}$ is also independent of the reemployment hazard q . Consequently, changes in labor market conditions do not impact the size of the group that quits employment immediately to seek benefits (I). These parameters do however

¹⁸ Parameter values used for the simulation are $\mathbf{b} = 0.9$, $p = 0.5$, $u(d) = 1$, $s = 0.1$, and $q = 0.5$. Since p is assumed constant in the sub-population depicted, variation in \mathbf{n} can be viewed as arising from variation in w .

unambiguously impact the size of the conditional applicant group. Because higher s and lower q reduce the value of job search, more adverse labor market conditions increase the share of workers applying for benefits in the event of job loss, policy (C).¹⁹

Next, consider an increase in the supply of benefits. Logically, increases in d and p shift both $\tilde{\mathbf{n}}_{IC}$ and $\tilde{\mathbf{n}}_{CR}$ rightward, raising the total share of workers who eventually seek benefits, both immediately and after job loss. The magnitude of the impact at the two thresholds differs, however:

$$(5) \quad \frac{\partial \tilde{\mathbf{n}}_{CR}}{\partial d} > \frac{\partial \tilde{\mathbf{n}}_{IC}}{\partial d} > 0 \quad \text{and} \quad \frac{\partial \tilde{\mathbf{n}}_{CR}}{\partial p} > \frac{\partial \tilde{\mathbf{n}}_{IC}}{\partial p} > 0 \quad \text{and} \quad \frac{\partial^2 \tilde{\mathbf{n}}_{CR}}{\partial d \partial p} > \frac{\partial^2 \tilde{\mathbf{n}}_{IC}}{\partial d \partial p} > 0.$$

Increases in d and p – and the interaction of the two – shift the conditional/remain-in-labor-force locus, $\tilde{\mathbf{n}}_{CR}$, farther rightward than the immediate/conditional locus, $\tilde{\mathbf{n}}_{IC}$. Provided that the density of \mathbf{n} is weakly increasing between the previous $\tilde{\mathbf{n}}_{IC}$ locus and the new $\tilde{\mathbf{n}}_{CR}$ locus (as would be the case if the distribution of \mathbf{n} were uniform), the size of the conditional applicant will rise relative to the size of the immediate applicant group.

Finally, it is straightforward to show using the cross-partial derivatives of $\tilde{\mathbf{n}}_{IC}$ and $\tilde{\mathbf{n}}_{CR}$ that an increase in the supply of benefits interacts positively with adverse labor market conditions to increase the relative size of the conditional applicant group. The more generous are program benefits or the less stringent is program screening, the more that adverse labor market conditions increase the size of the conditional group (and vice versa).²⁰

¹⁹ It bears emphasis that this result – that direct quits are not influenced by labor market conditions – arises in part from our assumption that w is fixed; workers keep their current wage until job loss. While this assumption is clearly too strong, it is qualitatively consistent with well known evidence that wages of incumbent workers are substantially more sheltered from labor market conditions than those of job seekers [cf., Beaudry and DiNardo 1991; Card and Hyslop 1997; Kahn 1997]. We therefore expect the direct impact of s and q on w among employed workers to be second order. By contrast, it is quite likely that the expectation of w for *job losers* falls substantially at job displacement due to the destruction of specific capital or other incumbency related rents [Jacobson, LaLonde and Sullivan 1993]. Broadening the model to permit expectations of w to depend on labor market conditions and the worker's employment/unemployment state would likely *increase* the differential attractiveness of disability application for job losers relative to employed.

²⁰ More formally, the cross-partial derivatives $\partial^2 \tilde{\mathbf{n}}_{CR} / \partial d \partial s$ and $\partial^2 \tilde{\mathbf{n}}_{CR} / \partial p \partial s$ are strictly positive while

In net, we find that that ‘conditional’ application is likely to be elastic to three forces: benefits supply, benefits demand, and the interaction of the two. By contrast, direct quits are only elastic to the first of these three forces and, in general, less elastic than is conditional application.²¹ Our model therefore suggests that less stringent DI screening and higher replacement rates coupled with declining labor market prospects for the low skilled are likely to have increased the propensity of job losers to exit the labor force to seek disability benefits.

We explore two implications of the model below. In Section III, we use the prediction from (5) that shifts in DI screening stringency should induce larger application responses where replacement rates are higher to test whether DI application rates and labor force participation among low skilled were differentially affected by the pre- and post-1984 shifts in DI screening in high versus low replacement rate states. In section IV, we explore the model’s main implication: the responsiveness of DI application and labor force exit to adverse demand shocks should have risen secularly post DI liberalization.

III. DISABILITY BENEFITS AND LABOR FORCE PARTICIPATION: INSTRUMENTING FOR BENEFITS SUPPLY

We begin the empirical analysis by exploiting the disability retrenchment of 1979 – 1984 and subsequent liberalization of 1984 – 1998 to study the impact of shifts in the supply of disability benefits on labor force participation. The contrast between these two periods provides a useful setting for the analysis. Per-capita disability receipt among non-elderly adults (SSI & DI combined) contracted at 0.12 percentage points annually during the 1979 – 1984 and then expanded at 0.16 percentage points annually

$\partial^2 \tilde{n}_{CR} / \partial d \partial q$ and $\partial^2 \tilde{n}_{CR} / \partial p \partial q$ are strictly negative. All four corresponding cross-partial derivatives for the immediate/conditional threshold \tilde{n}_{IC} are zero. Note that after sufficient time elapses, all “conditional applicants” exit the labor force, at which point the program exerts no further effect on their labor force participation. It is therefore appropriate to think of the model as applying to a single cohort of workers, with new cohorts entering the market in each period.

²¹ A disadvantage of our focus on steady states is that we do not model the labor market impacts of unanticipated changes in parameter values that may induce immediate labor force exits that would not be visible in equilibrium. Consequently, our model should not be taken to imply that the impact of DI benefits on direct quits is negligible, only that the response of ‘conditional’ applications is likely to be more elastic than direct exits.

during the subsequent 14 years.²² If the supply of disability benefits impacts labor supply, it should have raised labor force participation during the first five years of our sample and lowered it thereafter.

Suppressing subscripts, we write the conditional expectation function for labor force participation as:

$$(6) \quad E[LFP | X, w, d, p, h] = \mathbf{a} + \mathbf{f}g(d, p) + \mathbf{b}_1 w + \mathbf{b}_2 h + X\mathbf{b}_3,$$

where LFP is a dichotomous variable equal to one if an individual is a labor force participant, w is the opportunity wage, h is health, and X is a vector of individual characteristics. We denote the Disability benefits ‘supply’ faced by the potential labor force participant as $g(d, p)$, which is assumed to be increasing in both the replacement rate d and the odds of obtaining benefits conditional on application p . The coefficient of interest in (6) is \mathbf{f} , the derivative of labor force participation with respect to benefits supply.

There are a number of difficulties in estimating this equation. First, we cannot typically observe both d and w for a given individual. Second, objective measures of h are normally not available from survey data. And, finally, as stressed by Bound [1989], because individuals with poor health are likely to command lower wages, omission of h from (6) will bias estimates of \mathbf{b}_1 and, if d and h are correlated with w (as is quite likely), \mathbf{f} as well.²³

A. OLS estimates

To surmount (some of) these obstacles, we estimate a state level analog of (6) in first differences:

$$(7) \quad \Delta LFP_{jt} = \mathbf{a} + \mathbf{f}\Delta DI_{jt} + \mathbf{b}_1 \Delta w_{jt} + \mathbf{b}_2 \Delta h_{jt} + \Delta X_{jt} \mathbf{b}_3 + \mathbf{e}_{jt},$$

where j subscripts the 50 U.S. states excluding the District of Columbia and Δ denotes the first difference operator over years t and $t-1$. OLS estimates of (7) are given in Table IV, where the dependent variable is the annualized percentage point change in state labor force participation by demographic

²² Corresponding figures for DI and SSI separately are -0.10 and -0.01 during 1979 – 1984 and 0.07 and 0.08 during 1984 – 1998.

²³ An additional difficulty is the possibility of unmeasured compositional shifts in the high school dropout population, which declined from 26 to 12 percent of overall population during 1979 – 1998. To (imperfectly) account for composition, we control for high school dropout age structure in each state in all models.

subgroups, calculated from the merged monthly files of the Current Population Survey for 1978 to 1998. As a proxy for changes in the supply of disability benefits, we initially use the observed contemporaneous state level changes in DI and SSI recipients per 1,000 non-elderly population ages 25 – 64 ($\Delta DI_{jt}, \Delta SSI_{jt}$). Since SSA does not report the educational attainment of DI and SSI beneficiaries, we use the SSA's total count of non-elderly recipients by state. Models also control for the age distribution of the relevant demographic subgroups. We initially assume that, conditional on age and education, average wage and health changes are common across states and hence allow them to be absorbed by α . In section VI, we directly examine these (and other) alternative explanatory variables.²⁴

Column (1) of Table IV indicates that the rapid decline in disability rolls per population during 1979 to 1984 was significantly positively correlated with contemporaneous cross-state *increases* in the labor force participation of high school dropout males. A one-tenth of a percentage point decline in disability receipt is predicted to have raised male high school dropout labor force participation by one-third of a percentage point during this five year interval. Since high school dropouts comprise a far larger share of the disability recipient population than their share in the workforce, this coefficient is of reasonable magnitude.²⁵ Specification (2) disaggregates the change in disability receipt into DI and SSI components. Consistent with the differing labor force histories of the beneficiaries of these two programs, we find that the column (1) result is driven entirely by DI receipt. SSI rolls are not significantly related to labor force participation.

Columns (3) and (4) display analogous estimates for the labor force participation of high school dropout males during the post-liberalization era. Despite the fact that the DI and SSI programs were contracting rapidly during 1979 – 1984 and expanding rapidly during 1984 – 1998, the estimated impacts of disability receipt on labor force participation are remarkably comparable across periods. Male high

²⁴ A key assumption here is that health is not itself procyclical. Ruhm [2000] provides evidence that health is countercyclical.

