Local Labor Market Conditions and the Federal Disability Insurance Program: New Evidence from the Bakken Oil Boom

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Abstract

The Social Security Disability Insurance (DI) program is the largest income replacement program in the United States for non-elderly adults. Growth in the DI program since the 1970s coincided with a well-documented decline in wages and labor force participation of low-skilled workers. Since DI is more attractive as outside options decline, a key question in labor and public economics is the extent to which secular changes in the labor market have led to increases in DI program participation. In this paper, I exploit an exogenous positive labor demand shock caused by a boom in oil production in the Bakken formation covering parts of Montana, North Dakota, and South Dakota to estimate the impact of earnings growth on DI payments and participation. Using the value of county oil reserves as an instrument for earnings, my estimates suggest a strong negative relationship between local economic conditions and DI payments and participation. I find an elasticity of DI payments with respect to local earnings of -1 and an elasticity of DI participation with respect to earnings of -0.7.

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I. Introduction

The Social Security Disability Insurance (DI) program is the largest income replacement program in the United States for non-elderly adults (Autor and Duggan, 2003; Black et al., 2002). Furthermore, the DI program has been growing in real terms since the 1970s. In 2013, there were approximately 9 million individuals in the United States receiving nearly $120 billion in DI benefits. This represents an increase from nearly 5 million beneficiaries receiving about $50 billion in benefits in 2000.[1] This decades-long expansion of DI expenditures coincided with a well-documented decline in wages and labor force participation of low-skilled workers. Various explanations for this secular change in labor force participation include skill-biased technological change, the increase in import penetration and labor outsourcing, and the decline in unionization, among others.[2] Since DI is more attractive as outside options decline, a key question is the extent to which secular changes in the labor market have led to increases in DI program participation.[3]

A fundamental empirical challenge in this literature is that, in equilibrium, earnings, employment, and DI participation are jointly determined, making it difficult to estimate a causal relationship between labor market conditions and DI payments and participation.[4] In particular, it is difficult to separate the effects of labor demand shocks from labor supply shocks. Positive shocks to labor demand increase the value of labor force participation, thus making employment

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[1] These estimates come from the *Statistical Abstract of the United States*, Table 545 (US Census Bureau, 2012).

[2] See Bound and Johnson (1992).

[3] Bound and Burkhauser (1999) provide a review of the substantial existing literature examining the relationship between DI, labor force participation, and economic conditions. This literature includes Bound (1989 and 1991), Bound and Waidmann (1992), Gruber (2000), Gruber and Kubik (1997), Haveman and Wolfe (1984), Parsons (1980, 1984, 1991a, and 1991b), and Stapleton et al. (1998), among others.

[4] An increase in county-level earnings will increase both employment and the value of an individual's potential DI payments. The value of individual DI payments is expected to increase due to the increase in earnings, which increases the level of income replacement from DI.

options seem more attractive. Labor supply shocks, including increases in DI benefit generosity, increase the value of DI participation relative to labor force participation.

The previous literature has attempted to separate the impacts of these two shocks. Black et al. (2002) exploited shocks to labor demand from the coal boom and bust of the 1970s and 1980s in Appalachia (Kentucky, Ohio, Pennsylvania, and West Virginia).[5] In particular, the boom in coal production coincided with a dramatic rise in world coal prices. The coal boom represented a favorable shock to labor demand that increased earnings in coal-producing regions. Following the boom, a steep decline in world coal prices led to a sharp decline in U.S. coal production, resulting in an adverse labor demand shock to coal producing areas. Black et al. (2002) focused on the coal-producing four-state region in Appalachia. Natural endowments of coal varied across counties and the value of coal changed over time, generating county-by-time variation in the value of coal reserves. Therefore, the demand for labor varied across counties, with the value of coal reserves, in a way that was plausibly uncorrelated with changes to labor supply and the DI program. Using an instrumental variable (IV) strategy, they estimated the causal impact of this shock to local economic conditions on DI program participation, finding that, during the coal bust, workers in coal counties saw their earnings fall 13.5 percent relative to those in counties without coal. For the DI program, they found that the elasticity of payments with respect to local earnings is approximately -0.4.

In a second influential study, Autor and Duggan (2003) used an IV strategy to identify exogenous variation in both the supply and demand of DI benefits. They emphasized the role that 1984 programmatic changes that increased benefit generosity, as well as rising replacement rates,

[5] Other studies have further examined the extent to which economic conditions impact growth in DI participation. Rupp and Stapleton (1995) summarize earlier work exploring the relationship between unemployment rates and DI participation. These works generally find that a 1 percentage point increase in the unemployment rate increases DI awards by between 2 and 6 percentage points, with some studies finding a negligible effect (Hambor, 1975 and 1992; Lando, 1979; Levy and Krute, 1983; Muller, 1982).

play in the financial incentive to apply for DI. These changes increased the supply of benefits. At the same time, the declining demand for less-skilled workers coincided with changes that liberalized the DI screening process, increasing the demand for DI benefits. They argued that the interaction between the progressive formula used in determining replacement rates and rising earnings inequality from the decrease in labor demand resulted in the relative increase of replacement rates for low-skilled workers.[6] This effectively increased the value of participation in the DI program, and decreased the value of labor force participation, for low-skilled workers.

In the current paper, I attempt to identify the effect of labor market conditions on DI, focusing on a positive labor demand shock that changes the value of labor force participation. This increase in the value of labor force participation, in turn, impacts DI caseloads and payments. In an analysis that largely follows Black et al. (2002), I exploit exogenous time-series and spatial variation in earnings growth for counties in Montana, North Dakota, and South Dakota (henceforth known as "the three-state region") due to a boom in oil production in the Bakken formation of the Williston Basin. In particular, for the oil-rich counties in these states, the oil boom led to an exogenous shock to the value of labor force participation that increased earnings. Yearly oil production in these states more than quintupled from approximately 50 million barrels of oil in 2000 to 250 million barrels of oil in 2010. This boom in oil production is part of a larger increase in oil and natural gas production in the United States that was made possible by a combination of rising oil prices and advancements in extraction technologies, including horizontal drilling and hydraulic fracturing, colloquially known as fracking. Much of the oil activity and, by extension, economic activity takes place around the Bakken formation,

[6] According to Autor and Duggan (2003), real weekly earnings of full-time workers with less than a high school degree fell by 19.1 percentage points between 1975 and 1999. During the same period, the SSA's mean wage series increased by 21.6 percentage points in real terms.

where there are large amounts of proven reserves. The oil boom differentially impacts counties with oil in a way that is plausibly uncorrelated with the DI program.

To circumvent the identification problems discussed above, I estimate a causal relationship between earnings and DI payments and participation using the value of county oil reserves as an instrument for earnings. I implement this IV strategy using a county-level panel dataset of administrative earnings data from the Internal Revenue Service (IRS) and DI payment and participation data from the Social Security Administration (SSA) for 2000 through 2009. I construct the instrument using oil reserves data and West Texas Intermediate (WTI) crude oil prices from the U.S. Department of Energy's Energy Information Administration (EIA). This methodology allows me to exploit natural variation in oil reserves across counties and time-series variation in oil prices.

This paper differs from the Black et al. (2002) paper in three ways. First, labor market conditions have changed markedly, particularly for low-skilled workers, since the 1970s, impacting labor force attachment. Second, programmatic and systematic changes to DI benefits effectively increased program generosity, increasing the demand for benefits.[7] Autor and Duggan (2003) exploit these changes, finding a strong interaction between changes to DI benefits and the secular change in labor force participation of low-skilled workers. This interaction suggests labor force attachment and the relationship between DI and economic conditions have changed over time. Finally, this analysis of the oil boom in the three-state region is temporally and geographically different from that of Black et al. (2002).

Overall, my IV estimates suggest that there is a substantial, statistically significant negative relationship between local economic conditions and DI payments and participation. I

[7] Due to a 1984 eligibility policy change, DI beneficiaries are now younger and suffer from more musculoskeletal conditions and mental impairments (Bound and Waidmann, 2002; Autor and Duggan, 2006; Duggan and Imberman, 2009; von Wachter et al., 2011).

estimate the elasticities of DI payments and participation with respect to local earnings for the three-state region. I find an elasticity of DI payments with respect to local earnings of -1 and an elasticity of participation with respect to local earnings of -0.7. These estimates suggest that the oil boom led to decreases in payments and participation that were 2.5 percent and 1.6 percent greater for oil counties, compared to counties without oil. While qualitatively similar, these estimates are quantitatively larger than those of Black et al. (2002).[8] To the extent that the labor demand shock differentially impacted low-skilled workers in the three-state region, these estimates are consistent with both Black et al. (2002) and Autor and Duggan (2003). Beyond providing these new estimates, this paper contributes to a growing body of literature that examines the impact of natural resource booms on various labor market outcomes, such as earnings, employment, migration, and social insurance (Acemoglu et al., 2013; Aldy, 2014; Allcott and Keniston, 2014; Black et al., 2002; Black et al., 2005; Carrington, 1996; Cascio and Narayan, 2015; Feyrer et al., 2014; Marchand, 2012; Vachon, 2014; Weber, 2012).

The rest of this paper proceeds as follows. Section II presents a description of the DI program. Section III provides an overview of the oil boom; the exposition of this section largely draws upon that in Vachon (2014). Section IV describes the econometric specifications. Section V presents the identification strategy. Section VI outlines the results. Section VII describes the impact of the boom on DI caseloads. Section VIII presents possible program interactions between DI and other SSA programs, and Section IX concludes.

