5-2016

The Effects of Federal, State, and Private Oil and Gas Ownerships on County Wages in the Intermountain West

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THE EFFECTS OF FEDERAL, STATE, AND PRIVATE OIL AND GAS OWNERSHIPS ON

COUNTY WAGES IN THE INTERMOUNTAIN WEST

by

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A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Applied Economics

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UTAH STATE UNIVERSITY
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2016

ABSTRACT

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Utah State University, 2016

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Advances in drilling technology and increasing resource prices contributed to a boom in oil and natural gas production in the Western U.S. in the first decade of the 2000s. Following the boom, a strain of state-level legislation emerged calling for the transfer of federal lands to the states. A justification for the proposed transfers is the claim that state management will responsibly increase oil and gas production levels currently held back by federal regulations and management. However, a substantial literature indicates that dependence on mineral wealth can be a problematic economic development strategy resulting in slower growth and other undesirable socioeconomic outcomes. Using geological variation in oil and gas abundance in the Intermountain West, this study examined the effects of resource abundance on county wage levels and growth rates over the period 1990 to 2010. Areas of oil and gas abundance were further classified by federal, state, and private surface land ownership to examine institutional ownership effects on wage levels and growth rates.

Overall oil and gas abundance was shown to have a positive impact on wage levels and growth rates, while institutional ownerships were found to have significantly differing effects on county wages. State ownership was usually associated with higher wage levels and growth rates than federal ownership, likely due to a lengthy permitting process for drilling on federal lands. Private ownership had insignificant effects on local wages, likely due to absentee ownership. The results provide no evidence of a 'curse of natural resources' in the region and lend a modicum of support to state land transfer bills.

(73 pages)

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The objectives of the study were twofold. First, geological variation in oil and gas abundance was used to examine long-term effects on county wage levels and short-term effects on wage growth from 1990 to 2010. Second, land ownership data was used to classify areas of oil and gas abundance into federal (Forest Service and Bureau of Land Management), state, and private ownership categories to test for significantly differing effects on wages across ownership types.

Results indicate that overall oil and gas abundance had a positive impact on wage levels and growth rates in the region, while institutional ownership categories were associated with significantly differing wage effects. State ownership was usually associated with higher wage levels and growth rates than federal ownership, likely due to a lengthy permitting process for drilling on federal lands. Private ownership had insignificant effects on local wages, likely due to absentee ownership. The results provide no evidence of a ‘curse of natural resources’ in the region and lend a modicum of support to state land transfer bills.

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INTRODUCTION

Natural resources have long been an essential part of the local economies of the Rocky Mountain region. In recent years a boom in oil and natural gas production has been driven by high prices and advances in drilling technology. In the Intermountain states of Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming natural gas production increased 38% and oil production jumped 12% over the period 2000-2010 (Low et al., 2014; Fig. 1). Following the resource boom, a strain of public lands legislation emerged in some western states which calls for the transfer of federal lands to the states, generally excluding national parks, national monuments, wilderness areas and military reservations (Utah, 2012; Idaho, 2013; Wyoming, 2013; Nevada, 2013; Montana, 2013; National Association of Counties, 2013). The American Legislative Exchange Council, an influential conservative group that drafts and shares model state-level legislation, characterizes the objective of the land transfer bills as

> "to responsibly unleash trillions of dollars of abundant resources locked up on federally controlled lands, and with them American independence and ingenuity, as the only solution big enough to realistically and sustainably resolve national unemployment, deficits, debts, unfunded obligations and environmental degradation" (American Legislative Exchange Council, 2013).

Observers have noted that the sequence of events – an oil and gas boom followed by the introduction of land transfer bills – is not mere coincidence but can be at least partially explained by the states' desire to capture more revenue from oil and gas production (Mencimer, 2015; Keiter and Ruple, 2015; Puckett 2015). If a public land transfer did occur, Stambro et al. (2014) find that states would need to cover land management costs currently paid by the federal government. In Utah alone these costs are estimated to be $280 million ($2013) annually. Since a majority of revenue from the public lands in question come from mineral leasing (primarily oil, natural gas, and coal), consistently high oil and gas prices (Stambro et al., 2014) or "a massive increase in development" (Keiter and Ruple, 2015) would be necessary to cover land management costs. While a massive increase in oil and gas production may help drive economic growth, economists have long noted a seeming paradox of natural resource-based development: economic dependence on natural resources tends to be negatively correlated with growth (Auty, 1993; Sachs and Warner, 1997). Moreover, dependence on concentrated 'point' resources such as oil and gas may more negatively affect growth since resource rents from such operations are more easily misallocated by institutional overseers than are the more dispersed rents from other primary production activities such as agriculture (Auty, 2001; Sala-i-Martin and Subramanian, 2003; Mehlum et al., 2006a).

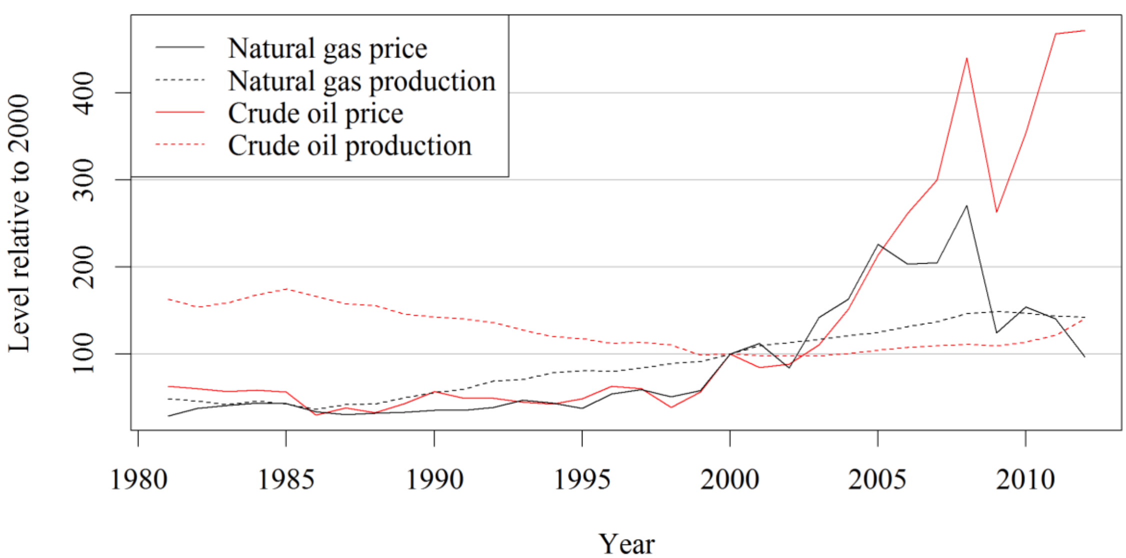

Fig. 1. National real prices and aggregate Intermountain West production levels of crude oil and natural gas relative to 2000 levels (=100). Prices reflect annual U.S. crude oil first purchase prices and U.S. natural gas wellhead prices. Production levels are aggregated values for Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming. Source: U.S. Energy Information Administration (www.eia.gov).