²⁵ Male high school dropouts comprised 7.9 percent of the labor force over 1984 – 1998 (CPS data) and comprised 25 percent of all disability recipients in 1999 (SIPP data).

school dropouts were differentially *entering* the labor force in states with large reductions in disability receipt during the retrenchment and differentially *exiting* in high disability growth states following the liberalization. Notably, comparable specifications for males with at least a high school education in columns (5) – (8) show small and typically insignificant relationships between labor force participation and disability receipt in both periods. Although as shown in Table II, DI receipt did increase among more educated adults, this growth does not appear to have been accompanied by labor force exit.

The lower panel of Table IV provides analogous estimates for the labor force participation of females by education group. Although the point estimates are less precise than in the corresponding male models, we again find that DI but not SSI receipt is negatively related to the labor force participation of high school dropouts during both the retrenchment and reform periods. No similar relationship is detected for females with a high school education or greater. Since the growth in DI rolls was proportionately larger among women than males during 1984 to 1998, these patterns suggest that the strong correlations detected between DI and labor force participation are not merely an artifact of the declining labor force participation of less educated males (Table II).

B. Instrumental variables estimates

A concern with the Table IV estimates is that growth in disability benefits is driven both by changes in the supply of benefits due to the program retrenchment and reform and by changes in the demand for benefits due to earnings and health shocks. Depending on the cross-state correlation between supply and demand shocks, the Table IV estimates may be biased either upward or downward. To address this concern, we exploit cross-state variation in replacement rates to instrument for changes in the supply of benefits. Because as shown above, the DI benefits formula is progressive but does not account for variation in regional wage levels, potential replacement rates are substantially higher in low wage states at a point in time. Drawing on the March 1978 Current Population Survey-Social Security Earnings Records Exact Match file, in which workers' labor force data are merged to complete Social Security earnings histories, we calculate that the median potential DI earnings replacement rate of currently employed males in 1978 ranged from a low of 18 percent in Alaska to a high of 38 percent in South Carolina, with a

cross-state standard deviation of 2.6 percentage points.²⁶

The potential replacement rate provides a plausible instrument for the supply of DI benefits, ΔDI_{jt} in (7), since it induces variation in d that should not otherwise be correlated with health or labor supply. Since the variation in replacement rates available is cross-sectional, it does not necessarily provide an instrument for the *change* in the supply of benefits in our estimating equation (7). However, as indicated by equation (5) of the model, shifts in screening stringency are predicted to have a greater impact on DI rolls where the level of the replacement rate is higher. Hence, the interaction between cross-state variation in DI replacement rates and national shifts in the DI screening regime may serve as instruments for cross-state *changes* in DI benefits supply in equation (7).

We implement this approach in Table V. Column (1) presents the OLS estimated relationship between DI receipt and labor force participation of high school dropout males during 1979 – 1984 and the subsequent column presents the analogous instrumental variables estimate. The first stage coefficient tabulated beneath indicates that, as implied by the model, the per-capita *contraction* in DI rolls over 1978 – 1984 was substantially greater in states with higher replacement rates. And conversely, per-capita *expansion* in DI rolls was substantially greater in high replacement rate states after the 1984 relaxation of screening stringency.²⁷

The instrumental variables models in Table V confirm the patterns of the OLS estimates in Table IV. Inward shifts in the supply of DI benefits raised the labor force participation of low skilled males and females during 1978 – 1984; outward supply shifts reduced them thereafter. Effect sizes are quite

²⁶ Nor is this variation primarily an artifact of differing educational (and hence earnings) levels across states. The corresponding median values for male high school dropouts were 20 and 44 percent in Alaska and South Carolina respectively, with a cross-state standard deviation of 4.6 percentage points.

²⁷ This specification is identical to column (1) of Table IV except that we drop the SSI variable. The instrumental variable employed is the earnings replacement rate at the 75th percentile of the male potential DI replacement rate distribution calculated from the CPS-SSER. We use the earnings of males exclusively because of their high rate of labor force attachment, and use the 75th percentile replacement rate – typically corresponding to low earnings workers – because of our focus on labor supply of low skilled. Using the median replacement instead does not qualitatively impact our results. The interpretation of the first stage coefficient in column (2) of panel A of the table is that for each additional percentage point of replacement rate in 1978, state disability rolls fell by 0.077 recipients per 1,000 non-elderly adults per year during 1979 – 1984.

comparable across genders. Notably, IV estimates again show no impact of DI benefits on the labor force participation of more skilled workers.

Although the limited precision of the IV estimates cautions against drawing strong inferences about magnitudes, these models suggest that OLS estimates are not downward biased. Marginal DI recipients impacted by benefits supply shifts appear more likely than typical DI recipients to be high school dropouts. Since less educated workers faced a weakening labor market throughout the 1980s and 90s and were able to replace a growing share of income with DI benefits, this result appears sensible.

IV. DO DISABILITY BENEFITS AFFECT HOW LOW-SKILLED WORKERS RESPOND TO ADVERSE EMPLOYMENT SHOCKS?

The finding that shifts in DI benefits impact labor supply is consistent with two (not mutually exclusive) explanations: a once-and-for-all labor supply response, corresponding to an increase in direct quits in our model; or a secular shift in the sensitivity of labor force exit to adverse demand shocks, corresponding to an increase in ‘conditional exits.’ Our model predicts that the latter mechanism should have become increasingly significant following DI reform: reduced screening stringency, rising replacement rates, and declining demand for low skilled workers should each have raised the relative attractiveness of DI application and labor force exit for workers facing adverse shocks.

To test this implication, we require a measure of plausibly exogenous labor demand shocks. Following the approach developed by Bartik [1991] and employed by Blanchard and Katz [1991] and Bound and Holzer [2000], we exploit cross-state differences in industrial composition and national-level changes in employment to predict individual state employment growth. Specifically, we calculate the predicted log employment change \hat{h}_{jt} for each state j between years t and t as

$$(8) \quad \hat{h}_{jt} = \sum_k g_{jkt} h_{jkt},$$

where h_{jkt} is the log change in 2-digit industry k 's employment share nationally and g_{jkt} is the share of state employment in industry k in state j in the initial year. The subscript j in h_{jkt} indicates that each

state's industry k employment is excluded in calculating the national employment share change.²⁸

This methodology predicts what each state's change in employment would be if industry level employment changes occurred uniformly across states and state-level industrial composition was fixed in the short term. States with a relatively large share of workers in declining industries will have predicted employment declines, while those states differentially employing workers in growing industries will have predicted increases. Provided that national industry growth rates (excluding own state industry employment) are uncorrelated with state level labor supply shocks, this approach will identify plausibly exogenous variation in state employment.

A. Estimation Framework

We consider a modified form of equation (6) in which we write the conditional expectation of DI application for a displaced worker as:

$$(9) \quad E[Apply | Job Loss, X, w, d, p, h] = \mathbf{a} + \mathbf{s}g(d, p) + \mathbf{b}_1w + \mathbf{b}_2h + X\mathbf{b}_3,$$

where $g(\cdot)$ again represents the disability supply function. Our model implies that $\mathbf{s} > 0$, greater benefits supply increases the propensity of adversely shocked workers to exit the labor force. As above, we estimate this equation using state level data. Here, the move from individual to aggregate data is less straightforward. Ignoring demographic characteristics in (9) for the moment, we write the model for the flow of state DI applications in year t through \mathbf{t} as

$$(10) \quad Apps / Pop_{jt} = \mathbf{a} + \mathbf{I}_t \Delta Emp / Pop_{jt} + \mathbf{e}_{jt},$$

where \mathbf{I}_t measures the direct impact of employment losses on DI application flows in year t . Similarly, we model labor force exit as

$$(11) \quad \Delta NILF / Pop_{jt} = \mathbf{g} + \mathbf{q}_t \Delta Emp / Pop_{jt} + \mathbf{I}_t \Delta Emp / Pop_{jt} + \mathbf{n}_{jt}.$$

²⁸ In excluding own-state employment, our projected employment changes differ from the authors cited earlier. We found that including own-state employment substantially increased the predictive power of the employment projections, which raised a concern about a potential mechanical relationship. Also distinct from Bound and Holzer [2000], we compute \mathbf{h}_{jkt} as the change in log industry employment *shares* rather than levels. This make the demand index strictly a relative measure.

In this equation, declines in labor force participation come from two sources: workers who withdraw from the labor force but do not seek DI benefits (measured by q_t); and job losers who leave the labor force to seek DI benefits (I_t). As the equation underscores, our data do not permit a direct estimate of s in (9).

Instead, estimates of (11) will yield a reduced form that combines both sources of labor force exit:

$$(12) \quad \Delta NILF / Pop_{jt} = \mathbf{a}_0 + \mathbf{p}_t \Delta Emp / Pop_{jt} + \mathbf{u}_t, \text{ where } \mathbf{p}_t = I_t + q_t.$$

Given this constraint, we estimate equations (10) and (12) separately in both the pre- and post- DI liberalization eras to obtain estimates of ΔI_t and Δp_t , the change in the responsiveness of DI applications and labor force exit to demand shocks of given magnitude. With these estimates, we may distinguish three cases. First, if DI application sensitivity has risen but labor force exit propensity has not ($\Delta \hat{I}_t > 0$ and $\Delta \hat{p}_t \approx 0$), this would suggest that rising DI benefits supply has increased program take-up but not impacted labor force exit. Conversely, if $\Delta \hat{I}_t \approx 0$ and $\Delta \hat{p}_t > 0$, this would indicate that labor force exit has risen for given shocks but that this change is unrelated to the supply of DI benefits. Finally, if $\Delta \hat{I}_t \approx \Delta \hat{p}_t > 0$, application and labor force exit propensity have risen conformably, we will view this as evidence that the rising supply of DI benefits has increased the propensity of adversely shocked workers to withdraw from the labor force to apply for DI benefits. A limitation of this approach is that it does not separately identify the impacts of rising replacement rates and declining screening stringency on labor force exit propensity. The measured effect that we identify will be a sum of these structural components.