[8] For the DI program, Black et al. (2002) find that the elasticity of payments with respect to local earnings is between -0.3 and -0.4. This estimate corresponds to a differential decrease in DI payments of 1.26 percent for Appalachian coal counties, compared to counties without coal.

II. DI Program Background

The DI program provides income replacement for disabled former workers and is part of the Social Security safety net. To qualify for DI benefits, an individual must be deemed disabled by SSA and meet minimum work history and earnings requirements (the “recent work test”). For example, to meet the recent work test, workers 31 years old and older must have worked during 5 years out of the 10-year period (20 out of the past 40 quarters) ending with the quarter the disability began. According to SSA rules, an individual is deemed disabled if he or she is unable “to engage in substantial gainful activity by reason of a physical or mental impairment.” In 2013, “substantial” employment was determined by an individual’s ability to earn more than $1,040 per month. In addition, the impairment must last for at least 12 months or be expected to result in death. While the eligibility criteria for the federal DI program are uniform across states, applicants file their claims to state-appointed boards.

SSA maintains a list of work-limiting impairments that qualify individuals for benefits. If individuals have conditions not on this list, however, they may still qualify for benefits if physicians determine that the conditions result in sufficient impairment. In making the determination of impairment, the applicant's age, education, and work experience are also considered when deciding whether an applicant is able to work. Such work does not need to exist in the area in which the applicant resides, nor does there need to exist a job vacancy for the individual.

DI payments are based on past earnings. The determination of an individual’s DI benefits proceeds in two steps (Autor and Duggan, 2003). First, the beneficiary’s Average Indexed Monthly Earnings (AIME) is calculated as

(1) $$AIME = \frac{1}{T}\sum_{t=1}^{T} Y_t$$

where Y_t is real monthly earnings. Second, DI benefits awarded, the Primary Insurance Amount (PIA), are calculated using the following formula:

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

where $b1$ and $b2$ are the "bend points," or kink points, above which the level of income replacement decreases; these bend points are also adjusted each year to reflect growth in wages. As illustrated in (2), the benefits formula is concave. Although high-income individuals receive more benefits from DI than low-income individuals, this concavity means that the program is progressive. Consequently, low-income workers have higher replacement rates (the fraction of one's income that can be replaced with DI benefits) than high-income workers. Therefore, the relative reduction in income resulting from labor market withdrawal is smaller for disabled, low-wage workers than for disabled, high-wage workers.

This description of the DI benefit calculation further illustrates the identification problem outlined in the introduction. Earnings, employment and DI are jointly determined in the labor market. That is, an increase in earnings will increase both employment and the value of an individual's potential DI payments.

In 1984, Congress passed legislation that greatly liberalized the DI system. Generally, the 1984 reforms broadened the definition of disability and provided applicants and doctors greater opportunity to influence the decision process.[9] Three core features of the 1984 legislation contributed to the expansion of the DI program. First, mental illness screening guidelines were relaxed, placing more weight on the individual's ability to function in a workplace. Second, additional weight was placed on general pain in the disability determination process. Finally,

[9] See Autor and Duggan (2003), Goodman and Waidmann (2003), and Burkhauser and Daly (2011) for more detailed discussions of these policy changes.

criteria were relaxed such that an individual would qualify for DI if he or she had numerous impairments, that alone would not qualify him or her for benefits, but together which could prevent the individual from participating in gainful activity. At the same time, Continuing Disability Reviews became much less common. As a result, fewer beneficiaries were terminated for failing to meet eligibility requirements.[10]

The analysis in this paper provides new estimates that, in a reduced-form sense, reflect these secular changes in the labor market over time as well as the effects of DI liberalization on labor force participation for current workers. Following Black et al. (2002), I exploit an exogenous shock to labor demand from the Bakken oil boom that increases earnings in the three-state region of Montana, North Dakota, and South Dakota. I describe the economic forces behind the boom in the next section.

III. Oil Boom Background

The source of oil is organic matter that is preserved and buried in some sedimentary rocks. Three important geological criteria must be met for an oil deposit to be considered for commercial production (Hyne, 2012). First, a subsurface source rock must have generated the oil (see Figure 1). The most common source rock is black shale. Black shale originated as organic matter-rich mud on ancient seafloors.[11] As the black shale source rock was covered with more and more sediments and buried further below the Earth’s surface, the heat from geological pressure turned the organic matter into oil. Second, a separate subsurface reservoir rock must hold the oil. Reservoir rocks are sedimentary rock layers that contain billions of tiny spaces, or

[10] Studies on these compositional changes resulting from liberalization find that DI applicants and beneficiaries are now younger and suffer from more musculoskeletal conditions and mental impairments (Autor and Duggan, 2006; Bound and Waidmann, 2002; Duggan and Imberman, 2009; von Wachter et al., 2011).

[11] The shale oil extracted from the Bakken was formed approximately 350 million years ago during the late Devonian and early Mississippian geologic periods (Hyne, 2012).

pores. Sandstone (composed of compressed grains of sand) and limestone (composed of broken down seashells and corals) are common reservoir rocks. Oil is able to flow through sandstone, limestone, and other reservoir rocks through the pore spaces between the sediments. Third, a geological trap and cap rock must concentrate the oil into commercially extractable quantities. The trap is a geological high point in the formation which prevents the oil from flowing upward, and the cap rock is a seal that prevents oil from flowing through it, concentrating the oil in the reservoir rock.

In "conventional" oil extraction, a well is drilled into the reservoir rock. Such methods characterized oil production in the United States, including North Dakota, for much of the previous century.[12] In contrast, the recent shale oil boom involves drilling into and extracting resources from the shale source rock. Shale is less porous and permeable than typical reservoir rocks (i.e. sandstone and limestone, among others) (Maugeri, 2012). Shale oil and gas are often referred to as "unconventional" resources because of their geology as well as the techniques used in extraction. Shale oil is extracted using the combined application of horizontal drilling and fracking techniques. Horizontal drilling is effective in shale formations because a greater portion of a well's surface area is exposed to the oil-rich rock as compared to traditional vertical drilling. Hydraulic fracturing is the process of injecting large volumes of fluids into a well to fracture the rock (shale, in this case). The fluid used is generally combined with sand before it is injected. The sand particles, known as propping agents, hold open the fractures in the shale, allowing oil to flow into the well (Hyne, 2012).

[12] While the focus of this paper is on the Bakken formation, the explanations of the geology of fossil fuels and extraction technologies can generally be applied to other regions with shale oil and gas reserves and extraction (i.e. Marcellus and Utica in the Appalachian region, Eagle Ford and Barnett in Texas, and Woodford in Oklahoma, among others).

Figure 2 presents price and production data for North Dakota, since production began in 1952. Geologists and petroleum experts have been aware of oil reserves in western North Dakota since the middle of the previous century when Amerada Petroleum Corporation drilled the area's first commercial oil well at the Clarence Iversen farm in Tioga, North Dakota in 1951. However, later that year Amerada made another important discovery at the Henry O. Bakken farm, also in Tioga. The Bakken well is important because it was the first in the area drilled into the older (deeper) geologic formation that became known as the Bakken formation. From 1951 through the 1970s, oil production averaged a modest 20 million to 25 million barrels per year. In the late 1970s and early 1980s, rising oil prices, as a result of the 1973 OPEC embargo and the oil crisis of 1979, led to a boom in oil production in North Dakota. Even with record-high oil prices, annual production peaked at approximately 50 million barrels in 1984, compared to nearly 900 million barrels produced in Texas (EIA, 2014).

While oil companies have had access to the technologies of fracking and horizontal drilling for some time, their combined application was not successful until 2000 when Mitchell Energy extracted natural gas from the Barnett shale in Texas (Maugeri, 2012). In North Dakota's Bakken, Continental Resources is credited with drilling the first commercially successful combined horizontal drilling and hydraulic fracturing oil well in 2004 (Continental Resources, 2014). North Dakota oil production hit nearly 250 million barrels in 2012 and continues to increase. Production resulting from this most recent boom dwarfs that of the 1980s.

IV. Econometric Specifications

The goal of this paper is to provide evidence of a causal relationship between local labor market conditions and DI program participation. I begin this empirical analysis by examining the relationship between county-level earnings and DI payments and program participation. Treating the county as the local labor market, I present the relationship between local earnings and DI payments as:

(3) $$ln(d_{ist}) = \varphi + \beta ln(y_{ist}) + \varepsilon_{ist},$$

where $ln(d_{ist})$ represents the natural logarithm of the value of DI payments or the number of DI participants for county i in state s in year t, and ε_{ist} is the error term. The main explanatory variable is $ln(y_{ist})$, the natural logarithm of real earnings. The focal parameter β represents the elasticity of the value of DI payments or participation with respect to local earnings.

I model ε as

(4) $$\varepsilon_{ist} = \pi_i + \tau_t + \phi_{st} + \mu_{ist} ,$$

where π represents a county-specific fixed effect, and τ represents a linear time trend. To account for this county fixed effect, I first difference (3) to yield:

(5) $$\Delta ln(d)_{ist} = \delta + \beta \Delta ln(y_{ist}) + \omega_{ist},$$

where Δ indicates a first difference, and ω is the differenced error term from (4):

(6) $$\omega_{ist} = \gamma_{st} + u_{ist}.$$

$\gamma_{st} \equiv \Delta\phi_{st}$ is a state-by-year fixed effect, and δ is the new intercept, where $\delta \equiv \Delta\tau_t$.

I construct a county-level dataset of aggregate earnings and DI payments and participation for the three-state region from 2000 through 2009. I use administrative earnings data from the IRS Statistics of Income (SOI) based on federal income tax returns. The IRS data contain information regarding wage and salary income. SSA Old-Age, Survivors, and Disability Insurance (OASDI) administrative data contain DI recipient count and benefit information. I measure real earnings and real values of payments at the county level in 2009 dollars, adjusted for inflation using the Consumer Price Index (CPI).