This paper presents an analysis of the effects of county oil and gas abundance, and the institutional ownerships associated with these resources, on county salary and wage levels and growth rates in the Intermountain West. Spatial datasets delineating land ownerships and oil and gas basins are used to measure the institutional oil and gas ownership characteristics of each county in the Intermountain Region. To the best of my knowledge this way of measuring the institutional influence on resource development outcomes is unique within the substantial literature on the development effects of resource wealth. The analysis considers salary and wage levels in 1990, 2000, 2007 and 2010, and on salary and wage growth over the time periods 1990-2000, 1990-2007, 1990-2010, 2000-2007 and 2000-2010. While 2007 and 2010 are only separated by three years, both time periods are included in the analysis in order to account for any effects of the Great Recession which began in December 2007.

The rest of the paper is organized as follows. Section two is a review of the literature on the national and regional scale effects of resource-based development. Section three provides an overview of the historical context and current management issues related to oil and gas development on public lands in the western U.S. Section four describes the empirical models and data sources, and section five is a presentation of results. Section six is a discussion of the results, and section seven concludes with suggestions for future research.

LITERATURE REVIEW

2.1 Resource effects on economic development: National scale

The effect of natural resources on economic growth has long been a subject of interest in development economics. A series of influential empirical studies by Sachs and Warner (1995, 1997, 2001) spurred a resurgence of interest in the subject in recent decades by identifying a phenomenon dubbed the 'curse of natural resources.' Using cross-country growth regressions over the time period 1970-1990, Sachs and Warner demonstrated a robust negative correlation between a country's natural resource wealth and its subsequent economic growth rate. Their growth equations have the following general form (Sachs and Warner 1997):

$$\ln(y_T/y_0)/T = \beta_0 + \beta_1 \ln(y_0) + \beta_2 RD + \beta_3 Z + \varepsilon \quad (1)$$

Where y_0 and y_T are measures of GDP divided by the economically active population at time 0 and time *T*; *RD* is a measure of the share of primary product exports in GDP; and *Z* is a vector of other economic characteristics that affect a county's steady state income level and thus its growth rate. Variables in *Z* included investment, institutional quality, global commodity price shocks, and integration with the global economy. Alternative *RD* measures were tested: the share of mineral production in initial GDP; the share of primary exports to total exports; and the log of land area per person. They also tested decadal growth rates rather than growth over the 20 year period. In all cases, the *RD* variable was found to be negatively associated with subsequent growth.

The negative relationship has been confirmed in other cross country studies (Rodriguez and Sachs, 1999; Papyrakis and Gerlagh, 2004) as well as across U.S. States (Papyrakis and Gerlagh, 2007) and counties (James and Aadland, 2011). The resource curse hypothesis is conceptually puzzling, as abundant natural wealth should drive economic growth, not restrain it.

Why then does resource dependence seem to lead to slower growth? Most explanations for the curse follow a crowding out logic: "Natural resources crowd out activity *x*. Activity *x* drives growth. Therefore natural resources harm growth" (Sachs and Warner, 2001). Sachs and Warner find a negative effect of resource dependence on manufacturing sector output and a positive effect on the ratio of services to manufacturing output, so they identify *x* as traded manufacturing activities. An explanation for this finding is that positive wealth shocks from the resource sector contribute to increased local demand, driving price increases in the factors of production for manufacturers. This reduces profits for manufacturers, who sell their products on international markets, and attracts labor to high wages in the resource sector. To the extent that the manufacturing sector has positive production externalities such as technology spillovers and higher returns to investments in human capital (Sachs and Warner, 1995; Gylfason, 2000), such a reallocation of labor adversely impacts growth and can spur a vicious cycle whereby lower returns to human capital development in the resource sector incentivizes reduced investment in education and locks people in low-skill, resource intensive industries (Gylfason, 2001). Adding to resource-rich economies' potential woes, the concentrated rents from mineral resources may act as an inducement for rent-seeking and corruption, resulting in misallocation of rents and the deterioration of institutional quality (Gylfason, 2001; Torvik, 2002; Papyrakis and Gerlagh, 2004; Boschini et al., 2007).

Crowding-out explanations for the resource curse hypothesis are supported by the findings of Papyrakis and Gerlagh (2004, 2007), who provide empirical evidence that resource dependence primarily affects growth indirectly through its negative effects on investment, openness, schooling, and corruption. In cross-country (2004) and cross-U.S. state (2007) regressions over the periods 1975-1996 and 1986-2000, respectively, they estimate the direct effect of resources on these transmission channels, then estimate the share of each transmission channel in the overall negative effect of resource dependence on growth. After controlling for these indirect effects, they find that resources have a positive effect on growth in the cross-country regressions (Papyrakis and Gerlagh, 2004), while in cross-U.S. state regressions the negative resource effect is completely explained by the indirect effects through transmission channels. Evidence of U.S. state-level resource curse mechanisms leads Papyrakis and Gerlagh (2007) to conclude that the resource curse is not just a problem of countries with weak institutions but is a potentially common threat to both developing and developed economies. Importantly, they note that exceptions to the curse phenomenon – such as positive development outcomes in resource-abundant Norway, Iceland, Texas, and New Mexico – indicate that there is not a necessary causality from resource dependence to lower growth. In light of this observation, they make a general call for "prudent economic policies and cautious planning" (2007) focused on "preventing the occurrence of these indirect phenomena" (2004). While their findings are empirically interesting, they do not provide a theoretical explanation for curse effects beyond reiterating the probable crowding-out mechanisms hypothesized by Sachs and Warner.

Mehlum et al. (2006a; 2006b) provide a theoretical context and empirical results which they conclude fully explain Sachs and Warner's findings. They assert that the variance in growth outcomes observed in the resource curse literature can be explained by how resource rents are distributed via the institutional arrangement and its effect on the allocation of scarce entrepreneurial resources, in other words, by the interaction of resource dependence and institutional quality. They consider two institutional arrangements. In a "producer-friendly" institutional context, rent-seeking and production are complementary activities. High bureaucratic quality, rule of law, low corruption in government and low risk of government repudiation of contracts contribute to a context in which rent-seeking must be for a legitimate cause, and it is difficult to be a rent seeker unless you are also a producer. Resource based development in a producer friendly institutional context will therefore have a positive effect on income levels. In contrast, in a "grabber-friendly" institutional arrangement, malfunctioning bureaucracies, weak rule of law and corruption mean that rent-seeking and production are competing activities since entrepreneurs can capture gains from specialization in unproductive activities such as political influence peddling. Entrepreneurial activity is thus diverted out of production until the relative profits of engaging in production versus grabbing behavior are equivalent.