B. Estimation: Adverse Employment Shocks and DI Application Flows

Estimates of equation (10), the impact of employment shocks on DI application flows, are given in Table VI. The dependent variable in this table is the annualized state level flow of unique DI applications per-capita during 1978 – 84 and 1984 – 1998. The independent variable is the annualized projected state log employment shock measure \hat{h}_{jt} for the corresponding time interval. Models also include time dummies and control for changes in the age and gender distribution of non-elderly adult state residents.

As above, we initially make the assumption that wage and health variables are uncorrelated with employment shocks but examine their impact directly in section VI.

Column (1) of Table VI provides an estimate of equation (10) for the pre-DI liberalization period of 1978 – 1984. The point estimate of -0.13 indicates that a one-percent projected log state employment contraction yielded 1.3 additional DI applications per 1,000 non-elderly adults over these five years. The subsequent column repeats this estimate for the 1984 – 1998 period and obtains a point estimate that is four times as large. Column (3) pools data for the entire time period, adding an interaction between the shock measure, \hat{h}_{jt} , and a post-1984 dummy variable. The increase in \hat{I} from the retrenchment to the reform era is large and precisely estimated. Adding state dummies to control for fixed differences in DI application flows has little impact on this finding.

To potentially improve upon the precision of these estimates, we re-estimate these models using stacked data on application flows and projected demand shocks by state at three-year intervals. These models found in the subsequent four columns provide qualitatively similar results. The estimated growth in DI application sensitivity is not as sizable in the stacked models, but remains quite large and significant.²⁹ To illustrate the source of this result, Figure III plots the conditional relationship between estimated log demand shocks (multiplied by 10^3) and DI applications per 1,000 population for four five-year sub-periods of our sample. Consistent with the contemporaneous rise in replacement rates and the decline in screening stringency post 1984, the slope of the demand shock-DI application locus increases secularly in each adjacent panel. By the 1993 – 1998, we estimate that this slope has increased sevenfold.

We have performed numerous robustness tests to verify these relationships. If the disability application variable is replaced with the flow of DI awards or the change in DI recipients per population, we find qualitatively similar patterns [Autor and Duggan 2001]. We have also utilized county level DI

²⁹ The stacked estimates are not strictly preferable since they may accentuate the importance of measurement error in the demand instrument at short intervals, particularly in models with state fixed effects. To implement these estimates, we use changes for 1978–81 and 1981–84 for the 1978–84 period. For the 1984–98 estimates, we use changes for 1984–87, 1987–90, 1990–93, 1993–96, and (due to sample truncation) 1995–98.

receipt data to explore the sensitivity of disability rolls over 1984 – 1998 to *within-state* variation in local demand shocks generated by variation in county-level industrial structure. Our estimates confirm that within states, counties experiencing relatively negative predicted employment shocks saw substantially faster growth in DI rolls over 1984 – 1998.

Panel B of Table VI presents a variant of the models above in which we estimate the impact of changes in the overall high school dropout employment to population ratio on DI application flows while instrumenting high school dropout employment with the projected demand shock measure. Because these models only allow demand shocks to impact DI applications through their covariance with the high school dropout employment to population ratio, it is notable that IV estimated impacts of demand shocks on DI applications are closely comparable to the stacked OLS models in columns (5) – (8) of panel A. Apparently, high school dropout employment levels and DI applications are responding to the same component of the demand shock measure.³⁰

C. Estimation: Adverse Employment Shocks and Labor Force Exit of High School Dropouts

Since essentially all disability applicants are labor force non-participants, the finding of rising DI application sensitivity for given shocks has two potential explanations. One is that since 1984, employment shocks have increasingly spurred labor force non-participants to apply for disability benefits, perhaps in anticipation of difficulty finding work at labor market reentry. A second is that the share of job losers exiting the labor force to seek disability benefits has risen. In terms of equation (12), these cases correspond to $\Delta \mathbf{p}_t \approx 0$ versus $\Delta \mathbf{p}_t > 0$.

We distinguish these possibilities by estimating (12) using projected demand shocks to instrument for net employment losses at the state level. Using the identity that $\Delta Unemp / Pop_{jt} = -(\Delta NILF / Pop_{jt} + \Delta Emp / Pop_{jt})$, we can decompose the impact of employment shocks into the

³⁰ Because the first stage of the long change models in columns (1) – (4) is weak, we focus discussion on the stacked models. A significant limitation of these models is that our DI application measure is not disaggregated by education level and hence it is unlikely that the data satisfy the implied exclusion restriction that demand shocks impact DI applications only through high school dropout employment changes.

component accruing to unemployment and the component accruing to labor force exit. To facilitate comparison to the DI application regressions, we present results for both male and female high school dropouts combined and disaggregated estimates by gender. These are found in Table VII.

During 1978 – 84, a one percentage point shock to the employment to population ratio of high school dropouts induced a 0.46 percentage point increase in non-participation rate and, by implication, a 0.54 percentage point increase in unemployment per population. In the succeeding fourteen years, shocks to employment of equal magnitude lead to substantially larger declines in labor force participation. In both 1984 – 1990 and 1990 – 98, we find that essentially all declines in high school dropout employment led to increases in non-employment rather than unemployment.

To control for persistent state trends in labor force exit that would bias the results if correlated with the demand shock measure, we add state fixed effects to models in columns (2), (6) and (8). Their addition has little impact on the pattern of estimates. To further explore robustness, columns (7) and (8) pool data for 1978 – 98, adding an interaction between the employment loss measure and a post-1984 dummy variable. The pooled estimates confirm a significant increase in the labor force exit propensity of displaced high school dropouts after 1984, on the order of 35 percent. Inclusion of state fixed effects raises the standard errors slightly, but does not alter the findings. As shown in panel B, the pattern of results is essentially identical for both genders.

It bears emphasis that these estimates do not imply that commencing in 1984, all – or even most – high school dropouts who lost jobs exited the labor force. Since our demand shock captures net rather than gross employment declines over comparatively long three-year intervals, displaced high school dropouts who obtain reemployment within the measurement window are not detected. In addition, the shock measure does not impact the labor market exclusively through job loss. Adverse shocks will induce some subset of workers to choose to exit employment and, perhaps more importantly, slow the prevailing rate of reentry of non-participants into the labor force. Similarly, some share of those exiting may be previously unemployed workers whose re-employment prospects were harmed by entry of new unemployed. Each of these forces will reduce the employment to population ratio and yield corresponding

increases in non-participation. What is unambiguous from Table VII is that unemployment rates of low skilled workers have become significantly less sensitive to adverse demand shocks while their rate of labor force non-participation has become substantially more so.

Could the increased generosity of the DI program plausibly account for this behavioral change? To make this calculation, note that $\Delta\hat{I}_t$ in Table VI measures the impact of employment shocks on DI applications for the entire non-elderly population, while $\Delta\hat{p}_t$ in Table VII is measured only for high school dropouts. To make the magnitudes commensurate, we calculate

$$(13) \quad \Delta\hat{I}_t^D = (1/d)\mathbf{x}\Delta\hat{I}_t,$$

where d is the high school dropout share of population in the years of estimation, equal to 16 percentage points in our sample, and \mathbf{x} is the share of the total flow of DI applications submitted by high school dropouts, which we estimate to be 47 percent.³¹ Our estimate of $\Delta\hat{I}_t$ from Table VI ranges from -0.05 to -0.17, i.e., the fraction of all non-elderly adults applying for DI benefits in response to a one log point adverse demand shock rose by 0.5 to 1.7 applicants per 1,000 adults post liberalization. In this equation, $1/d$ rescales the estimated increase in DI applications per population to an increase per *high school dropout* population, while the parameter \mathbf{x} adjusts this estimate downward to account for the fact that only part of the growth in DI applications is due to high school dropouts.

Substituting into (13), we obtain that the implied increase in high school dropout labor force exit propensity for a one log point employment contraction, $\Delta\hat{I}_t^D$, ranges from 0.15 to 0.50. That is, if the increase in high school dropout application propensity were entirely accounted for by labor force leavers, the estimated increase in application sensitivity implies a 15 to 50 percentage point increase in their conditional probability of labor force exit. This estimate is in close accord with the findings in Table VII. Columns (7) and (8) indicate that the share of high school dropouts exiting the labor force in response to a

³¹ The rate of DI receipt among high school dropouts averaged 4.6 times that of those with at least a high school degree during 1984 – 1999 (Table II). Assuming this ratio carried over to applications, high school dropouts would

one unit shock post-liberalization increased by 34 percentage points ($\Delta\hat{p}_t^D = 0.34$). Notably, the estimates of $\Delta\hat{I}_t^D \in [0.15, 0.50]$ from (13) fall symmetrically at one-standard error above and below this estimate. Based upon this (necessarily) rough calculation, we conclude that $\Delta\hat{I}_t \approx \Delta\hat{p}_t$: the increasing supply of DI benefits post-1984 can plausibly account for both greater DI application flows for given shocks and greater propensity of adversely shocked low-skilled workers to exit the labor force. Future analyses using micro-data on the employment and DI application behavior of low-skilled, displaced and discouraged workers should be able to improve on the precision of this result.