Table 1 presents summary statistics for the entire sample period. Montana, North Dakota, and South Dakota are small states; according to the 2000 Census, their respective populations were 902,000, 642,000, and 755,000. From column 1, the average population per county is 13,500. Average annual earnings growth is 1.5 percent. Throughout the period of interest, the three-state region experienced average annual increases in DI payments and participation of 4.4 percent and 3.5 percent, respectively.

The OLS estimates of β in column 1 of Table 2 indicate a fairly weak link between earnings growth and DI payment growth. I find an elasticity of DI payments with respect to county earnings of -0.15. In addition, following Black et al. (2002), I add to (5) a vector of control variables, $\boldsymbol{x}_{ist}$, that includes county Metropolitan Statistical Area (MSA) status and the logarithm and log difference of county population as well as the share of workers in manufacturing in 1999.[13] These results are presented in column 2 of Table 2. Again, I find an elasticity of DI payments with respect to county earnings of -0.15. These OLS estimates suggest that a 10 percent increase in county earnings would result in an approximately 1.5 percent decrease in the value of DI payments in the county. The estimates also show a small, statistically insignificant negative relationship between DI payments and county earnings growth. In columns 3 and 4 of Table 2, I repeat the analysis for DI beneficiaries rather than payments. Again, OLS estimates indicate a small, negative relationship between earnings growth and growth in the number of DI beneficiaries. I find an elasticity of approximately -0.16. Based on these OLS estimates, a 10 percent increase in county earnings would result in an approximately 1.6 percent

[13] I control for whether or not the county is in a Metropolitan Statistical Area for the 2000 Census due to the concern that persons with disabilities may move to a metropolitan area for better access to health care. Controls for population serve as a proxy for access to medical care and the provision of public services, amenities which may attract individuals with disabilities.

decrease in the number of DI beneficiaries in the county. In both cases, the estimates do not appear sensitive to the inclusion of control variables.

V. Identification Strategy

In the previous sections, I outlined the central challenge of estimating the relationship between earnings growth and DI payments and participation. As employment, earnings, and DI are jointly determined at the labor market level, increases in earnings at the county level will increase employment and the value of individual DI payments. Consequently, I expect OLS estimates of the focal parameter, β, to be biased upward to zero. To surmount this challenge, I estimate the parameters in (5) using an IV strategy following Black et al. (2002) and Vachon (2014). This strategy is based on natural variation in county-level oil reserves. The oil reserve data used in this analysis come from the 2004 EIA assessment of the Bakken formation of the Williston Basin and the 2001 assessments of Montana Thrust Belt and Powder River Basin. I calculate oil reserves using EIA shape files and MapInfo software. I use midpoint estimates for each oil field, as the reserves are listed in ranges, then aggregate to the county level. Based on this method, there are 32 counties in the three-state region that have oil reserves, and 143 counties that have no reserves. From column 2 of Table 3, the average oil county has nearly forty-four million barrels of oil reserves. I calculate the value of oil reserves by multiplying county-level reserves by the price of West Texas Intermediate (WTI) crude oil, also obtained from the EIA. From Panels A and B of Table 3, the average price per barrel of WTI crude oil increased from $38 to $75 between the early and later years of the oil boom. I use the value of oil reserves as an instrument for earnings to econometrically capture the impact of the oil price-generated increase in local labor market earnings on DI. [14]

Figures 3 through 5 present a visual depiction of my identification strategy. Estimates are based on data from 2000-2009. Figure 3 shows the level of oil reserves for the Bakken formation of the Williston Basin (eastern Montana, western North Dakota, and northwest South Dakota), Montana Thrust Belt (northwestern Montana), and Powder River Basin (southeast Montana and southwest South Dakota). The counties with the darkest shading have the highest levels of oil reserves; those areas that are white have no oil reserves. The darkest shaded counties have between 50 and 217 million barrels of oil. The counties shaded in dark gray have between 5 and 50 million barrels of oil. The counties shaded in the light gray have less than less than 5 million barrels of oil (but more than zero). The most oil-rich part of the region is the Bakken formation of the Williston Basin.

Figure 4 represents quartiles of average annual earnings growth rates. The areas with the darkest shading have the greatest increases in average annual earnings growth over the timeframe. The first through fourth quartiles represent income growth below 0.6 percent, between 0.6 percent and 1.4 percent, between 1.4 percent and 2.2 percent, and above 2.3 percent, respectively. The lowest growth county experienced a 1.7 percent decrease in average annual earnings; the highest growth county experienced a 7.5 percent increase.

Figure 5 depicts quartiles of average annual DI payment growth rates at the county level. Areas with the darkest shading have the highest growth in DI payments. The first through fourth quartiles represent DI payment growth below 3 percent, between 3.1 percent and 4.4 percent, between 4.9 percent and 5.5 percent, and above 5.5 percent, respectively. The county with the

[14] During the late part of the oil boom from 2005 through 2009, oil production in the Bakken increased from 1 million to 5 million barrels per month. In 2009, oil production in the Bakken was approximately 3 percent of the US total monthly oil production. From 2009 to 2012, oil production in the Bakken increased from 5 million to 22 million barrels per month. In 2012, oil production in the Bakken represented approximately 10 percent of the US total monthly oil production (Federal Reserve Bank of Minneapolis, 2012).

lowest DI payment growth experienced a 4.7 percent decrease in payments; the county with the highest payment growth experienced a 12.7 percent increase in payments.

Figures 3 and 4 represent the first-stage relationship between oil reserves and earnings growth. Those counties with high earnings growth have the highest levels of oil reserves, as evidenced by the dark shading on both maps. The reverse is also true; areas with low earnings growth have little to no oil reserves. Figures 3 and 5 represent the reduced-form relationship between oil reserves and DI payments. There is a negative relationship between oil reserves and growth in DI payments. Those areas with high levels of oil reserves have low levels of DI payment growth. This is evidenced by the fact that high oil reserve counties are more darkly shaded while low DI payment growth counties are lightly shaded.

VI. Estimation and Results

I move beyond the graphical analysis to IV estimation. The first-stage of the IV estimation is:

(7) $$\Delta ln(y_{ist}) = \rho + \boldsymbol{\alpha Z}_{ist} + \gamma_{st} + u_{ist},$$

where $\boldsymbol{Z}$ is a vector of instruments. The key instrument is the log difference of oil reserve value, $\Delta ln(v_{ist})$.[15] The value of county oil reserves, v, is measured in 2009 dollars, adjusted for inflation using the CPI. This varies over time with oil prices, generating county-by-time variation in the value of oil reserves that is plausibly exogenous. The value of oil reserves changes earnings through the increased demand for labor.

[15] Following Black et al. (2002), the log difference in the value of oil reserves and two if its lags are the elements of the vector of instruments, $\boldsymbol{Z}$. Estimates from specifications relying on the complete instrument set are presented in this paper and do not differ quantitatively from those in specifications where only the key instrument (log difference in the value of oil reserves) is used.

Table 4 presents estimates of $\boldsymbol{\alpha}$ from (7). These estimates illustrate the relationship between growth in the value of oil reserves and earnings growth. The estimate in column 1 implies that a doubling in the value of oil reserves leads to a 4.5 percent increase in county-level earnings. The associated F-statistic is 9.03, suggesting that the value of oil reserves is a relatively strong instrument. From column 2, adding a vector of control variables, $\boldsymbol{x}_{ist}$, increases the point estimate to 4.8 and the F-statistic to 9.8. Following Black et al. (2002), columns 3 and 4 show additional first-stage estimates that add two lags of the log difference of the value of oil reserves to the instrument set, where the estimates in column 4 reflect the addition of the vector of control variables. In principle, expanding the instrument set should increase the power of the first stage. In practice, the F-statistic increases to 10.4 for the model without a vector of control variables and 11.4 for the model with control variables, suggesting that the value of oil reserves and two lagged values make a stronger instrument set. The estimates in column 4 suggest that a doubling in the value of oil reserves in the current year leads to a 4.9 percent increase in county-level earnings. The estimates for the lagged value of oil reserves suggest a doubling in the value of oil reserves in the previous year increases earnings by 6.7 percent while a doubling two years prior increases earnings by 2.1 percent.

Columns 1 and 2 of Table 5 present the IV estimates of β using the broader instrument set with and without control variables.[16] These estimates suggest a strong, statistically significant impact of earnings growth on DI expenditures. The point estimate in column 2 shows an elasticity of DI payments with respect to earnings growth of -1. This estimate implies that a 10 percent increase in a county's earnings would result in a decrease in DI payments within the

[16] Estimates of β using only the value of oil reserves (and no lagged values) are both qualitatively and quantitatively similar to those using the more robust instrument set.

county of nearly 10 percent. Clearly, increases in county earnings substantially decrease DI payments.

In columns 3 and 4 of Table 5, I provide the IV estimates of β with the logarithmic difference in the number of county DI beneficiaries as the dependent variable. Again, these estimates are presented with and without the control variables, and the addition of controls does not seem to impact the results. The point estimate of -0.7 in column 4 represents the elasticity of DI payments with respect to earnings growth. This estimate implies that a 10 percent increase in a county's earnings would result in a decrease in DI participation within the county by nearly 7 percent. This represents a substantial and statistically significant inverse relationship between county earnings growth and growth in the number of DI beneficiaries in the county. During the oil boom, oil counties experienced annual earnings growth that was 2.4 percent greater than counties without oil. This growth differential combined with the point estimates from Table 5 suggest the oil boom led to a 2.5 percent decrease in DI payments and a 1.6 percent decrease in participation in oil counties relative to counties without oil.