Mehlum (2006a) empirically tests the hypothesis that resources are only a curse when resources are grabber friendly using the same data and the same methodology as Sachs and Warner (1997), with the addition of an interaction term between institutional quality[1] and resource dependence. They find that the resource curse is completely explained by the interaction term, such that resources are a curse when institutions are grabber-friendly and a blessing when institutions are producer-friendly. Their conclusion is that the quality of institutions determines whether countries avoid the resource curse. This compelling finding sheds significant light on Sachs and Warner's resource curse findings, but does not explain Papyrakis and Gerlagh's (2004, 2007) finding of significant negative associations between resource dependence and investment, openness, schooling and corruption. That is, it leaves unanswered questions regarding the direction of causation between measures of institutional quality, resource dependence, and growth.

Brunnschweiller and Bulte (2008) perform an analysis of these directions of causation using a dataset describing per capita GDP growth for 60 countries over the period 1970-2000. Their point of departure is the potential endogeneity of the measure of resources used in the Sachs and Warner studies, and by extension much of the resource curse literature. While Sachs and Warner refer to the ratio of primary exports to GDP as 'resource abundance', Brunnschweiller and Bulte (2008, p. 249) observe that

[1] The institutional quality variable is an unweighted average of five indexes: a rule of law index, a bureaucratic quality index, a corruption in government index, a risk of expropriation index, and a government repudiation of contracts index. See Knack and Keefer (1995).

> "this ratio is more appropriately thought of as a measure of dependence (or intensity) than as a measure of abundance. The denominator explicitly measures the magnitude of other activities in the economy. Consequently, the scaling exercise—dividing by the size of the economy—implies that the ratio variable is not independent of economic policies and the institutions that produce them."

To account for this likely endogeneity, they instrument for resource dependence as follows:

$$RD = \beta_0 + \beta_1 X + \beta_2 RA + \beta_3 CV + \beta_4 I + \epsilon \qquad (2)$$

Where *RD* measures resource dependence as the share of primary exports in GDP; *X* is a set of conditioning variables including openness and regional dummies; *RA* is an exogenous measure of resource abundance such as the log of total mineral resources; and *CV* and *I* are two variables which measure different aspects of a country's institutional context. *CV* provides a measure of a country's 'deep and durable' institutional characteristics; in Eq (2) it is represented by dummy variables indicating the presence of a presidential regime or of majoritarian electoral rules (as opposed to parliamentarian regimes and proportional representation). The justification for these variables is that incumbent decision-makers in countries with presidential regimes and majoritarian electoral rules (as opposed to parliamentarian regimes and proportional representation) are not dependent on a stable majority among the legislators and are therefore more likely cater to the needs of special interests (Glaeser et al., 2004). *I* measures characteristics of institutional quality which are in a greater state of flux, such as rule of law or bureaucratic efficacy. Their results point to presidential regimes and poor institutional quality as causal factors of resource dependence, not the other way around, contradicting Papyrakis and Gerlagh's findings: "we find that countries with certain institutional designs may fail to industrialize – and failing to develop significant non-resource sectors may make them dependent on primary sector extraction."

Noting that measures of institutional quality may also suffer from endogeneity in growth regressions to the extent that they reflect policy outcomes that are in a state of flux, Brunnschweiller and Bulte estimate an instrument for it using the following equation which also allows them to assess its relationship with resource abundance:

$$I = \alpha_0 + \alpha_1 X + \alpha_2 RA + \epsilon \tag{3}$$

Where *I* is the institutional quality variable from Eq (2), rule of law or government effectiveness; *X* is a set of conditioning variables including distance from the equator and regional dummy variables; and *RA* is the exogenous resource abundance measure from Eq (2). They find that resource abundance has a positive effect on institutional quality, again contradicting common curse findings. A plausible mechanism for this finding is that resource booms have a positive effect on the wages of civil servants, which may reduce their willingness to take bribes and/or improves morale (Mookherjee, 1997; Chand and Moene, 1999).

Finally, Brunnschweiller and Bulte use the instruments estimated in Eqs (2) and (3) to specify a growth regression using exogenous measures of resource dependence, institutional quality, and resource abundance:

$$G = c_0 + c_1 RD + c_2 I + c_3 RA + c_4 X + \epsilon \tag{4}$$

Where *G* is growth in per capita income over the period 1970-2000; *RD* and *I* are instruments estimated in Eqs (2) and (3); RA is exogenous resource abundance; and *X* is a set of conditioning variables. In this specification, they find resource abundance and institutional quality have positive and significant effects on income growth while the exogenous resource dependence variable has a negative but insignificant effect. Since institutional quality appeared to be the underlying mechanism causing slow growth, they conclude that a curse attributable directly to natural resources may not exist.

A final concern regarding the estimation of resource-based development welfare effects regards the time period analyzed. Several authors have expressed concern about using growth rates measured over relatively short time spans of 20 or 30 years as the dependent variable in econometric models of resource effects (Alexeev and Conrad, 2009; Davis, 2011). Since resource production inherently involves intertemporal tradeoffs, measuring welfare in terms of rates of growth may be problematic. Moreover, due to the mean-reverting nature of mineral extraction, a high current value is likely to be lower in future periods, and vice-versa. Failing to control for the rate of growth in the resource sector would therefore produce biased parameter estimates on the resource variable. Davis (2011) provides empirical evidence supporting this view. He adds the change in mineral sales per worker from 1971-1990 to Sachs and Warner's growth regressions and finds that the curse can be largely explained by a slow-growing resource sector, a phenomenon he calls a resource 'drag'. Although he cannot rule out that crowding out also occurs, he concludes that the presence of the curse is primarily driven by *when* variables are measured.

Alexeev and Conrad (2009) take a different approach by focusing on the long term impact of resources on income levels, not growth rates. This way of measuring GDP captures the influence of the entire arc of resource discovery, extraction, and depletion on measures of economic welfare. Since high GDP levels imply high growth at some point, they posit that using levels rather than growth rates as the dependent variable in regression equations provides a more accurate indication of the overall effect of resources on income. Noting the endogeneity concerns associated with using a ratio measure of resource dependence, they measure resources as the log of a country's hydrocarbon deposits per capita. They find that when per capita GDP levels are regressed on this exogenous measure of resource abundance and geographic, ethnic fractionalization, and institutional quality controls, the coefficient on the resource wealth variables are positive and significant: a resource blessing. These results hold when the ratio of oil output to GDP (as preferred by Sachs and Warner) is used in place of the per capita resource wealth measures preferred by Alexeev and Conrad.

2.2 Resource effects on economic development: Regional scale

While much of the resource curse literature has focused on national-scale effects, several studies have assessed regional resource effects across the sub-national units of a single country such as U.S. states and counties. This section provides an overview of this literature including several studies which examined the effects of oil and gas resources on economic outcomes in the western U.S.

James and Aadland (2011) use an approach directly analogous to Sachs and Warner's seminal curse studies on a nationwide sample of counties to show that resource dependent counties grow more slowly than other counties. They test the effect of county resource dependence, measured as the share of earnings in the agriculture and mining sectors, on annual growth in per capita personal income over 5, 10, 15, 20, and 25 year time periods beginning in 1980, the first year for which they had consistently available data. They find the curse to be present in all time periods after controlling for state-specific fixed effects, racial homogeneity, demography, population density, educational attainment, and spatial correlation. However, the curse effect tended to dissipate over longer time horizons, partly because the resource dependence of counties that were heavily resource-dependent at the first time step did not increase at an increasing rate over later time steps. This suggests a potential resource drag (Davis 2011) may be an underlying causal mechanism. They note there is a reduced need to control for differences in institutions, spoken language, currencies, and corruption at the county level, and suggest that future research examine counties that have avoided the 'curse.'