V. IMPLICATIONS FOR THE AGGREGATE LABOR MARKET

The reduced sensitivity of high school dropout unemployment to adverse labor demand shocks implies that the share of high school dropouts unemployed at present is lower than it would have been had the supply of DI benefits not shifted outward after 1984. Consider that the typical high school dropout in 1984 was employed in an industry that over the next 14 years declined by 8.53 percentage points as a share of aggregate employment. Combining this negative relative demand contraction with the estimate of $\Delta\hat{p}_t^D = 0.34$, we calculate that the share of high school dropouts who are presently unemployed would be 2.9 percentage points higher in 1998 ($8.53 \times 0.34 = 2.90$) but for the liberalization of DI that occurred in 1984. Since high school dropouts accounted for 12.1 percent of the non-elderly adult population in 1998, this suggests that the aggregate unemployment rate would have been approximately six-tenths (0.57) of a percentage points higher in 1998 were it not for DI liberalization.³²

Although we have focused on the 1984 – 1998 period, it would be inaccurate to conclude that the labor market impact of the DI program had culminated by 1998. As is shown in Figure IV, though per-capita DI awards peaked in 1992 and declined after 1995 (that is, until the 2000 recession), the rate of DI receipt grew steadily throughout the late 1990s. These facts – rising recipients despite declining awards –

have accounted for 47 percent of all DI applications received in this period.

³² Because the unemployment rate is denominated by labor force and not by population, the estimated impact using the 1998 high school dropout participation rate of 62 percent is $(2.90 \times 0.121)/0.62 = 0.57$.

indicate that the DI recipient population was below steady state size. Due to post-1984 declines in DI beneficiary mortality and retirement rates (Figure I), the expected duration of DI receipt for new entrants considerably exceeded that of previous cohorts, implying an increase in the steady state size of the program.

To make a simple projection of the new steady state size, we use the fact that in steady state, benefit terminations must equal benefit awards. Hence, $P^*I = A$, where P^* is the steady state population, I is the termination rate, and A is the number of new awards. Using data from SSA's Annual Statistical Supplement [various years], Figure IV depicts estimates of P^* normalized by population for the years 1976 to 2001. Following the 1984 program liberalization, the steady state program size rapidly doubled from its 1982 low. At the onset of the 1991 recession, award rates increased by another 50 percent, and the projected program size rose accordingly. By 1995, the projected steady state program size had reached 5.1 percent of non-elderly adults, where it largely remained for the balance of the decade.

Given that 3.7 percent of non-elderly adults received DI benefits in 2001, this calculation augurs another 40 percent growth in DI program size relative to population over approximately the next decade.³³ Notably, application rates per population rose an additional 22 percent between 1999 and 2001, indicating the potential for another rise in steady state program size. The DI recipient population may never reach this projected size, however. As the figure indicates, steady state program size in 1976 *exceeded* its 2001 steady state level. It was SSA's recognition of this fact that galvanized the DI program retrenchment and subsequent liberalization that form the backdrop to our study.

VI. ALTERNATIVE EXPLANATIONS: DECLINING WAGES AND HEALTH, RISING IMMIGRATION, INCARCERATION, AND UNEMPLOYMENT BENEFITS.

Our conclusions above must be tempered to the extent that post-1984 increases in the DI application and labor force exit propensities of low-skilled workers are explained by factors other than shifts in the

³³ By using average termination rates, the calculation does not adjust for the fact that more recent DI entrants are likely to have lower mortality and retirement rates than incumbent recipients. Accounting for these cohort effects would likely raise the steady state projection considerably.

supply of DI benefits. Plausible alternative explanations for the cross-state patterns of labor force decline that are the focus of our study include: real wage declines, differential health trends, rising immigration and incarceration rates, and shifts in state Unemployment Insurance (UI) benefits. We explore each of these alternatives below. Means and cross state standard deviations of these measures are given in the first column of Table VIII.

We begin with wages. As argued by Juhn [1992] and Juhn, Murphy and Topel [1991], a sizable elasticity of labor force participation coupled with declining real wages could explain the substantial decline in labor force participation of low skilled males in the 1980s and 1990s. To be clear, we view falling wages as a complement rather than a substitute for the role for the DI program in reducing labor force participation. Indeed, an important component of the rise in replacement rates for low-skilled workers is the interaction between declining wages and the indexation and progressivity of the DI benefits formula. For declining real wages to be the *primary* explanation for our findings, however, it would have to be the case that – not implausibly – wages fell by substantially more in states that had larger declines in labor force participation.

To explore this hypothesis, we use CPS Merged Outgoing Rotation Group earnings data for 1984 and 1998 to construct two measures of the change in the opportunity wage faced by low-skilled workers in each state: the change in the real fixed-weighted median log wage of high school dropout males ages 25 – 64 and the change in the real fixed-weighted log wage of prime age males 25 – 54 at the 25th percentile.³⁴ Because the declining wage hypothesis implies that workers with the lowest potential earnings are least likely to work, we follow Chandra [2002] in including non-participants in the quantile calculations, thus assuming that the potential earnings of non-participants fall below the median (or 25th) percentile of the conditional state wage distribution. Median potential wages of male high school dropouts declined 18.6 log points between 1984 and 1998. In the same period, there was a modest rise at the 25th percentile for

³⁴ In an effort to maximize the explanatory power of alternative hypotheses, we chose the more inclusive measure of wages for male high school dropouts (i.e., ages 25 – 64 rather than 25 – 54). Empirically, the wage measure for the younger group of high school dropouts works similarly but has less predictive power in labor force participation

prime age male workers, reflecting strong earnings growth during the late 1990s [Katz and Krueger 1999].

Although aggregate health improved during the two decades of our sample, differential cross-state health trends could be in part responsible for our findings. To test this possibility, we exploit an objective health measure: the rate of non-accidental, non-homicidal mortality among state residents ages 25 – 64.³⁵ We control for both levels and changes of this measure since each should impact the response of state DI rolls to a reduction in DI screening stringency. Mortality rates declined by one-quarter between 1984 and 1998.

A third potential confound is immigration. Because less-educated immigrants typically have greater labor force attachment than native born high school dropouts [Trejo 2001] and are not eligible for disability benefits until five years after arrival, geographically concentrated immigrant inflows during the 1980s and 1990s could induce negative cross-state correlations between high school dropout labor force participation and DI receipt. We measure non-elderly foreign born population using data from the 1980 and 1990 Census of Populations and the 1998 CPS. The foreign born share of non-elderly adults rose by close to 5 percentage points during 1984 – 1998, with sizable cross-state variation.

A fourth concern is growing incarceration. Because the incarcerated population is included in neither the numerator nor denominator of our labor force calculations, it is not intrinsically a source of bias. However, potential criminals have below average rates of labor force participation relative to other high school dropouts [Western, Kling and Weiman 2001]. If states with low DI growth also experienced differential increases in incarceration over 1984 – 1998, this would bias our estimates. We assemble Bureau of Justice Statistics data on state prison populations (excluding local jails), denominated by state population ages 18 – 64 [U.S. Department of Justice 2002]. Consistent with other authors [Freeman 1991; Katz and Krueger 1999; Western and Pettit 2000], we find that incarceration rates rose by a sizable 0.46

regressions.

³⁵ We focus on an objective measure due to the evidence in Bound and Waidmann [1992 and 2000] that male health

percentage points during 1984 – 1998.

Finally, the UI system provides an alternative (albeit short term) source of wage replacement for displaced workers. Declines in the value of UI benefits during the 1980s and 1990s [Anderson and Meyer 1997] could potentially induce displaced workers to seek DI instead. We measure UI generosity as the 1984 – 1999 change in the state UI replacement rates for a full-time minimum wage worker using data from the U.S. House of Representatives *Green Book* [various years]. Although the mean UI replacement rate did not change appreciably between 1984 and 1998, some states made substantial adjustments.

We present two sets of estimates with these variables. Table VIII shows the relationship between each measure and the annualized percentage point growth in DI rolls per non-elderly state population over 1984 – 1998. Table IX presents analogous estimates for the annualized change in high school dropout labor force participation in the same period. Because results are for the most part comparable for the two dependent variables, we discuss them in combination.

The first three columns in each table include our two main explanatory variables: DI replacement rates (as a proxy for shifts in DI benefits supply) and projected employment shocks. Each has a significant impact on DI growth and high school dropout labor force non-participation. When entered in combination, the projected shock measure is not precisely estimated in the labor force participation equation while the replacement rate measure remains significant at the 10 percent level. Subsequent columns of Tables VIII and IX explore the relationship between the two outcome measures and the other candidate variables, each entered in combination with the replacement rate. Higher initial mortality (though not its change), declines in median wages of high school dropouts, and decreases in the share of foreign born, each contributed to growth in state DI rolls and declines in high school dropout labor force participation during these 14 years.³⁶ We do not find a significant relationship between incarceration or UI replacement rates and either DI receipt or high school dropout labor force participation. Notably, none

self-reports closely track expansions and contractions in the supply of disability benefits.

³⁶ Surprisingly, growth in the median wage for prime-age males is positively (i.e., wrong) signed in both the DI

of these measures greatly affects the estimated impact of the replacement rate on growth in DI rolls and declines in labor force participation.

The final three specifications in each table combine groups of candidate variable shown to be significant in previous columns. In all cases, DI benefits supply appears a robust determinant of both growth in DI rolls and declines in high school dropout labor force participation.

VII. CONCLUSION

Following the 1984 liberalization of the federal Disability Insurance program, the fraction of non-elderly adults receiving DI benefits rose by 60 percent. Contemporaneously, the DI recipient population became younger, less predominantly male, more likely to suffer from low mortality disorders, and far more encompassing of the low skilled population. We trace these shifts to reduced screening stringency, rising cash income replacement rates, and the increasing in-kind value of Medicare benefits provided. We explore the impact of the supply of DI benefits on both the level of labor force participation among the less skilled and their employment responses to adverse demand shocks. As our model underscores, because disability application is more attractive to the unemployed – who intrinsically face lower opportunity costs of exiting the labor force to seek benefits – increases in the supply of DI benefits are likely to induce differential exit of low-skilled workers facing employment downturns, thereby reducing measured unemployment.