As a final robustness check, I use an estimator that follows Cliff and Ord's seminal work (1973 and 1981) to provide IV estimates of the relationship between local economic conditions and net migration that account for spatial autocorrelation. I generate an inverse-distance spatial weighting matrix (spatial correlation decreases with the distance between two counties), where distance is measured between the geographic center of one county and another. Table 6 presents IV estimates from the spatial error model of the relationship between local labor market conditions and net migration rates for North Dakota.[17] The estimates from the spatial error model in Table 6 suggest that a 10 percent increase in earnings will reduce DI payments by 13 percent and DI participation by 12 percent. The estimates of the elasticities of DI payments and

[17] These specifications use only the first difference of the natural logarithm of oil reserves as an instrument.

participation with respect to earnings growth are quantitatively similar to my primary estimates from Table 5.

VII. Changes in DI Caseloads

DI participation changes largely through changes in the number of new DI cases. As such, I use the estimates presented in this paper to provide a back-of-the-envelope calculation of the rate of reduction in new cases as a result of the oil boom. Following Black et al. (2002), if expenditures are equal across cases, changes in expenditures can be expressed as:

(8) $$\Delta E_t = N_t - \rho E_{t-1}$$

where ΔE_t is the change in expenditures, N_t is expenditures resulting from new cases, ρ is the rate at which old cases leave the DI rolls, and E_{t-1} is the level of expenditures in the previous period. Dividing both sides of (8) by E_{t-1} yields:

(9) $$\%\Delta E = {}^{N_t}/_{E_{t-1}} - \rho.$$

From the 2000 through 2010 SSA Annual Statistical Supplements, the annual rate of outflows, ρ, appears to be 8 percent of total caseloads. There are three main components to the outflow rate, ρ: "aging out" of DI by reaching the full retirement age, death, and "recovery" from the work-limiting disability.[18] Between 2000 and 2009, DI expenditures grew at an annual rate of approximately 6 percent. As $\%\Delta E = 0.06$, the rate of inflows, N_t/E_{t-1}, must equal 0.14. If the oil boom reduces DI expenditures through changes in the inflow of new cases, for oil counties:

[18] Based on data from the 2000 through 2009 SSA Annual Statistical Supplements, approximately 3.5 percent of caseloads age out by reaching full retirement age, 3 percent die, and less than 1 percent recovers. Full retirement age is the age at which individuals receive 100 percent of the benefits for which they are eligible. For individuals born prior to 1938, full retirement age is 65; the full retirement age gradually increases to 67 for those born in 1960 or later.

(10) $$\%\Delta E^{oil} = (1-\theta)\left({N_t}/{E_{t-1}}\right) - \rho$$

where $\theta < 1$ represents the reduction in new cases resulting from the coal boom. From (10), it follows that

(11) $$\%\Delta E - \%\Delta E^{oil} = \theta(0.14).$$

Because the boom led to a 2.5 percent decrease in DI payments, $\theta = 0.25$, so the increase in earnings reduced new DI entrants by 25 percent. However, this calculation does not take into consideration the impact the boom had on migration, which could potentially affect program outflows. In Vachon (2015), I find that the boom increased the net migration rate in oil counties by 2.6 percentage points from -1.5 percent to 1.1 percent. Mean net migration rates range from -5.8 percent (out-migration) to 7.2 percent (in-migration). Assuming DI beneficiaries have the same net migration rate as the county, (10) becomes:

(12) $$\%\Delta E^{oil} = (1-\theta)\left({N_t}/{E_{t-1}}\right) - \rho - \mu,$$

where $-0.058 \leq \mu \leq 0.072$ is the net migration rate. Accounting for migration, the rate of reduction of new cases arising from the oil boom, θ, ranges from 16.5 percent to 42.7 percent. These calculations overestimate the responsiveness of new entrants to changes in earnings if some of the existing DI caseloads did return to work.

VIII. SSA Program Interactions

Applicants and beneficiaries for two other SSA programs – Social Security retirement (OAS) and Supplemental Security Income (SSI) – may be sensitive to changes in local economic conditions. The responsiveness of these programs to changes in earnings and local labor market conditions suggests the possibility of program interactions with DI. As mentioned in the previous section, aging out of DI into OAS is the primary mechanism for outflows from the DI rolls. SSI is a means-tested welfare program, and beneficiaries may be jointly eligible for SSI and DI. In 2009, nearly 85 percent of SSI beneficiaries were disabled (SSA Annual Statistical Supplement, 2010).

Table 7 presents IV estimates of the impact of earnings growth on OAS and SSI payments and participation. While many of these coefficient estimates are not statistically significant at conventional levels, their magnitudes may shed light on the impact of the boom on other SSA programs as well as their interactions with the DI program. Columns 1 and 2 present estimates of the income elasticity of OAS payments and participation. These estimates suggest that a 10 percent increase in earnings will reduce OAS payments by 2.8 percent and participation by 2 percent. The estimates in column 3 suggest that a 10 percent increase in earnings reduces payments per beneficiary by 0.4 percent. The positive shock to earnings may reduce OAS payments and participation in two ways. First is the out-migration of older residents, who are OAS beneficiaries. However, I examine changes in the age distribution using the American Community Survey (ACS) between the pre-boom and boom periods and find no significant changes, providing suggestive evidence that migration is not likely driving these changes. A second explanation is that older workers may see labor force participation and retirement as substitutes and delay retirement decisions in the presence of strong local labor market conditions.

Columns 4 and 5 of Table 7 present estimates of the income elasticity of SSI payments and participation, respectively. These estimates suggest that a 10 percent increase in earnings will reduce SSI payments by nearly 8 percent and participation by 3 percent. The estimate in column 6 suggests that a 10 percent increase in earnings will reduce payments per beneficiary by 0.8 percent. Higher earnings may reduce SSI payments through relative increases in the value of labor force participation such that workers become ineligible for benefits as earnings rise; this increase in earnings may also preclude disabled family members from eligibility for SSI benefits.

Given that SSI is a means-tested program designed to provide low-income aged and disabled workers with additional income security, the responsiveness of program payments and participation, including joint participation with DI, to changes in local economic conditions may shed light on changes to the income distribution of DI applicants and beneficiaries between the pre-boom and boom periods. As explained in the previous section, changes in DI payments and participation occur largely through reductions in new entrants. Autor and Duggan (2003) refer to those potential beneficiaries who apply for DI benefits in the presence of adverse economic conditions as "conditional applicants." Finding little or no relationship between earnings growth and joint SSI and DI participation may suggest that these conditional applicants are from higher in the earnings distribution. Column 1 of Table 8 presents IV estimates of the income elasticity of joint SSI and DI participation. The estimate in column 1 suggests a small and statistically insignificant, albeit positive, relationship between earnings growth and joint SSI and DI participation.[19] In addition, the point estimates in tables 5, 7, and 8 suggest that for both DI and SSI, payments, rather than participation, appear to be more sensitive to changes in earnings. That is, for a given change in earnings, the reduction in program payments is larger than the reduction in participation, suggestive of the idea that the conditional applicants, in this case, may be from higher in the income distribution.

[19] I subtract the number of SSI participants who are over 65 from the total for those who are jointly eligible for SSI and OASDI to provide a coarse measure of those who are jointly eligible for SSI and DI.

IX. Summary, Caveats, and Implications

In this paper, I use variation in local labor market conditions to estimate the impact of economic growth on DI program participation. The oil boom created an exogenous shock to local economies. I use data from three oil-producing states and use the oil boom as a natural experiment to identify the causal impact of earnings growth on the DI program. Overall, I find that for the DI program, the elasticity of payments with respect to earnings growth is approximately -1; the elasticity of program with respect to earnings growth is approximately -0.7. These estimates suggest the oil boom led to a 2.5 percent decrease in DI payments and a 1.6 percent decrease in participation in oil counties relative to counties without oil.

My research contributes to the literature in two important ways. First, I provide new causal estimates that suggest current workers may exhibit a higher degree of substitutability between DI and labor force participation. These results are substantially larger than the estimates from Black et al. (2002); but my findings are consistent with Autor and Duggan (2003), who suggest that current workers will be more responsive to changes in economic conditions due to various programmatic and systematic changes to DI. Second, this paper contributes to the growing literature examining impact of natural resources on labor market outcomes (Acemoglu et al., 2013; Aldy, 2014; Allcott and Keniston, 2014; Black et al., 2002; Black et al., 2005; Carrington, 1996; Cascio and Narayan, 2015; Feyrer et al., 2014; Marchand, 2012; Vachon, 2014; Weber, 2012).

In addition, between June 2014 and February 2015, oil prices fell by just over 50 percent from $106 to $51 per barrel. This decrease in prices represents a negative shock to local economic conditions. The new estimates that I present in this paper can provide insight into how changes in the price of oil will impact DI payments and participation. Based on my first stage estimates, this decrease in prices will reduce earnings by nearly 2.5 percent. From my IV estimates, a 50 percent decrease in prices will increase DI payments by 2.6 percent and DI participation by 1.7 percent at the county level. These somewhat speculative estimates assume a symmetric response of economic conditions to increases and decreases in the price of oil.