In a follow up study of U.S. states, James and James (2011) find that slower per capita income growth in mining dependent states from 1980-2000 can be mostly explained by a slow growing mining sector. They consider a hypothetical two sector economy comprised of a mining sector and a composite sector, which is everything other than mining. Growth in such an economy will be the weighted average of the growth rates of the two sectors. Hence, arithmetic insists that a relatively mining-dependent economy will grow relatively slowly when the mining sector grows more slowly than the composite sector. Given observed annual growth rates in the national aggregate (0.0154) and mining sectors (-0.04) from U.S. Census Bureau data, James and James estimate that the expected coefficient on an economy's share of overall earnings in the mining sector would be -0.045 in an annual growth rate regression over the period 1980-2000. Data from 49 states is then used to fit a resource curse model in which per capita income growth is regressed on the initial share of earnings in the mining sector. Using a T-test, they show that the negative coefficient estimated for the mining variable (-0.053) is not significantly different from the expected value (-0.045), supporting the idea that common curse findings may be detecting a resource drag (Davis 2011). Finally, they directly account for the rate of growth in the mining sector in a fully specified growth regression using additional covariates from James and Aadland (2011) and find that resource dependence was positively associated with growth.

Boyce and Emery (2011) use data from U.S. states over the time period 1970-2000 to support a theoretical explanation for the slower growth of resource dependent economies based on Hotelling production of an exhaustible resource stock in the absence of institutional or market failures. Noting that a surprising omission from most curse literature is the lack of a well specified natural resource market, they consider a theoretical small two-sector open economy comprised of a manufacturing sector and a resource sector. They define production as a function of labor allocation to the two sectors, where the resource sector is subject to a positive but diminishing marginal product of labor reflecting an unspecified fixed factor of production, while manufacturing is a constant returns to scale industry. In this scenario, they identify three factors that determine the net flow of labor into the resource sector and consequently the growth of per capita income in a mixed economy relative to a non-resource economy. First, the intertemporal tradeoff of resource extraction, the Hotelling effect, means that resource owners face an opportunity cost associated with resource production in the international capital markets. All else constant, this causes labor to flow out of the resource sector as the resource is depleted, resulting in slower growth in the mixed economy. The second effect is the relative rate of technological progress in the resource sector compared to the manufacturing sector. When technological change in the resource sector outpaces change in the manufacturing sector, the mixed economy will grow faster than the non-resource economy. The third effect is the real resource price level. When this price is increasing, the resource sector grows faster; when it is falling the resource sector grows more slowly. Finally, population growth also affects per capita incomes as resource rents are spread more thinly.

Using this theoretical scenario, Boyce and Emery articulate several expectations regarding resource-based development. First, as long as at least some resource rents are captured in the resource sector, an economy currently engaged in resource production *will* have higher per capita income levels than an equivalent economy with no resource production (Fig. 2). Second, growth rates in a resource dependent economy may be slower than those in a non-resource economy without market failures or an enigmatic curse. For example, assuming a higher rate of technological change in the manufacturing sector and constant or declining real resource prices, the theoretical rate of income growth will be slower in the resource sector than the manufacturing sector. Hence, a negative correlation between growth and natural resource dependence does not require the invocation of a "curse." Conversely, higher rates of technological progress in the resource sector and increasing real resource prices would contribute to higher growth rates in the resource sector: a resource blessing.

Boyce and Emery provide empirical evidence supporting their theoretical expectations using panel data on U.S. states over the time period 1970-2000. In a preliminary step, they fit curse models which show a negative correlation between the share of employment in the mineral sector and subsequent per capita income growth rates, supporting common curse findings. Then, drawing on their theoretical two-sector economy, they specify a growth model which includes not only the employment share in the mineral sector but also its interactions with growth rates of mineral sector employment, the price of minerals, and population. The interaction terms are important because the employment share in the mineral sector scales the influence of the other variables; as mineral sector employment approaches zero, an increase in the other variables has less effect on the economy. They note that during the time period analyzed resource prices and the share of employment in the mineral sector was declining, and the population was growing, thus they expect to find higher levels of resource dependence to be associated with lower per capita income growth rates. This indeed is precisely what their empirical models show. Finally, to test the effect of resource dependence on income levels, they specify a level regression equation which defines per capita income levels as a function of the employment share in the mineral sector. As expected, the coefficient on the employment share variable is positive and significant, showing that states engaged in natural resource production – reflected in their greater employment shares in the mineral sector – have higher per capita income levels, all else constant.

They conclude that slow growth in resource dependent economies may simply reflect well-functioning natural resources markets which require that the marginal profit be equalized across time. The slower growth does not necessarily imply a curse effect such as Papyrakis and Gerlagh (2007) posit; nor does it necessarily require institutional failures as Mehlum et al. (2006a) suggest.

Michaels (2010) examines the long term effects of resource-based specialization in the counties of several southern U.S. states over the period 1890-1990. He identifies a county as ‘oil abundant' if it is located above at least one large oilfield which was estimated to contain at least 100 million barrels of oil before any oil was extracted. Using a panel data modeling approach, he estimates the long term effects of this exogenous resource variable on decennially measured levels of median and per capita income, population and employment densities, educational attainment, and transportation infrastructure. While oil abundant counties were not significantly different than other counties in the region in the late nineteenth century, specialization in oil production in the early 20th century spurred a virtuous cycle of development effects in oil abundant counties. Increased incomes attracted migrants to the region while crowding out employment in agriculture. Higher population densities in turn contributed to improved