Using state level data from the Current Population Survey paired to SSA administrative data on disability applications, awards, and receipt by state and year, we implement two approaches to identify the labor market impacts of shifts in the supply of DI benefits. Initially, we exploit the interaction of state disability replacement rates with national changes in program stringency to identify plausibly exogenous state level shifts in the supply of DI benefits. This analysis finds that state level reductions in benefits supply induced large (relative) increases in the labor force participation of male and female high school dropouts during the DI retrenchment, followed by large declines during the DI subsequent expansion. No

recipient and labor force participation regressions.

corresponding relationship is observed for changes in SSI rolls, or for changes in the labor force participation of more educated workers.

We next investigate whether the declining stringency and growing generosity of the DI system have hastened the labor force exit of low skilled workers facing adverse demand shocks. To distinguish supply from demand in this setting, we use cross state variation in industrial composition to identify potentially exogenous shocks to employment of low-skilled workers both pre- and post- DI reform. Following the liberalization of DI in 1984, we find that DI application rates became two to three times as responsive to adverse labor demand shocks of equal magnitude. Simultaneously, male and female high school dropouts became almost twice as likely to exit the labor force in the event of an adverse shock – and correspondingly less likely to enter unemployment. While our reduced form approach does not quantify the relative importance of reduced DI screening stringency and rising replacement rates in inducing these behavioral shifts, simple calculations suggest that the net impact of outward shifts in the supply of DI benefits is a plausible explanation for both phenomena.

Accounting for the role of the DI program in inducing labor force exit among the low-skilled unemployed, our illustrative calculations suggest that measured U.S. unemployment in 1998 would have been more than half a percentage point higher had it not been for the liberalization of DI that occurred in 1984. Our analysis confirms the findings of Juhn [1992] and Juhn, Murphy and Topel [1991] that declining real wages contributed importantly to the labor force exit of the low skilled in this time period. But declining wages do not by appear a sufficient explanation for our findings. Controlling for cross-state variation in the wage declines faced by low skilled workers, we find that non-participation and disability receipt grew substantially more in states with larger shifts in the supply of DI benefits. In the absence of a significant change in DI program parameters, the aggregate size and accompanying labor market impact of the DI program is likely to increase substantially in the current decade.

DATA APPENDIX

A.1 Employment, Unemployment, and Labor Force Non-Participation

Annual, state-level data on employment, unemployment and labor force non-participation by gender, age, and education category for individuals between the ages of 25 and 64 were calculated using the complete Current Population Survey monthly files for years 1978 – 1999. The number of observations ranges from 1.1 to 1.3 million annually. All calculations use CPS sampling weights. To attain comparable educational categories (high school dropout, high school graduate, some college, college-plus graduate) across the redefinition of Census's Bureau's education variable introduced in the 1992 CPS, we use the method proposed by Jaeger [1997]. In particular, prior to 1992, we define high school dropouts as those with fewer than 12 years of completed schooling. In 1993 forward, we define high school dropouts as those without a high school diploma or GED certificate.

A.2. Wage Data from the CPS Merged Outgoing Rotation Group files

We calculate two measures of the change in the opportunity wage faced by low-skilled workers in each state between 1984 and 1998: the change in the real fixed-weighted median log wage of high school dropout males ages 25–64 and the change in the real fixed-weighted log wage of prime age males 25–54 at the 25th percentile. Our sample includes all males in these age and education categories regardless of employment status excluding the self-employed (for whom wages are not given in the CPS), those working without pay, and employed workers for whom a wage could not be calculated (due to usual hours reported as 'variable'). For workers employed in the survey reference week, wages were calculated by dividing usual weekly earnings by usual weekly hours. Observations were dropped for which calculated wages fell outside the range of \$1 and \$150 per hour (in year 2000 dollars). In cases where state-year-age-education cells were empty, we assigned the median value of corresponding non-empty cells. We use fixed age weights corresponding to the shares of males (male high school dropouts) in state population in 1984 ages 25–34, 35–44, 45–54, and 55–64. Wages are inflated to 1998 values using the chain weighted Personal Consumption Expenditure deflator.

A.3. State level DI and SSI Recipient and Benefits Data

Annual, state-level data on DI and SSI recipients, benefit levels, demographics and qualifying impairments were obtained from various years (1978 – 2000) of the Social Security Administration's *Annual Statistical Supplement* [various years]. DI data includes only disabled workers receiving benefits whereas SSI data includes only disabled adult beneficiaries (thus excluding child and aged beneficiaries).

A.4. State level DI and SSI Application and Award Data

Administrative data on unique disability applications and awards by state for years 1979 – 1998 were generously provided to us by Kalman Rupp and David Stapleton (DI), Charles Scott (SSI), and Alan Shafer of the Social Security Administration. In our data set, the year with which disability applications and awards are associated is the year of application rather than the year of award.

A.5. Demographic data on DI and SSI Recipients from the Survey of Income and Program Participation

Since SSA does not report the educational distribution of DI recipients, we use the SIPP to estimate these numbers for 1984 and 1999. SIPP data are unfortunately not available for earlier years. Disability receipt rates by education category, age, and gender were estimated using data from the Survey of Income and Program Participation 1984 wave 1 and 1996 wave 12. A survey respondent is coded as a DI recipient if she "did receive income from Social Security for himself/herself in this month" and her reason for receipt

of Social Security was disability. An individual is classified as an SSI recipient if she “did receive any income from Supplemental Security Income for him/her self during the reference period.”

A.6. State Level DI Replacement Rates 1978 and National DI Replacement Rates 1979 and 1999

To calculate 1978 state-level potential DI replacement rates used in Tables V, VIII and IX, we use the CPS Social Security Earnings Records Exact Match file, which contains Social Security earnings records in each year 1951-1977 for currently employed males in the CPS sample, which is complete data for DI benefits calculations. We calculate the potential DI replacement rate for all employed males ages 25 – 61 in each state in 1978 and use the 75th percentile in each state as a measure of the potential replacement rate faced by low wage workers. The 1978 CPS-SSER exact match file is used by Bound and Krueger [1991] and was helpfully provided to us by Alan Krueger.

For the replacement rate calculations in Table I, we utilize annual earnings data from the 1964-1999 March CPS Annual Demographic Files and the 1978 CPS Social Security Earnings Records Exact Match file (CPS-SSER). The March files provide annual earnings data for the years 1963-1998 and the Exact Match file is used to estimate earnings percentiles from 1951-1962. In each year between 1951 and 1998, we calculate the 10th, 25th, 50th, 75th, and 90th percentile of earnings for males at each age 25 to 61 inclusive to construct an age-year earnings file with 1,776 observations (48 years, 37 ages). Because only earnings subject to the Social Security payroll tax are used in calculating Social Security benefits, all earnings percentiles in excess of the taxable maximum in a particular year are truncated at the maximum. We assume that an N th percentile worker who was M years old in year T was an N th percentile $M - t$ year old worker in year $T - t$ and estimate Average Indexed Monthly Earnings as follows:

$$(14) \quad AIME_{NMT} = \left(\frac{1}{\min[35, M - 24]} \right) \cdot \sum_{m=\max[25, M-34]}^M \left(\frac{Y_{Nmt}}{12} \right) \cdot \max \left[\frac{\bar{Y}_{T-1}}{\bar{Y}_t}, 1 \right]$$

In this equation, Y_{Nmt} is equal to taxable earnings for an m year old N th percentile worker in year t where t is equal to $T - (M - m)$. The indexing series factor, $\max[\bar{Y}_{T-1}/\bar{Y}_t, 1]$, is obtained from the Social Security Administration and is equal to mean national earnings in year $T - 1$ divided by mean national earnings in year t (with a minimum value of 1). We use the median AIME within each of four age brackets (30-39, 40-49, 50-54, 55-61), to calculate potential DI benefits in year $T + 1$ by applying the PIA formula in equation (2). The Cash Income Replacement Rate given in Table I equals the ratio of DI benefits in year $T + 1$ to after-payroll-tax earnings in year T . Calculation for 1999 use the 1965-1999 March CPS files, while the 1979 calculations utilize both the 1964-1979 March CPS files and the 1978 CPS-SSER file (for earnings from 1951-1962). Because the Social Security Administration only considered earnings after 1950 in calculating DI benefits in 1979, the maximum number of years of prior earnings in the 1979 AIME calculation is 28. Our calculation also assumes that individuals’ have a maximum of 35 years of earnings and that lowest earnings years occur before the age of 25. We do not impute wages for individuals who are out of the labor force. To the extent that male labor force non-participation has increased differentially at the low end of the earnings distribution, our algorithm is thus likely to understate the actual increase in replacement rates for low-skilled workers.

The simulated 1979 replacement rates found in Table I closely accord with the administrative figures from the CPS-SSER data. For example, the 1979 simulated replacement rates for males at the 25th percentile of the earnings distribution for age groups 30-39, 40-49, 50-54, and 55-61 are 41, 41, 41, and 45 percent. The corresponding replacement rates from the 1978 CPS-SSER data are 43, 41, 43, and 45 percent. We use the simulated replacement rates in 1979 for comparability with the simulated values for 1999 (for which no CPS-SSER data are available).

Replacement rates that include the value of Medicare benefits in the final two columns of Table I add average Medicare expenditures for DI beneficiaries in the relevant year to the DI benefit amount and scale earnings to account for average fringe benefit rates for individuals at each of the five earnings percentiles (10th, 25th, 50th, 75th, and 90th) in 1982 and 1996, the two years closest to 1979 and 1999 that were available from Bureau of Labor Statistics data. Average Medicare expenditures for DI beneficiaries in 1979 were \$2,890 (in 1998 dollars) and in \$,4749 in 1998 (the most recent year for which data was available). Average benefit-wage ratios in 1982 were 0.0923, 0.1911, 0.2512, 0.2780, 0.2801 for the 10th, 25th, 50th, 75th, and 90th earnings percentiles, while the corresponding ratios in 1996 were 0.0778, 0.1743, 0.2554, 0.2965, 0.2988. Benefit-wage ratio data were kindly provided by Brooks Pierce of the Bureau of Labor Statistics and are based upon calculations in Pierce [2001].