However, this study has one primary limitation. The three-state region I examine in this paper is more rural and less populous than the Appalachian region examined by Black et al. (2002). These differences could imply a higher level of DI generosity as well as a higher degree of substitutability between labor force participation and DI participation, especially among low-skilled workers. Additionally, it is possible that the concurrent oil boom and Great Recession have contributed to a unique set of local labor market conditions than has been previously studied during other more mild economic downturns. While these results should be interpreted with caution, the caveats provide avenues for future research. Extending the analysis beyond the three-state region to other areas impacted by the shale boom may broaden our understanding of the relationship between local economic conditions and the DI program.

References

Acemoglu, Daron, Amy Finkelstein, and Matthew J. Notowidigdo. 2013. "Income and Health Spending: Evidence from Oil Price Shocks." *The Review of Economics and Statistics* 95 (4): 1079–95.

Aldy, Joseph E. 2014. "The Labor Market Impacts of the 2010 Deepwater Horizon Oil Spill and Offshore Oil Drilling Moratorium." Working Paper 20409. National Bureau of Economic Research.

Allcott, Hunt, and Daniel Keniston. 2014. "Dutch Disease or Agglomeration? The Local Economic Effects of Natural Resource Booms in Modern America." Working Paper 20508. National Bureau of Economic Research.

Autor, David H., and Mark G. Duggan. 2003. "The Rise in the Disability Rolls and the Decline in Unemployment." *The Quarterly Journal of Economics* 118 (1): 157–206.

Autor, David H., and Mark G. Duggan. 2006. "The Growth in the Social Security Disability Rolls: A Fiscal Crisis Unfolding." *Journal of Economic Perspectives* 20 (3): 71–96.

Belotti, Federico, Gordon Hughes, and Andrea Piano Mortari. XSMLE: Stata Module for Spatial Panel Data Models Estimation. Statistical Software Components S457610. Boston College Department of Economics, revised March 15, 2014.

Black, Dan, Kermit Daniel, and Seth Sanders. 2002. "The Impact of Economic Conditions on Participation in Disability Programs: Evidence from the Coal Boom and Bust." *American Economic Review* 92 (1): 27–50.

Black, Dan, Terra McKinnish, and Seth Sanders. 2005. "The Economic Impact Of The Coal Boom And Bust." *The Economic Journal* 115 (503): 449–76.

Bound, John. 1989. "The Health and Earnings of Rejected Disability Insurance Applicants." *The American Economic Review* 79 (3): 482–503.

Bound, John. 1991. "The Health and Earnings of Rejected Disability Insurance Applicants: Reply." *American Economic Review* 81 (5): 1427–34.

Bound, John, and Richard V. Burkhauser. 1999. "Chapter 51 Economic Analysis of Transfer Programs Targeted on People with Disabilities." In *Handbook of Labor Economics*, edited by Orley C. Ashenfelter and David Card, 3, Part C: 3417–3528. North-Holland, Amsterdam.

Bound, John, and George Johnson. 1992. "Changes in the Structure of Wages in the 1980's: An Evaluation of Alternative Explanations." *The American Economic Review* 82 (3): 371–92.

Bound, John, and Timothy Waidmann. 1992. "Disability Transfers, Self-Reported Health, and the Labor Force Attachment of Older Men: Evidence from the Historical Record." *The Quarterly Journal of Economics* 107 (4): 1393–1419.

Bound, John, and Timothy Waidmann. 2002. "Accounting for Recent Declines in Employment Rates among Working-Aged Men and Women with Disabilities." *The Journal of Human Resources* 37 (2): 231–50.

Burkhauser, Richard and Mary Daly. 2011. *The Declining Work and Welfare of People with Disabilities: What Went Wrong and a Strategy for Change*. The AEI Press. Washington, DC.

Carrington, William J. 1996. "The Alaskan Labor Market during the Pipeline Era." *Journal of Political Economy* 104 (1): 186–218.

Cascio, Elizabeth U., and Ayushi Narayan. 2015. "Who Needs a Fracking Education? The Educational Response to Low-Skill Biased Technological Change." Working paper, Dartmouth College.

Cliff, Andrew D., and John K. Ord. 1973. Spatial Autocorrelation. London: Pion.

Cliff, Andrew D., and John K. Ord. 1981. Spatial Processes: Models and Applications. London: Pion.

Continental Resources. 2014. "Historical Timeline." http://www.clr.com/about/timeline/2004 (accessed November 11, 2014).

Drukker, David M., Hua Peng, Ingmar R. Prucha, and Rafal Raciborski. "Creating and managing spatial-weighting matrices with the *spmat* command." *Stata Journal* 13, no. 2 (2013): 242-286.

Duggan, Mark and Scott Imberman. 2009. "Why are the DI Rolls Skyrocketing? The Contribution of Population Characteristics, Economic Conditions, and Program Generosity," in *Health in Older Ages: The Causes and Consequences of Declining Disability among the Elderly* by David M. Cutler, David A. Wise, and Richard G. Woodbury, 337-379. University of Chicago Press. Chicago, IL.

Elhorst, J. Paul. 2010. "Applied Spatial Econometrics: Raising the Bar." *Spatial Economic Analysis* 5 (1): 9–28.

Federal Reserve Bank of Minneapolis. 2012. "Data on Demographic, Economic and Financial Activity in the Bakken." htp://www.minneapolisfed.org/publications_papers/fed gazette/oil/ (accessed December 20, 2013).

Feyrer, James, Erin T. Mansur, and Bruce Sacerdote. 2014. "Where's My Fracking Job? Geographic Dispersions of Economic Shocks from Hydrofracking." Working paper, Dartmouth College.

Goodman, Nanette J., and Timothy Waidmann. 2003. "Social Security Disability Insurance and the Recent Decline in the Employment Rate of People with Disabilities." In *The Decline in Employment of People with Disabilities: A Policy Puzzle*, edited by David C. Stapleton, and Richard V. Burkhauser, 339-369. Upjohn Press. W.E. Upjohn Institute for Employment Research. Kalamazoo, MI.

Gruber, Jonathan. 2000. "Disability Insurance Benefits and Labor Supply." *Journal of Political Economy* 108 (6): 1162–83.

Gruber, Jonathan, and Jeffrey D. Kubik. 1997. "Disability Insurance Rejection Rates and the Labor Supply of Older Workers." *Journal of Public Economics* 64 (1): 1–23.

Hambor, John C. 1975. "Unemployment and Disability: An Econometric Analysis with Time Series Data." Staff Paper - Social Security Administration, Office of Research and Statistics; No. 20.

Hambor, John C. 1992. "The Role of Economic Factors in the Decline of the DI Trust Fund." Unpublished Manuscript. U.S. Department of Treasury.

Haveman, Robert H., and Barbara L. Wolfe. 1984. "Disability Transfers and Early Retirement: A Casual Relationship?" *Journal of Public Economics* 24 (1): 47–66.

Hyne, Norman J. 2012. *Nontechnical Guide to Petroleum Geology, Exploration, Drilling, and Production*. PennWell Books. Tulsa, OK.

Lando, Mordechai. 1979. "Prevalence of Work Disability by State, 1976." Social Security Bulletin 42:41–44.

Levy, Jesse, and Aaron Krute. 1983. "The Impact of the Local Economy on the Disability Process: Further Results." Unpublished manuscript. Social Security Administration.

Marchand, Joseph. 2012. "Local Labor Market Impacts of Energy Boom-Bust-Boom in Western Canada." *Journal of Urban Economics* 71 (1): 165-74.

Maugeri, Leonardo. 2012. "Oil: The Next Revolution." Discussion Paper 2012-10. Belfer Center for Science and International Affairs, Harvard Kennedy School.

Muller, L. Scott. 1982. "The Impact of Local Labor Market Characteristics on the Disability Process." Working Paper 27. Office of Research and Statistics, Social Security Administration.

Parsons, Donald O. 1980. "The Decline in Male Labor Force Participation." *Journal of Political Economy* 88 (1): 117–34.

Parsons, Donald O. 1984. "Disability Insurance and Male Labor Force Participation: A Response to Haveman and Wolfe." *Journal of Political Economy* 92 (3): 542–49.

Parsons, Donald O. 1991a. "Self-Screening in Targeted Public Transfer Programs." *Journal of Political Economy* 99 (4): 859–76.

Parsons, Donald O. 1991b. "The Health and Earnings of Rejected Disability Insurance Applicants: Comment." *The American Economic Review* 81 (5): 1419–26.

Rupp, Kalman, and David Stapleton. 1995. "Determinants of the Growth in the Social Security Administration's Disability Programs—An Overview." Social Security Bulletin 58:43–70.

Stapleton, David, Kevin Coleman, Kimberly Dietrich, and Gina Livermore. 1998. "Empirical Analyses of DI and SSI Application and Award Growth." In *Growth in Disability Benefits*, edited by Kalman Rupp and David Stapleton, 31–92. Upjohn Press. W.E. Upjohn Institute for Employment Research. Kalamazoo, MI.

U.S. Census Bureau. 2012. *Statistical Abstract of the United States*: 131st Edition.<http://www.census.gov/compendia/statab/>. Washington, DC.

U.S. Energy Information Administration. "Texas Field Production of Crude Oil." United States Department of Energy. http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s-=MCRFPTX1&f=A (accessed September 5, 2014).

U.S. Social Security Administration, Office of Retirement and Disability Policy. 2015. "Annual Statistical Supplement, 2000." http://www.ssa.gov/policy/docs/statcomps/supplement/ (accessed April 20, 2015).

U.S. Social Security Administration, Office of Retirement and Disability Policy. 2015. "Annual Statistical Supplement, 2001." http://www.ssa.gov/policy/docs/statcomps/supplement/ (accessed April 20, 2015).

U.S. Social Security Administration, Office of Retirement and Disability Policy. 2015. "Annual Statistical Supplement, 2002." http://www.ssa.gov/policy/docs/statcomps/supplement/ (accessed April 20, 2015).