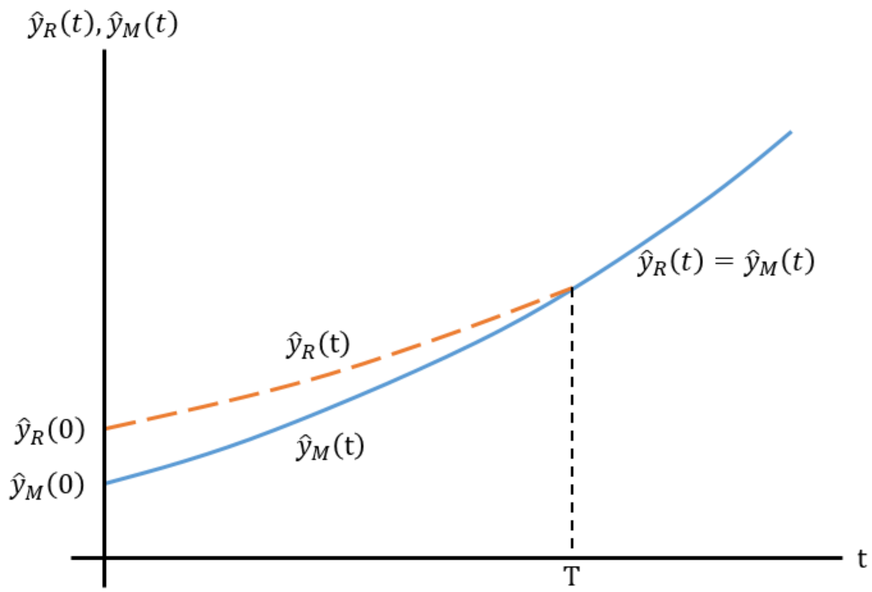

Fig. 2. Comparative growth rates of an economy engaged in Hotelling production of an exhaustible resource and a non-resource economy. Boyce and Emery (2011) illustrated that a mixed economy engaged in Hotelling production of an exhaustible resource stock with a positive but diminishing marginal product of labor will have a higher per capita income level ($\hat{y}_R$) during the period of resource extraction (until time T) than a purely manufacturing economy ($\hat{y}_M$) with constant returns to scale. If there is a higher rate of technological progress in the manufacturing sector than in the resource sector, and real resource prices are constant or declining, the growth rate in the mixed economy will be slower than in a manufacturing economy. Adapted from: Boyce and Emery (2011), Fig. 2.

infrastructure and the persistence of higher levels of income and population density. Oil abundant counties also enjoyed higher employment densities in the manufacturing sector in the decades following oil production. He finds that the positive development effects in oil abundant counties diminished over time, suggesting that benefits of resource wealth occur primarily during the period of resource extraction. Michaels concludes that the curse frequently found by other researchers did not occur in the U.S. South., and if other regions failed to develop it was likely due to interactions between abundant local natural resources and weak local institutions.

Several studies have assessed the impact of oil and gas development in the western U.S. Weber (2012) analyzes the effects of a natural gas boom in Colorado, Texas, and Wyoming counties from 1999-2007 on growth rates of total employment, total wage and salary income, median income, and the poverty rate. His primary predictor variable of interest is a *boom county* dummy variable, which he defines as a county in the top quintile for the change in gas production from 1999-2007. Weber recognizes the potential endogeneity of this variable since counties can influence their level of gas extraction and gas companies may select areas for drilling based on variables unobservable to the econometrician. He therefore instruments for boom county using the percent of the county overlaying unconventional gas formations. He also drops counties above the 90th percentile of population since they may excessively influence regression results. His dependent variables difference growth over the boom period with growth in the pre-boom period, 1993-1999. He finds that boom counties had higher median incomes than non-boom counties, but that the benefits were skewed toward higher incomes, as the effect of the boom on wage and salary income was four times greater than that on median income. The effect on the poverty rate was negative but insignificant. The effect the natural gas boom on employment was positive, but Weber’s estimates of employment gains were much smaller than those predicted by input-output modeling for hypothetical development of shale formations in Arkansas and Pennsylvania.

Weber (2014) assessed the impact of natural gas production on changes in sectoral and total employment, earnings per job, and population in the counties of Texas, Oklahoma, Louisiana, and Arkansas over the period 2000-2010. Measuring resources as the change in cubic feet of natural gas production in a county, he finds little evidence of a resource curse effect: increased gas production was associated with increased population, increased earnings per job, and increased overall and mining sector employment, with each additional mining job estimated to create 1.4 additional non-mining jobs. The positive multiplier effect of mining sector jobs on non-mining employment indicates that increased gas production did not contribute to increased resource dependence in the region. Weber used a spatial Durbin model (Anselin 1988) to test for spatial spillover effects of gas production on neighboring counties but found that spatial effects were insignificant.

Finally, Haggerty et al. (2014) analyze the effects of oil and gas specialization on per capita income growth and other socioeconomic variables in the counties of Colorado, Montana, New Mexico, North Dakota, Utah, and Wyoming over the period 1980-2011. Their resource variables were a “boom” variable, defined as the average percent of county income from oil and gas during 1980, 1981, and 1982; and a “duration” variable, calculated as the number of years from 1980-2011 in which income from oil and gas exceeded the average level for all study counties. They find a significant effect of the interaction term between boom and duration variables on per capita income growth, with positive effects of the boom variable decreasing with duration. This suggests that a booming resource sector can be a catalyst for growth but failing to diversify beyond the resource sector may contribute to a reduction in long run performance.

This review of the literature on resource effects on economic development yields several key points. First, the effect of institutions and institutional quality plays a prominent role in determining the outcomes of resource-based development. While there is a lack of consensus regarding whether resource wealth adversely impacts institutional quality, a near consensus exists that poor quality, “grabber-friendly” institutions reduce the likelihood of beneficial resource-based development outcomes. Second, the commonly used measure of resources employed in the literature is likely endogenous to underlying economic policies and institutions, making it a problematic variable to use in income growth or level regressions. Third, empirical estimates of resource effects on income growth are sensitive to the time period analyzed. Potential remedies for this concern include controlling for the growth rate of the resource sector or using levels rather than growth rates as the dependent variable in regression equations.

PUBLIC LANDS AND OIL AND GAS RESOURCES IN THE INTERMOUNTAIN WEST

Today's pattern of land ownership in the western U.S. is a reflection of the region's cultural and economic history and its climatic and topographic characteristics. During the period of Euro-American settlement of the west, U.S. Government policy promoted land disposal to private ownership in order to accelerate settlement and development. Due to the aridity and rugged topography of the region settlements were largely constrained to valley lands with arable soils and nearby reserves of reliable water, usually in the form of mountain snowpack. Miners and prospectors took advantage of the provisions of the General Mining Act of 1872, which promoted the private ownership and development of mining resources, to claim ownership of lands with proven mineral deposits (Souder and Fairfax, 1996), and railroads were granted huge swaths of land to facilitate the development of a trans-continental transportation system to link markets in the east and west (Gates, 1968). Conquered indigenous peoples were corralled onto reservations comprised of lands that were of little appeal for white settlers or prospectors. Remaining lands – often mountainous, arid, or remote – were left in the public domain and relegated to federal ownership. Under the provisions of the General Land Ordinance of 1785, western lands were surveyed using a rectangular grid to delineate 36-square-mile "townships" which were further subdivided into numbered one square mile "sections." At statehood, the federal government granted two sections per township to each state added between 1849 and 1896 (Nevada, Colorado, Montana, Idaho, and Wyoming) and four sections per township to states added after 1896 (Utah, Arizona, and New Mexico) as state trust lands to be used to fund state K-12 education systems, creating a checkerboard pattern of state land ownership that persists in the west today. Where the allotted sections were already claimed by settlers or reserved for national forests or Indian reservations, states could select "in lieu" lands which were generally larger blocks of contiguous lands, often on the boundaries of national forests. States were also granted other ‘block’ grants for the support of other public institutions such as public universities and state capitols (Souder and Fairfax, 1996). State trust lands are held in a legal status similar to a private charitable trust, such that the states are required to protect the body of the trust from diminishment while generating sustained income to support K-12 schools (Woodgerd and McCarthy, 1982).