A.7. Additional variables used in Section VI: Alternative Explanations

a. The rate of non-accidental, non-homicidal mortality among state residents ages 25 – 64 is calculated using mortality data from U.S. Department of Health and Human Services [1984 and 1998].

b. Non-elderly foreign born populations by state for 1984 and 1998 are estimated using data from the 1980 and 1990 Census of Populations and the 1998 CPS. Prior to 1994, the CPS did not collect information on nativity and hence we linearly interpolate 1984 state levels using the 1980 and 1990 Integrated Census Public Use Micro-samples (IPUMS) one percent files.

c. Incarceration rate data is calculated using Bureau of Justice Statistics data on state prison populations excluding local jails [U.S. Department of Justice, 2002] denominated by state population ages 18 – 64 from the CPS.

d. UI generosity corresponds to the 1984 and 1999 potential state UI replacement rate for a full-time minimum wage worker. These data are obtained from the U.S. House of Representatives *Green Book* [various years].

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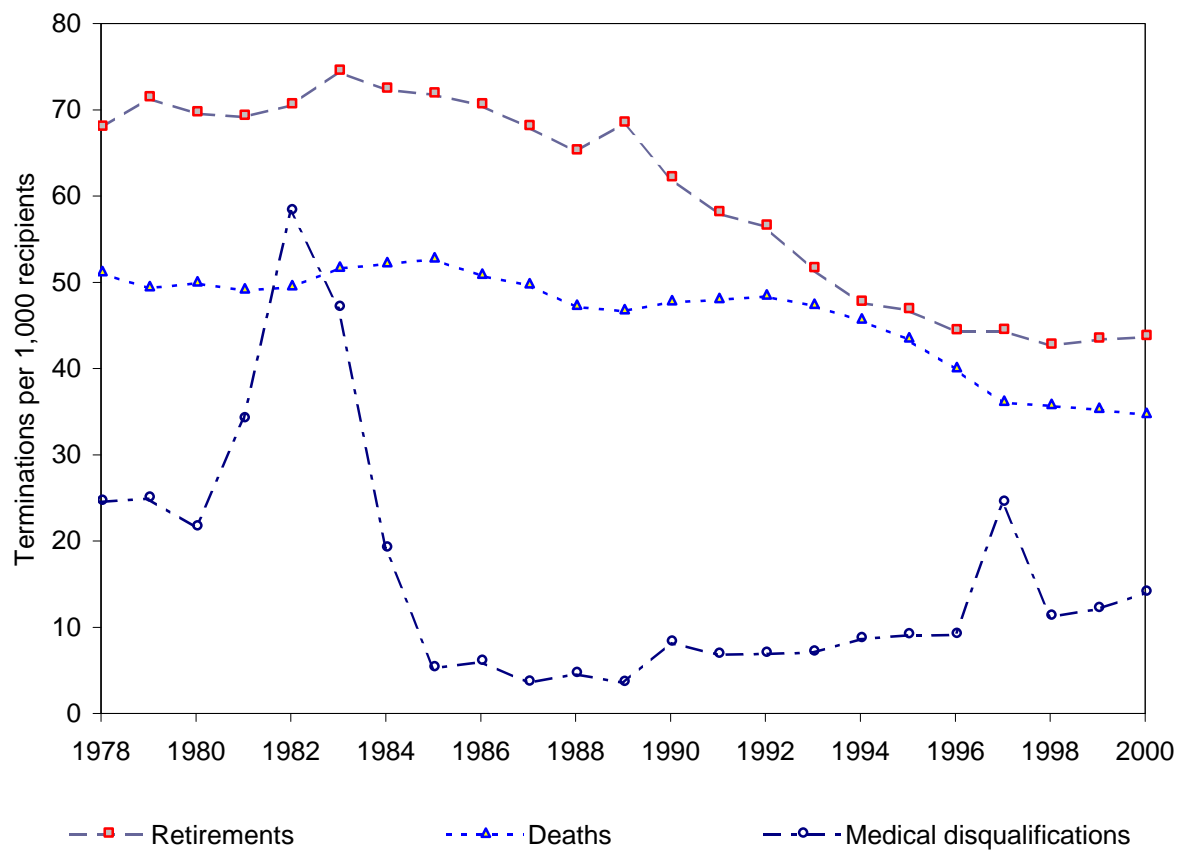


Figure I.
DI Termination Rates per 1,000 Beneficiaries by Reason, 1978 - 2000

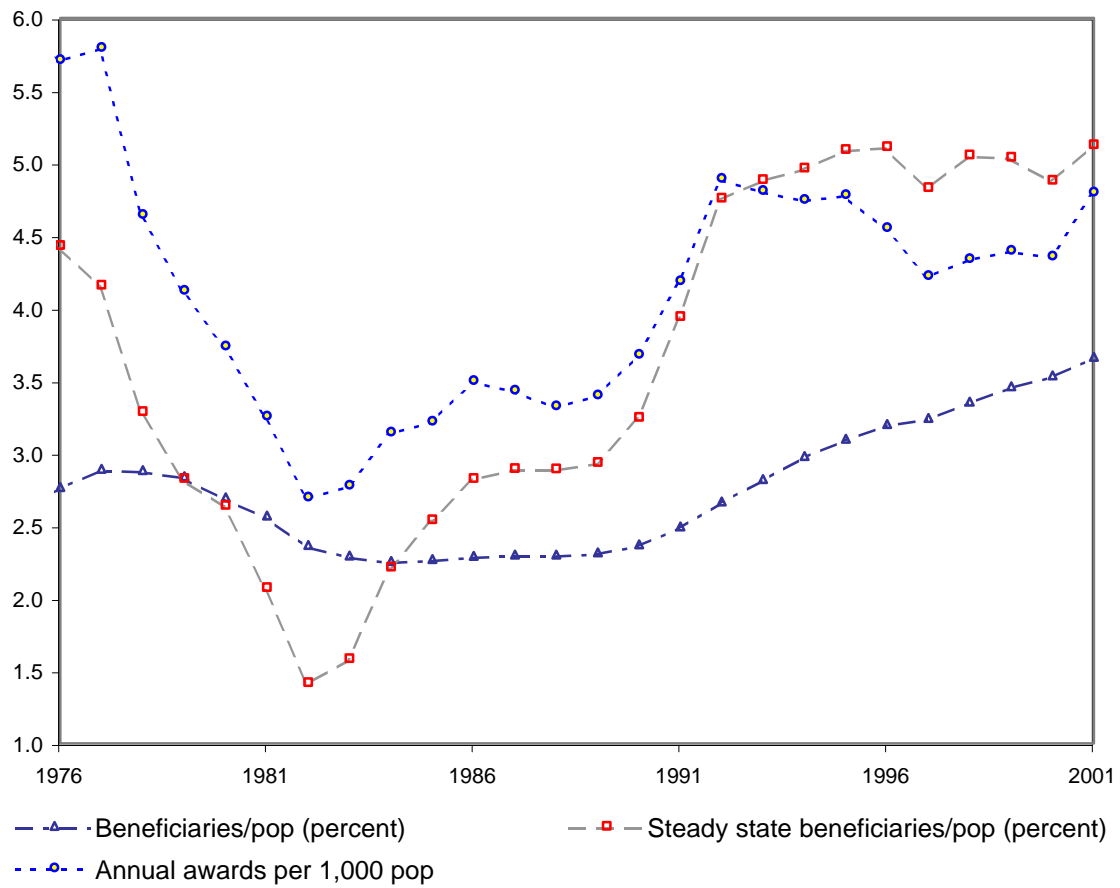


Figure IV.
DI Awards and Current and Steady State Recipients per Non-Elderly Adult Population, 1976 - 2001

TABLE I.
Potential DI Income as a Percentage of Current Earnings for Non-Elderly Males at Various Percentiles of the Wage Distribution, 1979 and 1999.

Age	Earnings Percentile	Cash Income Replacement Rate		Adding In-Kind Medicare Benefit	
		1979	1999	1979	1999
55 - 61	10	52	74	67	104
	25	45	54	48	63
	50	37	47	36	47
	75	27	32	26	31
	90	20	24	19	23
50 - 54	10	47	57	61	81
	25	41	47	44	55
	50	34	41	33	42
	75	26	32	25	31
	90	19	23	18	22
40 - 49	10	48	53	61	80
	25	41	45	44	55
	50	34	41	33	42
	75	26	33	25	32
	90	20	26	19	25
30 - 39	10	46	54	59	84
	25	41	46	44	58
	50	36	41	35	44
	75	29	36	27	35
	90	23	28	21	27

Replacement rates are calculated using the Social Security Administration Disability Insurance benefit formula for 1979 and 1999 in conjunction with annual earnings data from the March CPS files for the years 1963-1998 and the 1978 CPS Social Security Earnings Records Exact Match file for the years 1951-1962. The first two columns represent the ratio of potential disability benefits to current earnings for males in the labor force and with non-zero earnings in 1978 and 1998. The latter two columns add average Medicare expenditures to DI benefits and average percentile-specific fringe benefits to earnings to estimate a total compensation measure of the replacement rate. To calculate Average Indexed monthly Earnings (AIME) for an M year old Nth percentile worker in year T, we use equation (1) of the text and assume that this individual was an M-t year old Nth percentile worker in year T-t and that low earnings years (those excluded in the AIME calculation) occurred before the age of 25. Percentile ranks in this calculation are year and age specific. We use equation (2) of the text to estimate potential DI benefits as a function of the AIME. The final two columns add average Medicare expenditures for DI beneficiaries in the relevant year to the DI benefit amount and scale earnings to account for average fringe benefit rates for individuals at each of the five earnings percentiles using data from Pierce [2001]. See the Data Appendix for further details.