U.S. Social Security Administration, Office of Retirement and Disability Policy. 2015. "Annual Statistical Supplement, 2003." http://www.ssa.gov/policy/docs/statcomps/supplement/ (accessed April 20, 2015).

U.S. Social Security Administration, Office of Retirement and Disability Policy. 2015. "Annual Statistical Supplement, 2004." http://www.ssa.gov/policy/docs/statcomps/supplement/ (accessed April 20, 2015).

U.S. Social Security Administration, Office of Retirement and Disability Policy. 2015. "Annual Statistical Supplement, 2005." http://www.ssa.gov/policy/docs/statcomps/supplement/ (accessed April 20, 2015).

U.S. Social Security Administration, Office of Retirement and Disability Policy. 2015. "Annual Statistical Supplement, 2006." http://www.ssa.gov/policy/docs/statcomps/supplement/ (accessed April 20, 2015).

U.S. Social Security Administration, Office of Retirement and Disability Policy. 2015. "Annual Statistical Supplement, 2007." http://www.ssa.gov/policy/docs/statcomps/supplement/ (accessed April 20, 2015).

U.S. Social Security Administration, Office of Retirement and Disability Policy. 2015. "Annual Statistical Supplement, 2008." http://www.ssa.gov/policy/docs/statcomps/supplement/ (accessed April 20, 2015).

U.S. Social Security Administration, Office of Retirement and Disability Policy. 2015. "Annual Statistical Supplement, 2009." http://www.ssa.gov/policy/docs/statcomps/supplement/ (accessed April 20, 2015).

Vachon, Mallory C. 2014. “The Impact of Local Labor Market Conditions on Migration: Evidence from the Bakken Oil Boom.” http://malloryvachon.com/research/

Von Wachter, Till, Jae Song, and Joyce Manchester. 2011. “Trends in Employment and Earnings of Allowed and Rejected Applicants to the Social Security Disability Insurance Program.” *American Economic Review* 101 (7): 3308–29.

Weber, Jeremy. 2012. “The Effects of a Natural Gas Boom on Employment and Income in Colorado, Texas, and Wyoming.” *Energy Economics* 35 (5): 1580-88.