As noted above, the General Mining Act of 1872 encouraged private ownership of mineral-rich lands, including hydrocarbons such as coal, oil, and natural gas. Under the law, proof of the existence of minerals had to be provided in order to stake a claim to land ownership. Proof of the existence of oil and gas was difficult to provide due to the expensive and time-consuming drilling that had to be performed (Daintith, 2010, p. 209). Hence, when rumors of oil prospecting arose, “there converged on the scene countless “professional” entrymen” (Swenson, 1968, p. 732) interested in claiming the productive lands. Since subsurface oil and gas reserves often extend across surface ownership boundaries, drillers had an incentive to extract as much oil and gas as possible as quickly as possible, before another party did the same. In this way limited surface claims could effectively diminish the supply of oil and gas below large tracts of land. Eventually concern over securing a supply of oil for the U.S. Navy, which was transitioning from coal to oil fueling, prompted the passage of the Mineral Leasing Act of 1920. This act removed oil and gas from the minerals included in the General Mining Act, and applied to all lands belonging to the federal government which had not been privately owned (Daintith, 2010, p. 225; Nelson, 1982). The federal policy towards these “soft” minerals would be one of retention and leasing, not disposition (Stevens, 1985).

With the closing of the frontier in the late 19th century, the role of the federal government as land manager evolved from a focus on land disposal to a new mandate to manage for “multiple use.” Under the multiple use mandate, federal managers are charged with balancing the competing interests of preservation, resource production, grazing, and public access. Observers have noted that balancing such divergent interests is something of an impossible mandate which contributes to a lack of clarity on expected federal land management decisions (Stevens, 1985). Today, actions on federal lands require compliance with the 1970 National Environmental Policy Act (NEPA), a time and resource intensive review of potential impacts on natural, cultural and economic factors. The states of the region, with the exception of Montana, do not require an analogous environmental review process.

Environmental regulations are not the only costs faced by producers seeking to lease land for oil and gas production. Lessees also pay a rental fee, which is the amount of money per acre per year to hold the lease, a bonus payment based on the potential productivity of the leased area, and a royalty, which is a percentage of the production which the lessee must pay to the mineral owner (Woodgerd and McCarthy, 1982). These royalties make up one of the largest sources of non-tax income for federal and state governments (U.S. Government Accountability Office, 2010). The royalty rates on oil and gas production differ by land ownership, with state royalties higher than the federal rate of 12.5%, a level set by and unchanged since the passage of the Mineral Leasing Act of 1920. In contrast, the royalty rate for oil and gas production on state lands in Colorado, Montana, Utah, and Wyoming is 16.67%; in New Mexico it is 18.75% (Center for Western Priorities, 2015). The higher royalty rates on state lands reflect the states' revenue-maximizing mandate but are also a disincentive to producers since state lands are in competition with federal and private lands for the attention of potential oil and gas producers. In sum, with respect to the oil and gas leasing and permitting process, federal lands have higher regulatory barriers (e.g. NEPA) but lower royalty rates, while state lands have generally lower regulatory barriers (e.g. no NEPA) but higher royalty rates.

EMPIRICAL MODELING AND DATA

4.1 Empirical modeling

An area of inquiry on the role of institutions that has received little attention in the literature is the effect of the type of land ownership associated with areas of resource abundance. For example, differences between federal and state institutional mandates regarding land use and resource development in the western states may have significant effects on local economic outcomes. To the best of my knowledge, only two studies have noted the potential relevance of institutional land ownerships to resource-based development outcomes, although neither explored the issue in any detail. First, Haggerty et al. (2014) noted that public versus private ownership of oil and gas resources may have an effect on local socioeconomic outcomes due to the potential for private landowners to collect oil and gas royalties. To control for this, they include among their predictors a variable measuring the percent of oil and gas basin land under private ownership. However, they use a principal components analysis (PCA) to collapse this and other variables into a smaller number of orthogonal 'components' which describe most of the variance in the original predictors. Since the use of PCA hinders the direct interpretation of the effects of the original variables, they do not discuss the effect of the private land ownership variable. Second, Weber (2012) included a variable indicating whether a county had greater than 30% federal land ownership as a robustness check of his results. He reported that the federal ownership indicator did not change his results, and did not report the details of its inclusion in his regressions.

To contribute to this gap in the literature, this study estimates the effects of federal, state, and private ownerships of oil and gas resources in the counties of eight western states: Arizona, Colorado, Idaho, Montana, New Mexico, Nevada, Utah, and Wyoming. Recognizing the endogeneity concerns of measuring resources as a ratio to the magnitude of other activities in the economy, oil and gas endowment is measured as the percent overlap of a county with an oil and gas basin (Fig. 3); this measure of resource abundance does not change over time. GIS data on land ownerships in the region (Fig. 4) is then used to disaggregate this overall resource abundance measure to reflect institutional land ownerships associated with federal, state, and private entities.

As noted in the literature review, when considering the role of institutions in economic development, an important distinction exists between short term policy effects as opposed to the influence of 'deep and durable' institutional characteristics of a society (Brunnschweiller and Bulte, 2008). Noting that institutions can be considered the cumulative outcomes of past policy actions, Rodrik et al. (2004) suggest that institutions can be appropriately modelled as determinants of income levels, whereas policy effects are more appropriately estimated using growth equations. Following this line of reasoning and the approaches of Alexeev and Conrad (2009) and Michaels (2010), my main modeling specification uses income levels as the dependent variable:

$$Y_{i,t} = \beta_0 + \sum \beta_i X_i + \delta_1 OG\ PCT_i + \varepsilon_i \tag{5}$$

where $Y_{i,t}$ represents the natural log of per capita salary and wage income in county *i* in year *t*, $OG\ PCT_i$ is the percent of county land that overlaps an oil and gas field, and X_i is a set of control variables including state fixed effects. Resource effects on salary and wage levels are assessed at four times: 1990, 2000, 2007, and 2010. The 1990 and to a lesser extent the 2000 levels capture conditions before the natural gas boom in the region while the 2007 and 2010 levels reflect the tremendous increase in production associated with the oil and gas boom period. Although 2007 and 2010 are only separated by three years, both dates are used in order to control for effects of the Great Recession which began in December 2007.