TABLE II.
DI Receipt and Labor Force Participation by Gender, Education and Age 1979, 1984 and 1999.

Age	A. Males									B. Females								
	All			HS Dropout			HS Plus			All			HS Dropout			HS Plus		
	79	84	99	79	84	99	79	84	99	79	84	99	79	84	99	79	84	99
A. DI Recipients per 1,000 Non-Elderly Adults (SSA and Survey of Income and Program Participation data)																		
25 - 39	11	10	15	21	53	5	11	4	4	10	7	21	4	8				
40 - 54	35	28	42	52	105	18	26	15	12	30	35	60	10	21				
55 - 64	113	96	108	148	201	46	59	51	43	72	92	164	29	62				
B. Percent of Non-Elderly, Non-Participants Receiving DI benefits (Survey of Income and Program Participation data)																		
25 - 39	17.2	17.0	23.5	26.8	14.1	13.7	1.3	3.2	1.5	3.9	1.1	3.0						
40 - 54	36.9	32.7	38.5	40.0	35.6	29.6	4.9	10.0	7.4	11.7	3.3	9.5						
55 - 64	30.2	26.6	42.5	43.2	20.3	20.3	8.7	16.8	14.2	24.4	5.1	13.8						
C. Percent of Non-Elderly Adults Participating in Labor Force (Current Population Survey data)																		
25 - 39	95.7	94.7	93.1	91.0	88.1	86.1	96.6	95.8	94.1	63.9	70.0	76.3	49.6	50.3	55.0	66.9	73.2	78.7
40 - 54	92.7	92.7	90.2	86.5	85.0	76.3	95.4	95.0	91.9	60.3	65.7	77.4	48.8	49.8	54.0	64.9	70.6	80.1
55 - 64	73.0	68.6	68.1	64.2	60.2	53.2	79.0	73.3	71.2	41.9	41.8	51.6	33.8	33.3	32.4	47.0	46.0	55.7
D. Percent of Non-Elderly Adults Unemployed (Current Population Survey data)																		
25 - 39	3.7	6.3	3.1	7.0	12.5	6.0	3.0	5.4	2.7	3.9	5.0	3.2	6.2	8.3	6.7	3.4	4.5	2.8
40 - 54	2.5	4.3	2.4	4.0	7.2	4.5	1.9	3.4	2.2	2.4	3.4	2.1	3.1	4.8	3.8	2.2	2.9	1.9
55 - 64	1.9	3.4	1.9	2.3	4.7	2.1	1.7	2.6	1.8	1.3	1.8	1.4	1.5	2.4	1.7	1.1	1.4	1.3

DI receipt rates by age and gender in Panel A are calculated using recipient counts from Social Security Administration, Annual Statistical Supplement [various years] denominated by population estimates from the Current Population Survey Merged Monthly files. Education-specific DI receipt in Panel A and the fraction of labor-force non-participants receiving DI in Panel B are calculated with the Survey of Income and Program Participation, 1984 wave 1 and 1996 wave 12. Panels C and D were calculated from Current Population Survey Merged Monthly files.

TABLE III.
Distribution of Qualifying Impairments of DI Awardees at 5 Year
Intervals, 1983 - 1999.

Qualifying Impairment	4 Year Mortality Rate (%)	Percent of DI Awards			
		1983	1988	1993	1999
Neoplasms	81.0	16.8	13.2	12.6	10.6
Circulatory disorders	19.8	21.9	17.6	14.0	12.1
Musculo-skeletal	5.3	13.4	16.8	14.8	23.7
Mental disorders	5.4	16.3	20.9	26.1	22.5
All others	16.0	31.6	31.5	32.5	31.1

Source: Social Security Administration, Annual Statistical Supplement, 1984, 1989, 1994 and 2000. Four-year mortality rate is from administrative follow-up of those awarded benefits in 1985 [Hennessey and Dykacz, 1993].

TABLE IV.
Change in DI/SSI Rolls and Labor Force Participation of Non-Elderly Adults: OLS Estimates.
Dependent Variable: 100 x Annualized Change in Labor Force Participation.

	A. Δ Male Labor Force Participation								B. Δ Female Labor Force Participation							
	High School Dropouts				High School Grad Plus				High School Dropouts				High School Grad Plus			
	1979-1984		1984-1998		1979-1984		1984-1998		1979-1984		1984-1998		1979-1984		1984-1998	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ SSI & DI Rolls/1,000	-0.32 (0.10)		-0.31 (0.07)		-0.03 (0.04)		-0.06 (0.02)		-0.10 (0.12)		-0.12 (0.08)		0.11 (0.06)		0.02 (0.04)	
Δ DI Rolls/ 1,000 Pop		-0.82 (0.20)		-0.52 (0.16)		-0.07 (0.08)		-0.01 (0.05)		-0.41 (0.27)		-0.57 (0.20)		0.07 (0.14)		-0.05 (0.10)
Δ SSI Rolls/ 1,000 Pop		0.43 (0.29)		-0.15 (0.13)		0.02 (0.11)		-0.09 (0.04)		0.40 (0.40)		0.25 (0.17)		0.16 (0.19)		0.07 (0.09)
Intercept	-0.98 (0.14)	-1.41 (0.20)	0.28 (0.12)	0.30 (0.12)	-0.29 (0.05)	-0.32 (0.08)	-0.06 (0.04)	-0.06 (0.04)	-0.08 (0.17)	-0.34 (0.26)	0.47 (0.14)	0.52 (0.13)	1.10 (0.09)	1.07 (0.14)	0.54 (0.07)	0.54 (0.08)
R ²	0.37	0.46	0.58	0.60	0.18	0.19	0.19	0.21	0.07	0.10	0.21	0.31	0.18	0.18	0.02	0.03
Weighted Mean Δ		-0.59		-0.22		-0.25		-0.15		0.04		0.29		0.97		0.57

n = 50 U.S. states. Standard errors in parentheses. All estimates control for change in the age distribution in the state population for the relevant gender/education group (ages 25 - 39 and 40 - 54 with 55 - 64 omitted). Age controls are de-measured in each time period. Estimates are weighted by mean state share of U.S. population in the two years used to form the dependent variable. Δ SSI & Δ DI rolls are annualized changes in SSI and DI recipients per 1,000 state population ages 25 - 64.

TABLE V.
Change in DI Rolls and Labor Force Participation of Non-Elderly Adults: Instrumental Variables Estimates.
Dependent Variable: 100 x Annualized Change in Labor Force Participation.

	A. Δ Male Labor Force Participation								B. Δ Female Labor Force Participation							
	High School Dropouts				High School Grad Plus				High School Dropouts				High School Grad Plus			
	1979-1984		1984-1998		1979-1984		1984-1998		1979-1984		1984-1998		1979-1984		1984-1998	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ DI Rolls/ 1,000 Pop	-0.61 (0.15)	-1.35 (0.43)	-0.61 (0.14)	-0.51 (0.32)	-0.06 (0.05)	-0.20 (0.13)	-0.07 (0.04)	0.07 (0.09)	-0.22 (0.18)	-1.01 (0.47)	-0.38 (0.15)	-0.66 (0.31)	0.16 (0.10)	0.28 (0.25)	0.00 (0.08)	-0.14 (0.15)
Intercept	-1.24 (0.17)	-2.03 (0.47)	0.25 (0.11)	0.18 (0.25)	-0.31 (0.06)	-0.47 (0.14)	-0.09 (0.04)	-0.20 (0.07)	-0.19 (0.22)	-1.04 (0.52)	0.58 (0.13)	0.59 (0.14)	1.13 (0.11)	1.27 (0.27)	0.57 (0.07)	0.65 (0.13)
R ²	0.43	0.12	0.59	0.59	0.19	0.06	0.13	.	0.08	.	0.27	0.22	0.17	0.14	0.02	.
1st Stage Coefficient x 10 ⁻²		-0.77 (0.24)		0.51 (0.16)		-0.86 (0.24)		0.62 (0.14)		-0.87 (0.25)		0.53 (0.14)		-0.75 (0.25)		0.60 (0.12)

n = 50 U.S. states. Standard errors in parentheses. All estimates control for changes in the age distribution in the state population for the relevant gender/education group (ages 25 - 39 and 40 - 54 with 55 - 64 omitted). Age controls are de-meanned in each time period. Estimates are weighted by mean state share of U.S. population in the two years used to form the dependent variable. Δ DI rolls/pop is annualized changes in DI recipients per 1,000 state population ages 25 - 64. Instrument variable is potential earnings replacement rate at the 75th percentile of the state's earning replacement rate distribution in 1978 for currently employed non-elderly adult males ages 25 - 61 calculated from the 1978 Current Population Survey/Social Security Earnings Records Exact Match file.

TABLE VI.
Impact of Employment Losses on DI Applications Flows 1978 - 1998: Reduced Form and Instrumental Variables Estimates.
Dependent Variable: Annualized Flow of Disability Applicants per Non-Elderly Adult.