Figure 1 – Petroleum Geology and Extraction

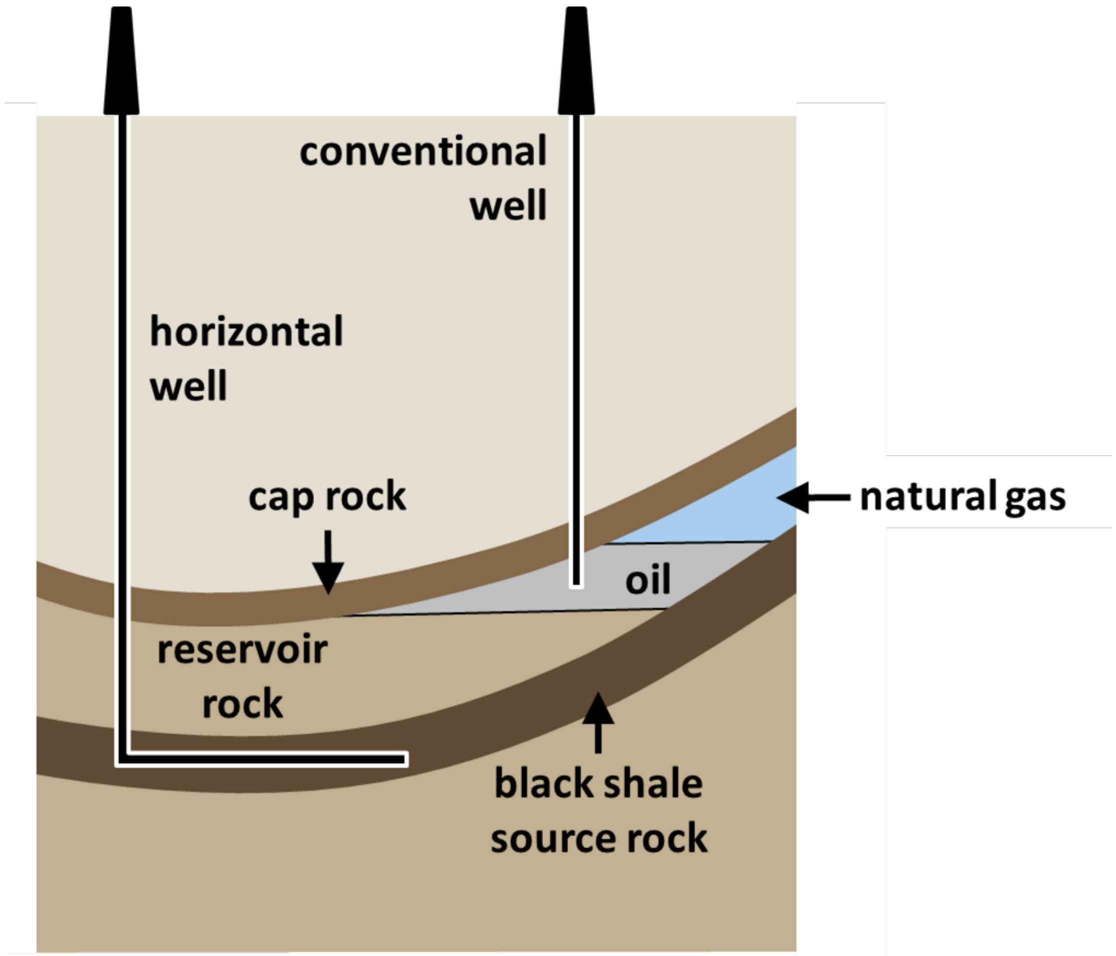

Figure 2 – Historical North Dakota Oil Production and Prices

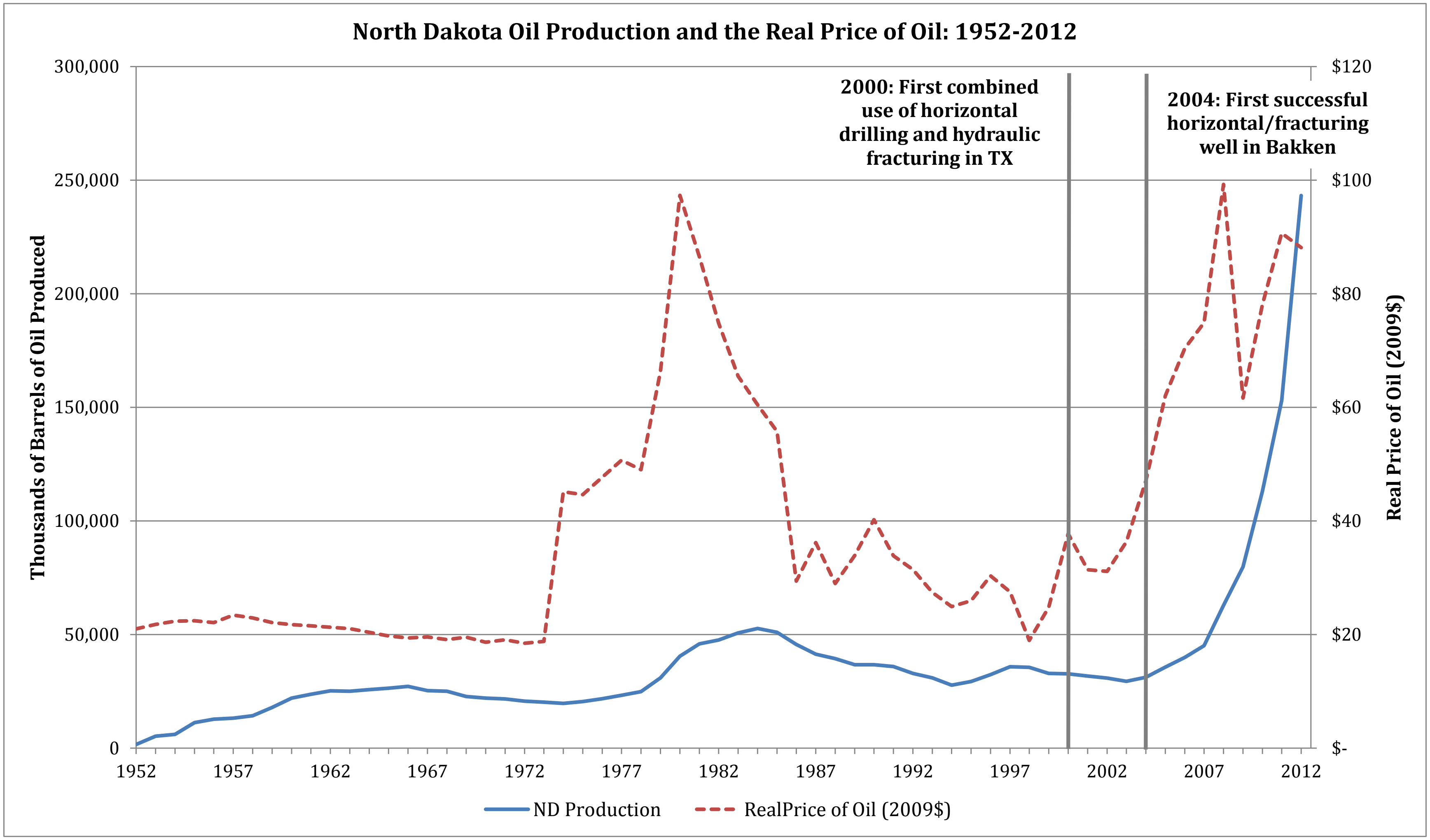

Figure 3 – Oil Reserves in Montana, North Dakota, and South Dakota

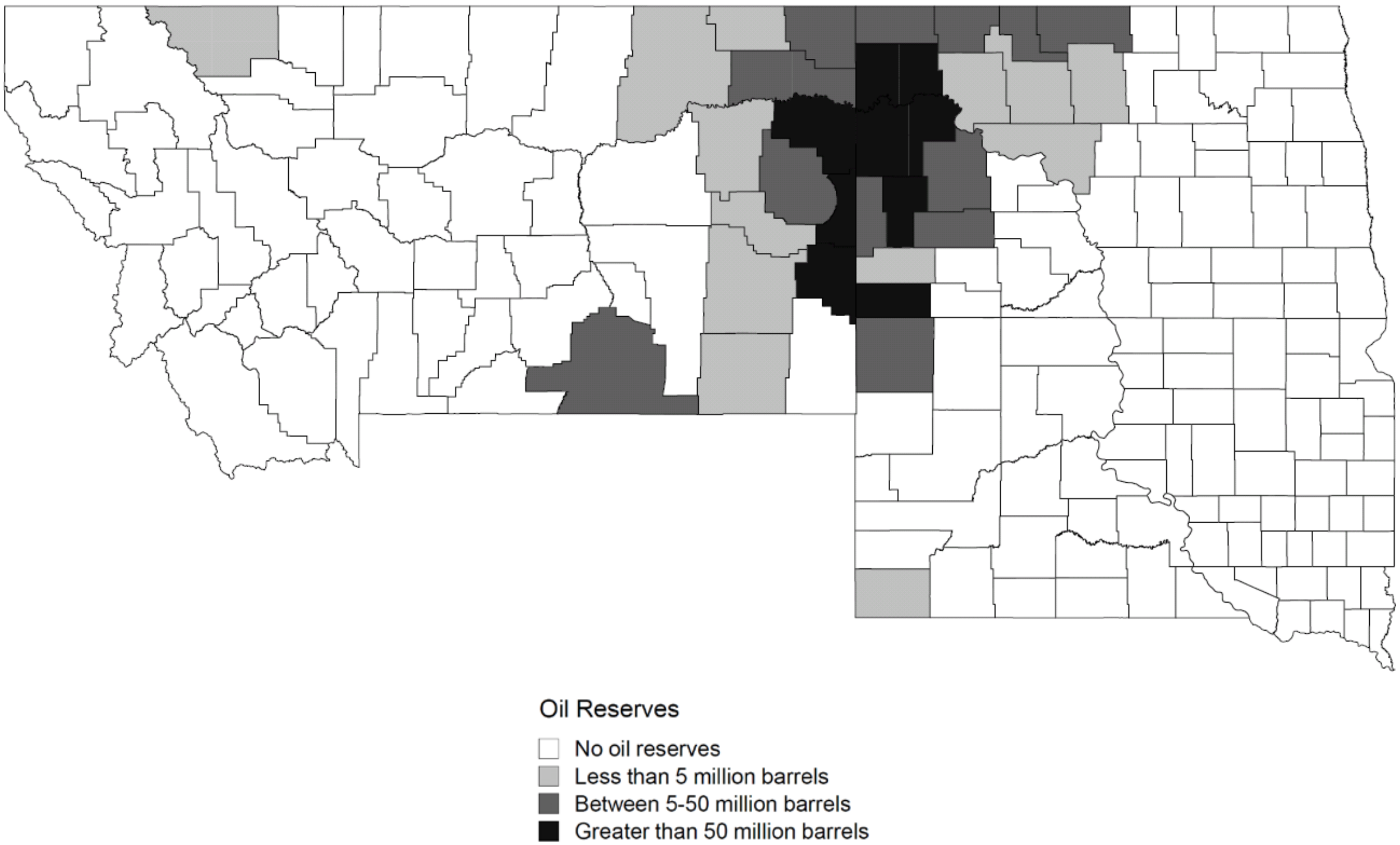

Figure 4 – Quartile of Average Annual Earnings Growth:
Montana, North Dakota, and South Dakota, 2000-2009

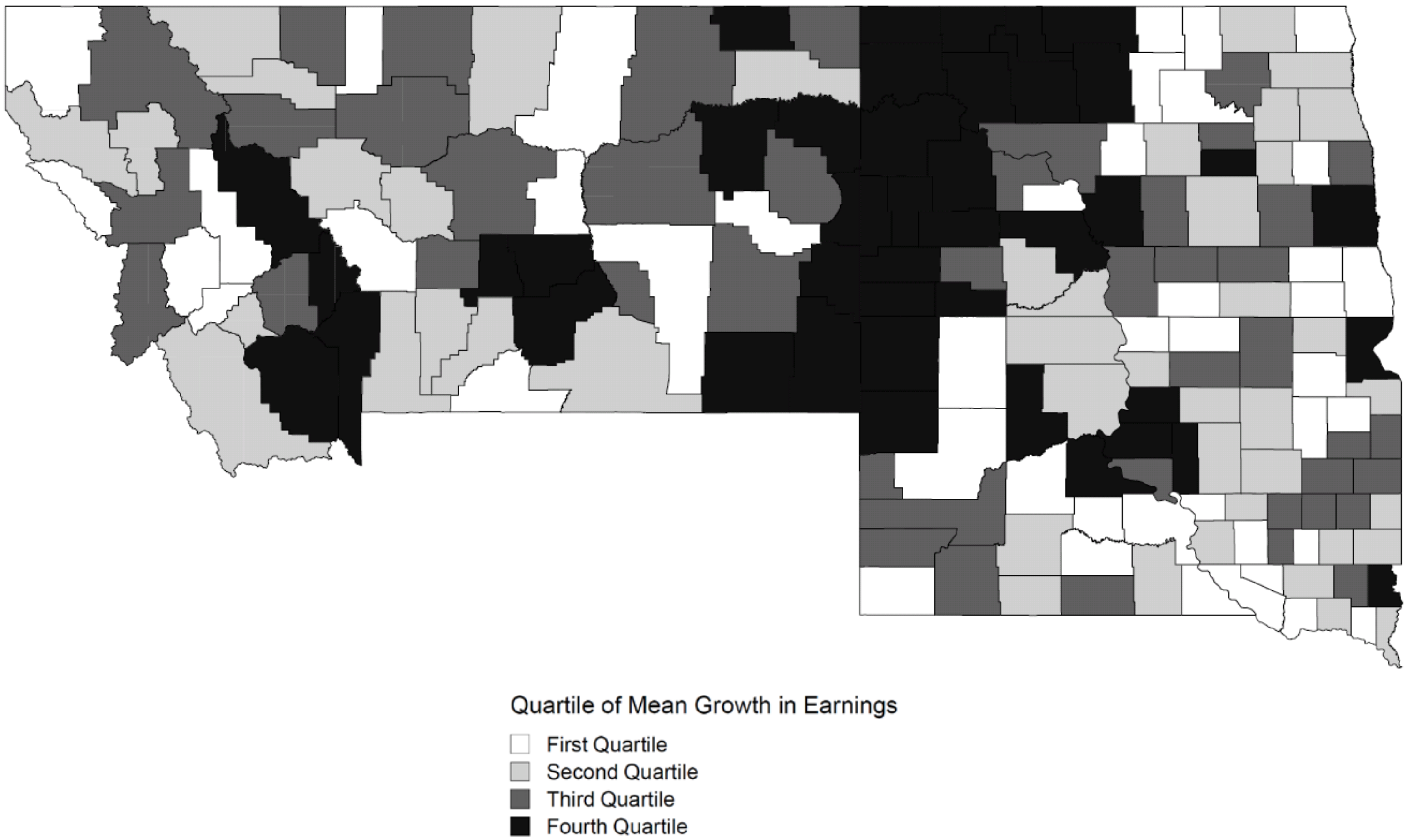

Figure 5 – Quartile of Average Annual Growth in DI Payments:
Montana, North Dakota, and South Dakota, 2000-2009