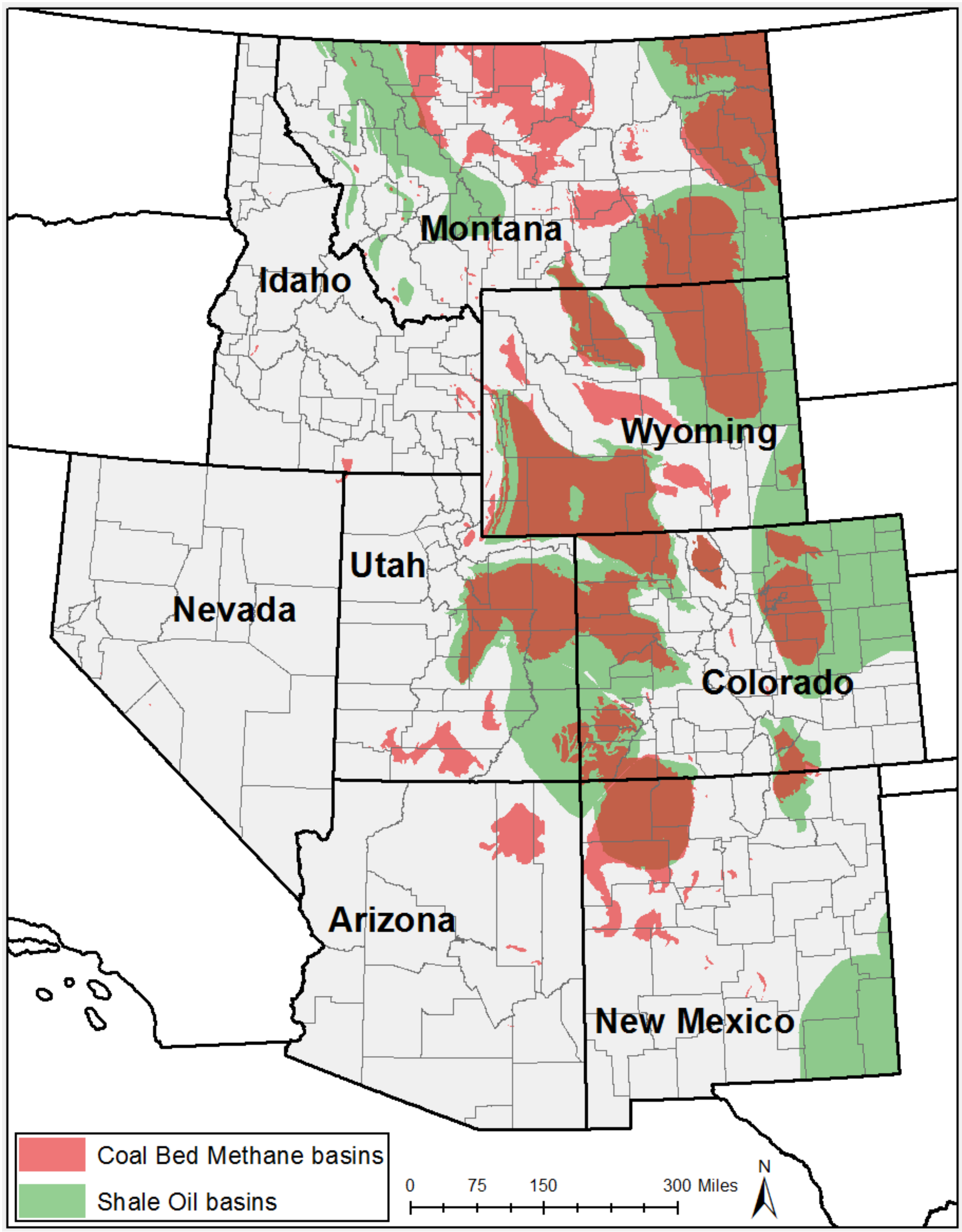

Fig. 3. Oil and gas basins in the eight states of the Intermountain West.

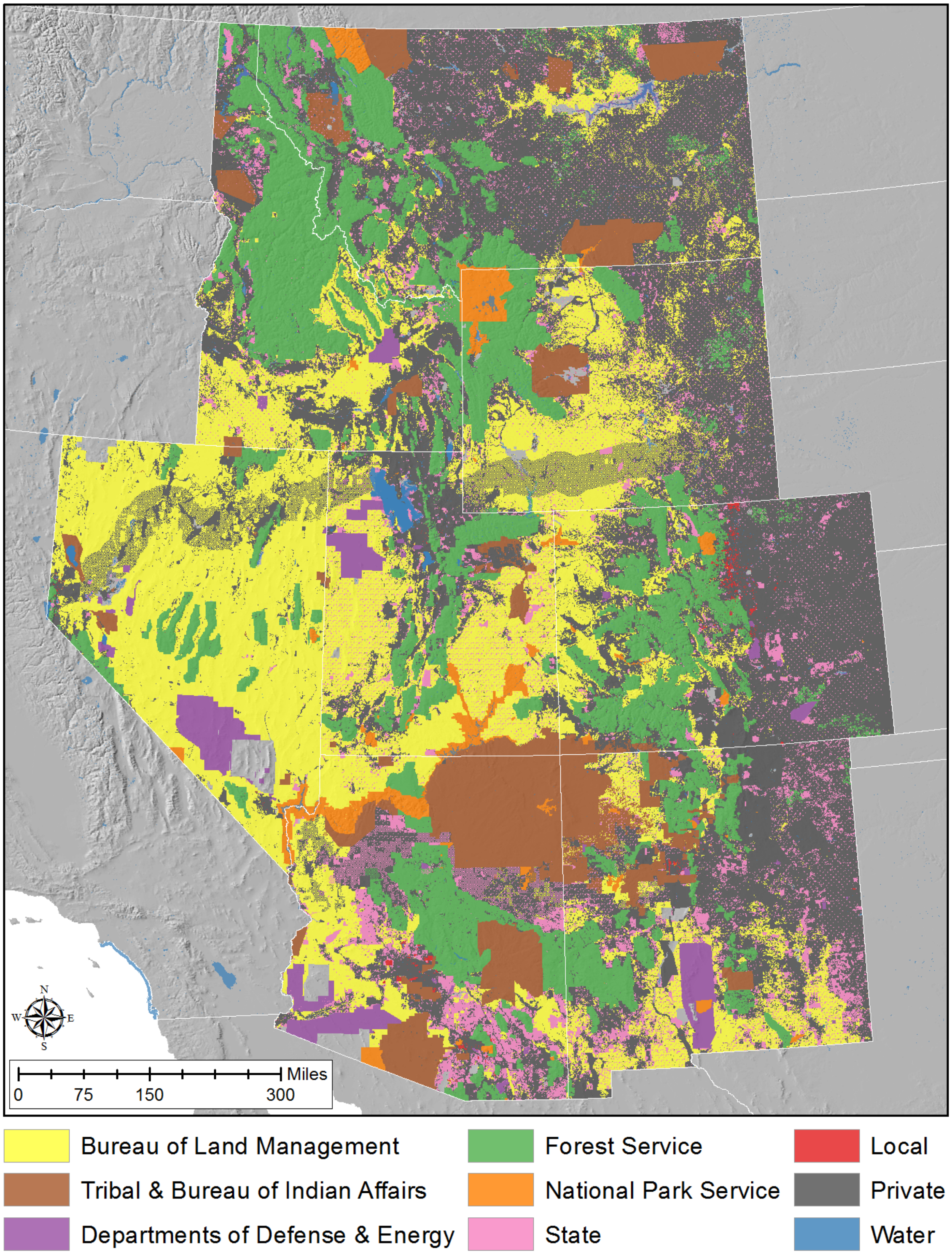

Fig. 4. Land ownership in the study area.