	A. Reduced Form Estimates: Impact of Predicted Δ Emp/Pop on DI Apps/Pop.								B. IV Estimates: Impact of High School Dropout Δ Emp/Pop on DI Apps/Pop, Instrumented by Predicted Δ Emp/Pop							
	Long Changes				Stacked 3-yr Diffs				Long Changes				Stacked 3-yr Diffs			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	78-84	84-98	78-98	78-98	78-84	84-98	78-98	78-98	78-84	84-98	78-98	78-98	78-84	84-98	78-98	78-98
Δ Emp/Pop	-0.13 (0.06)	-0.52 (0.10)	-0.13 (0.07)	-0.11 (0.05)	-0.12 (0.04)	-0.28 (0.07)	-0.11 (0.04)	0.00 (0.02)	-0.25 (0.20)	-1.13 (0.63)	-0.30 (0.22)	-0.05 (0.13)	-0.14 (0.07)	-0.27 (0.10)	-0.12 (0.07)	0.01 (0.02)
Δ Emp/Pop x Post 1984			-0.34 (0.09)	-0.26 (0.06)			-0.17 (0.05)	-0.05 (0.02)			-0.68 (0.67)	-0.34 (0.23)			-0.15 (0.11)	-0.05 (0.03)
State dummies	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes
1st Stage coef. (main effect)									0.51 (0.25)	0.46 (0.27)	0.52 (0.29)	1.07 (0.69)	0.85 (0.24)	1.03 (0.31)	0.90 (0.26)	1.26 (0.33)
1st Stage coef. (interaction)											0.54 (0.28)	1.69 (1.27)			1.01 (0.30)	1.62 (0.42)
F-statistic									3.97	2.82	7.87	1.19	12.02	10.94	17.26	11.41
P-value									0.05	0.10	0.00	0.31	0.00	0.00	0.00	0.00
R ²	0.29	0.47	0.32	0.97	0.31	0.36	0.35	0.90	.	.	.	0.76	.	.	.	0.87
n	50	50	100	100	100	250	350	350	50	50	100	100	100	250	350	350

Dependent variable is annualized flow of unique DI applications per state population ages 25 - 64 over relevant interval. Standard errors are in parentheses. Standard errors in models containing repeated observations per state and excluding state dummies account for clustering of state level observations. All models include an intercept, time dummies, and controls for annualized state level population changes in age by gender: male/female x ages 25-39/40-54/55-65 (6 categories, one omitted). Predicted employment share changes are calculated using national 2-digit industry employment share changes (excluding own-state employment) projected onto initial state industry shares. Employment to population ratio of high school dropouts and state age x gender distributions are calculated from merged CPS monthly files for years 1979 - 1998. Disability application counts provided by Social Security Administration.

TABLE VII.
Instrumental Variables Estimates of the Impact of Employment Losses on Labor Force Exit
of High School Dropouts, 1979 - 1998.
Dependent Variable: Change in High School Dropout Non-Participation.

A. Males and Females Combined								
	(1)	(2)	(3)	(4)	(6)	(6)	(7)	(8)
	1978-84	1978-84	1984-90	1990-98	1984-98	1984-98	1978-98	1978-98
Δ Emp/Pop	-0.46 (0.23)	-0.73 (0.16)	-1.47 (0.52)	-0.93 (0.21)	-1.10 (0.21)	-0.90 (0.18)	-0.57 (0.19)	-0.58 (0.19)
Δ Emp/Pop x (85-98 dummy)							-0.34 (0.16)	-0.36 (0.19)
State Dummies	No	Yes	No	No	No	Yes	No	Yes
R ²	0.69	0.86	.	0.86	0.74	0.83	0.71	0.71
n	100	100	100	150	250	250	350	350
B. Estimates by Gender								
	1978-84		1984-98		1978-98		1978-98	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Males	Females	Males	Females	Males	Females	Males	Females
Δ Emp/Pop	-0.45 (0.21)	-0.44 (0.40)	-0.98 (0.19)	-1.23 (0.34)	-0.54 (0.16)	-0.60 (0.29)	-0.54 (0.22)	-0.49 (0.22)
Δ Emp/Pop x (85-98 dummy)					-0.43 (0.25)	-0.60 (0.33)	-0.49 (0.27)	-0.56 (0.36)
State Dummies	No	No	No	No	No	No	Yes	Yes
R ²	0.68	0.67	0.70	0.83	0.72	0.83	0.70	0.86
n	100	100	250	250	350	350	350	350

Standard errors in parentheses account for clustering of state level observations in models excluding state dummies. All estimates include year dummies and controls for changes in the age distribution of state high school dropout population for the relevant high school dropout population (ages 25 - 39 and 40 - 54, with 55 - 64 omitted). Estimates are weighted by state share of U.S. population in each year. Instrument for change in employment to population ratio of high school dropouts is projected state level log employment shocks and in pooled 1978 - 1998 specifications, its interaction with a 1985 - 98 dummy. See Notes to Table 5 for further details.

TABLE VIII.
Determinants of Growth in DI Rolls, 1984 - 1998.

Dependent Variable: 100 x Annualized Change in Share of Non-Elderly Adults Receiving DI.

	Means	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
DI Replacement Rate	0.377 (0.028)	0.67 (0.15)		0.46 (0.17)	0.71 (0.15)	0.49 (0.15)	0.53 (0.16)	0.63 (0.16)	0.54 (0.14)	0.68 (0.15)	0.65 (0.15)	0.50 (0.16)	0.51 (0.15)	0.46 (0.17)
E[ΔEmp/Pop] x 10	-0.017 (0.017)		-1.01 (0.24)	-0.66 (0.26)								-0.65 (0.25)		-0.41 (0.34)
Δ HS Dropout Median Wage	-0.186 (0.120)				-0.06 (0.03)							-0.06 (0.03)		-0.04 (0.03)
Δ 25th Pcntile Wage	0.084 (0.121)					0.10 (0.03)								
Mortality Rate '84 x 100	0.510 (0.063)						0.15 (0.08)						0.06 (0.08)	0.08 (0.08)
Δ Mortality Rate x 100	-0.123 (0.038)							0.10 (0.12)						
Δ Share foreign born	0.049 (0.038)								-0.36 (0.09)				-0.30 (0.11)	-0.14 (0.16)
Δ Incarceration Rate x 10	0.046 (0.020)									-0.32 (0.18)			-0.11 (0.18)	-0.14 (0.16)
Δ UI Replacement Rate	-0.025 (0.118)										0.03 (0.03)			
Intercept	0.078 (0.032)	-0.17 (0.06)	0.10 (0.02)	-0.08 (0.07)	-0.19 (0.06)	-0.11 (0.06)	-0.21 (0.06)	-0.15 (0.07)	-0.09 (0.06)	-0.16 (0.06)	-0.16 (0.06)	-0.10 (0.07)	-0.12 (0.07)	-0.11 (0.07)
R ²		0.45	0.44	0.53	0.50	0.56	0.50	0.46	0.59	0.49	0.48	0.57	0.60	0.63
N		50	50	50	50	50	50	50	50	50	49	50	50	50

Standard errors in parentheses (cross-state standard deviations given for column of means). All models control for changes in age by gender shares of state population ages 25 - 64 (males/females by ages 25-39/40-54/55-64) and are weighted by states' average share of population in beginning and end year.

DI Replacement rate is the 75th percentile DI potential earnings replacement rate of employed non-elderly males calculated from the 1978 Current Population Survey-Social Security Earnings Records Exact Match file.

E[ΔEmp/Pop] is the annualized state projected log employment change for 1984 - 1998. See equation (8) in the text.

Δ Male School Dropout Median Wage is the change in the fixed weighted median wage of all male high school dropout state residents ages 25 - 64 excluding the self-employed, those working without pay, and employed workers for whom a wage could not be calculated. Weights correspond to 1984 state male population shares for ages 25 - 64 in 10 year brackets (4 categories).

Δ 25th Percentile Wage is the analogous fix weighted wage for male prime-age residents ages 25 - 54.

Mortality rate is the number of non-accidental, non-homicidal deaths among ages 25-64 divided by the average of state population 25-64 in the previous and current year. Δ Mortality rate is the change in this number.

Δ Share foreign born is the 1984 to 1998 change in share of population 25-64 that is foreign born calculated from the 1998 Current Population Survey and linearly interpolated for the year 1984 using the 1980 and 1990 Census PUMS 1 percent samples.

Δ Incarceration Rate is the change in state prison population (excluding jails) per capita 18 - 64 from the Bureau of Justice Statistics.

Δ UI Replacement Rate is the 1984 - 1999 change in state UI replacement rate for a full-time minimum wage worker from the *Green Book: Overview of Entitlement Programs* (U.S. House of Representatives, various years) and is not available for Michigan.

TABLE IX.
Determinants of Change in High School Dropout Labor Force Participation, 1984 - 1998.
Dependent Variable: 10 x Annualized Change in High School Dropout Labor Force Participation.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
DI Replacement Rate	-0.35 (0.15)		-0.26 (0.15)	-0.33 (0.14)	-0.28 (0.15)	-0.32 (0.16)	-0.34 (0.15)	-0.30 (0.14)	-0.32 (0.15)	-0.38 (0.16)	-0.26 (0.15)	-0.30 (0.15)	-0.34 (0.18)
E[ΔEmp/Pop] x 10		0.55 (0.22)	0.31 (0.23)								0.31 (0.23)		-0.15 (0.36)
Δ Male HS Dropout Median				0.08 (0.03)							0.07 (0.03)		0.04 (0.03)
Δ 25th Pcntile Male Wage					-0.07 (0.03)								
Mortality Rate '84 x 100						-0.03 (0.07)						-0.01 (0.06)	0.00 (0.06)
Δ Mortality Rate x 100							-0.04 (0.10)						
Δ Share foreign born								0.31 (0.09)				0.30 (0.10)	0.30 (0.17)
Δ Incarceration Rate x 10									0.26 (0.19)			0.04 (0.19)	0.00 (0.20)
Δ UI Replacement Rate											0.02 (0.03)		
Intercept	0.12 (0.06)	0.00 (0.01)	0.10 (0.06)	0.13 (0.06)	0.10 (0.06)	0.13 (0.06)	0.11 (0.06)	0.10 (0.05)	0.10 (0.06)	0.13 (0.06)	0.10 (0.06)	0.09 (0.06)	0.11 (0.06)
R ²	0.39	0.39	0.49	0.47	0.44	0.39	0.39	0.51	0.41	0.40	0.49	0.51	0.54
N	50	50	50	50	50	50	50	50	50	49	50	50	50

Standard errors in parentheses. All models control for changes in age distribution of state high school dropout population ages (25-39/40-54/55-64 with one category omitted) and are weighted by states' average share of population in beginning and end year. See notes to Table VIII for variable definitions.