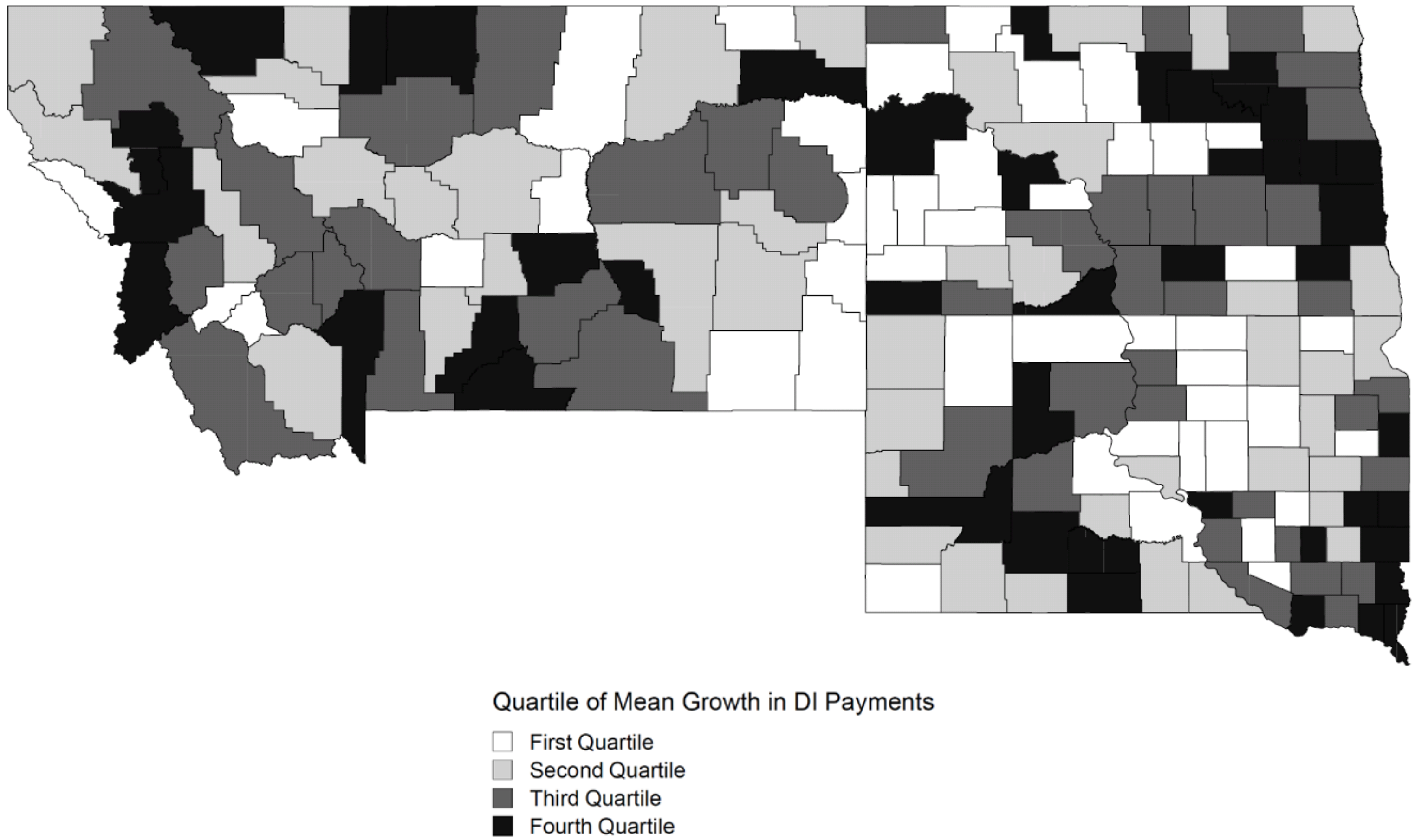

Table 1 - Summary Statistics of Sample:
Montana, North Dakota, and South Dakota, 2000-2009

	All Counties (1)	Oil Counties (2)	No Oil Counties (3)
DI Payments (Thousands of 2009$)	252.5	139.1	277.9
DI Beneficiaries	261.1	146.8	286.7
Earnings (Thousands of 2009$)	191,553.2	98,829.5	212,302.6
Logarithmic Difference in DI Payments	0.044	0.032	0.047
Logarithmic Difference in DI Beneficiaries	0.035	0.026	0.037
Logarithmic Difference in Earnings	0.015	0.029	0.012
Oil Reserves (Thousands of Barrels)		43,993.67	
West Texas Intermediate Crude Oil Price per Barrel (2009$)	56.18		
Logarithmic Difference in the Value of Oil Reserves		0.05	
Population	13,501.7	7,740.9	14,790.8
Logarithmic Difference in Population	-0.003	-0.005	-0.003
Fraction of Workers in Manufacturing (1999)	0.075	0.023	0.087
Fraction of Counties with an MSA (1999)	0.057	0	0.070
Number of Counties	175	32	143

Table 2 - OLS Estimates of the Impact of Earnings Growth on the Change in Disability Insurance Payments and Participation: Montana, North Dakota, and South Dakota, 2000-2009

	DI Payments		DI Participation	
	(1)	(2)	(3)	(4)
Earnings Growth	-0.152	-0.156	-0.164	-0.169
	(0.102)	(0.103)	(0.063)	(0.062)
Controls:				
County Contains MSA	No	Yes	No	Yes
County Population	No	Yes	No	Yes
Change in County Population	No	Yes	No	Yes
Fraction of Workers in Manufacturing (1999)	No	Yes	No	Yes
Observations	1575	1575	1575	1575

Notes: DI payments are log differences in real values (not including spousal or child benefits). DI participation is the log difference in the number of beneficiaries (not including spouses or children). Robust standard errors in parentheses are clustered at the county level. All models include state-by-year fixed effects.

Table 3 - Summary Statistics of Sample by Period:
Montana, North Dakota, and South Dakota, 2000-2004 and 2005-2009

	All Counties (1)	Oil Counties (2)	No Oil Counties (3)
Panel A: Pre-Boom (2000-2004)			
DI Payments (Thousands of 2009$)	220.1	127.3	240.9
DI Beneficiaries	233.4	136.1	255.2
Earnings (Thousands of 2009$)	180,821.4	90,738.2	200,979.9
Logarithmic Difference in DI Payments	0.045	0.040	0.046
Logarithmic Difference in DI Beneficiaries	0.037	0.032	0.038
Logarithmic Difference in Earnings	0.012	0.020	0.010
Oil Reserves (Thousands of Barrels)		43,993.67	
West Texas Intermediate Crude Oil Price per Barrel (2009$)	37.7		
Logarithmic Difference in the Value of Oil Reserves		0.06	
Population	13,237.5	7,750.0	14,465.4
Logarithmic Difference in Population	-0.006	-0.010	-0.005
Panel B: Oil Boom (2005-2009)			
DI Payments (Thousands of 2009$)	284.9	151.03	314.9
DI Beneficiaries	288.8	157.5	318.2
Earnings (Thousands of 2009$)	202,285.1	106,920.8	223,625.3
Logarithmic Difference in DI Payments	0.044	0.025	0.048
Logarithmic Difference in DI Beneficiaries	0.033	0.020	0.036
Logarithmic Difference in Earnings	0.018	0.037	0.013
Oil Reserves (Thousands of Barrels)		43,993.7	
West Texas Intermediate Crude Oil Price per Barrel (2009$)	74.6		
Logarithmic Difference in the Value of Oil Reserves		0.054	
Population	13,765.8	7,731.9	15,116.1
Logarithmic Difference in Population	-0.002	-0.0004	-0.002
Number of Counties	175	32	143

Table 4 - First-Stage Relationship between Oil Reserve Instruments and Earnings Growth: North Dakota, South Dakota, and Montana, 2000-2009

	Earnings Growth			
	(1)	(2)	(3)	(4)
Change in the Value of Oil Reserves	0.045 (0.015)	0.048 (0.015)	0.045 (0.015)	0.049 (0.015)
Change in the Value of Oil Reserves: One Lag			0.064 (0.023)	0.067 (0.024)
Change in the Value of Oil Reserves: Two Lags			0.023 (0.027)	0.021 (0.027)
Vector of Control Variables	No	Yes	No	Yes
F-Statistic	9.03	9.8	10.4	11.4
Observations	1225	1225	1225	1225

Notes: Robust standard errors in parentheses are clustered at the county level. All models include state-by-year fixed effects.

Table 5 - IV Estimates of the Impact of Earnings Growth on the Change in Disability Insurance Payments and Participation: Montana, North Dakota, and South Dakota, 2000-2009

	DI Payments		DI Participation	
	(1)	(2)	(3)	(4)
Earnings Growth	-1.206	-1.039	-0.827	-0.670
	(0.470)	(0.434)	(0.356)	(0.323)
Controls:				
County Contains MSA	No	Yes	No	Yes
County Population	No	Yes	No	Yes
Change in County Population	No	Yes	No	Yes
Fraction of Workers in Manufacturing (1999)	No	Yes	No	Yes
Observations	1225	1225	1225	1225

Notes: DI payments are log differences in real values (not including spousal or child benefits). DI participation is the log difference in the number of beneficiaries (not including spouses or children). Robust standard errors in parentheses are clustered at the county level. All models include state-by-year fixed effects.

Table 6 - Spatial IV Estimates of the Impact of Earnings Growth on the Change in Disability Insurance Payments and Participation: Montana, North Dakota, and South Dakota, 2000-2009

	DI Payments (1)	DI Participation (2)
Earnings Growth	-1.290	-1.179
	(0.665)	(0.634)
Observations	1,575	1,575

Notes: Standard errors are in parentheses.

Table 7 - IV Estimates of the Impact of Earnings Growth on the Change in Social Security Retirement and Supplemental Security Income Program Payments and Participation:
Montana, North Dakota, and South Dakota, 2000-2009

	OAS Payments and Participation			SSI Payments and Participation		
	Payments	Participation	Payments per Beneficiary	Payments	Participation	Payments per Beneficiary
	(1)	(2)	(3)	(4)	(5)	(6)
Earnings Growth	-0.282	-0.195	-0.042	-0.791	-0.327	-0.080
	(0.126)	(0.124)	(0.026)	(0.503)	(0.425)	(0.093)
Observations	1,225	1,225	1,225	1,184	1,199	1,183

Notes: The specifications in this table use the full det of control variables and instruments.Robust standard errors in parentheses are clustered at the county level. All models include state-by-year fixed effects.

Table 8 - IV Estimates of the Impact of Earnings Growth on the Change in Supplemental Security Income Program Participation: Montana, North Dakota, and South Dakota, 2000-2009

	Joint Eligibility		SSI Participation by Age	
	SSI and DI	SSI and OASDI	18-64	65 plus
	(1)	(2)	(3)	(4)
Earnings Growth	0.112	-0.794	-0.672	-1.180
	(1.120)	(0.431)	(0.460)	(0.668)
Observations	758	1,055	947	900

Notes: The specifications in this table use the full det of control variables and instruments. Robust standard errors in parentheses are clustered at the county level. All models include state-by-year fixed effects.