Equation 5 assesses the long term effect of oil and gas abundance on per capita salary and wage incomes. The use of levels instead of growth rates allows the entire arc of resource development – from discovery to production to (as applicable) eventual depletion – to be reflected in the parameter estimate on the resource variable. After assessing the overall effect of oil and gas abundance on salary and wag levels, institutional effects are estimated by dropping $OG\ PCT_i$ and replacing it with variables measuring the proportional federal, state, and private ownerships of oil and gas lands in county *i*.

The level regressions are intended to provide insight into the long-term impact of oil and gas abundance on county wage levels. Since resource abundance can have a significant effect on the historical development of a county's economic structure (Michaels, 2010), variables which measure a county's economic structure – such as dependence on mining, manufacturing, or service industries – are potentially endogenous to the influence of resource abundance and are not used in the level regressions.

To accommodate the more common use of growth regressions in the resource curse literature, I also estimate growth regressions by using the annual growth in per capita salary and wage income over the periods 1990-2000, 1990-2007, 1990-2010, 2000-2007 and 2000-2010 as the dependent variable in Eq. 5, and add the natural log of initial per capita salary and wage income as a control variable. In the growth regressions, exogenous demand shocks to the local labor market are controlled for using the Bartik Instrument (Bartik, 1991). This variable averages national employment growth across the farm, private non-farm, and government sectors using local sectoral employment shares as weights:

$$G_{mt-x,t} = \left[\sum_j w_{jmt-x} * \frac{E_{jt} - E_{jt-x}}{E_{jt-x}}\right] / x \qquad (6)$$

where $G_{mt-x,t}$ represents expected annual employment growth in county *m* from time *t-x* to time *t* due to exogenous labor demand shocks; w_{jmt-x} represents the proportion of total jobs in county *m* in industry *j* at time *t-x*, and E_{jt} and E_{jt-x} represent national employment levels in industry *j* at times *t* and *t-x*, respectively. Dividing the RHS term by the number of years, *x*, renders an estimate of the expected annual employment growth rate in county *m* due to exogenous labor demand shocks. Results from growth models will be more indicative of the short run influence of ownership types on performance during the recent natural gas boom in the region.

The robustness of the institutional effects in level and growth regressions is checked using an alternative model specification:

$$Y_{i,t} = \beta_0 + \sum \beta_i X_i + \delta_1 OG\ PCT_i + \delta_2 FED\ ALL_i + \delta_3 FED\ OG_i + \delta_4 STATE\ ALL_i + \delta_5 STATE\ OG_i + \varepsilon_i \quad (7)$$

where FED ALL and STATE ALL measure the total proportion of county land owned by the Forest Service and BLM, or by state agencies, respectively. In this specification, the δ_1 parameter measures the wage effect of overall oil and gas abundance, including the effect of those areas captured by the FED OG and STATE OG variables. The δ_2 and δ_4 parameters measure the effects of overall federal and state land ownerships, including both oil and gas abundant lands and other public lands. Finally, the δ_3 and δ_5 parameters measure the additional wage effects federal and state ownerships associated with areas of oil and gas abundance, respectively. Thus, the marginal wage effect of federal oil and gas ownership is captured by $\delta_1 + \delta_2 + \delta_3$, and the marginal effect of state oil and gas ownership is captured by $\delta_1 + \delta_4 + \delta_5$. The significance of the statistical difference between the FED OG effect and the STATE OG effect is assessed by netting out the δ_1 parameter and using and F-test on the equivalence of $\delta_2 + \delta_3$ (the FED OG effect) versus $\delta_4 + \delta_5$ (the STATE OG effect), which follow an F-distribution.

In the other models with institutional ownership variables, two-tailed t-tests are used to test for the equivalence of the parameter estimates on FED OG and STATE OG. In these tests, the null hypothesis is that the effects of the two variables are equivalent, and the alternative hypothesis is that they are not equivalent. The *t* statistic provides a measure of whether the difference in the parameter estimates on FED OG and STATE OG is sufficiently large to reject the null hypothesis:

$$t = \left(\hat{\delta}_1 - \hat{\delta}_2\right)/se\left(\hat{\delta}_1 - \hat{\delta}_2\right) \qquad (8)$$

where $\hat{\delta}_1$ and $\hat{\delta}_2$ are the parameter estimates on STATE OG and FED OG, and the denominator measures the standard error of the difference in the parameter estimates. The *t* statistic is then compared to critical values of the student's t distribution based on the degrees of freedom in the regression model to determine the statistical significance of the difference in the parameter estimates.

4.2 Data

4.2.1 Economic variables

Data on salary and wage income was acquired from the Bureau of Economic Analysis (BEA) and converted to constant 2012 dollars. Salary and wage income is used as the dependent variable because it excludes sources of unearned income such as dividends, social security payments, unemployment benefits and other government transfer payments. It is thus more reflective of the quality of the local labor market and is more closely linked to local resource abundance than would be total income. Salary and wage income levels were measured as the natural log of per capita salary and wage income in 1990, 2000, 2007, and 2010. Annual growth rates in salary and wage income over the periods 1990-2000, 1990-2007, 1990-2010, 2000-2007, and 2000-2010 were measured as the log of the ratio of end-of-period per capita salary and wage levels to initial per capita levels, multiplied by 100 and divided by the number of years. The Bartik Instruments used in the growth regressions were calculated using employment data on total jobs from the BEA. For the growth periods 2000-2007 and 2000-2010, the Bartik Instruments were calculated using 2001 as the base year so that definitions of farm, private non-farm, and government sectors consistently used North American Industry Classification System (NAICS) classifications.

The eight states of the study area are comprised of 281 counties. Broomfield County, Colorado was created out of portions of 4 other counties (Adams, Boulder, Jefferson, and Weld) in 2001. Growth rates could not be calculated for these five counties and they were not included in the analysis. Counties with large urban areas, identified by the presence of a Census-designated “central city”, are also excluded from the analysis. These regions have more diverse economies than rural counties and are likely to have higher wage levels and growth rates due to economies of scale (Dixit, 1973) and agglomeration effects (Krugman, 1991). Dropping the 26 counties that meet this criteria renders the final sample of 250 counties.

4.2.2 Oil and gas and land ownership variables

Resource endowment is measured as the percent of county land that overlays a coalbed methane or shale oil basin, as mapped by the United States Geological Survey (Fig. 4). There is significant spatial correlation in the location of the shale and coalbed methane basins, and often both oil and natural gas can be produced from the same geological strata. For clarity and simplicity, all shale basins and coalbed methane basins are referred to as oil and gas basins. It should be noted that the location of coal fields were not used in this study but were largely

Table 1. Data, sources and descriptions.

Dependent variables	**Description**	**Source**
WAGE 1990	Per capita salary and wage income in 1990 ($2012)	BEA
WAGE 2000	Per capita salary and wage income in 2000 ($2012)	BEA
WAGE 2007	Per capita salary and wage income in 2007 ($2012)	BEA
WAGE 2010	Per capita salary and wage income in 2010 ($2012)	BEA
WAGE 1990-2000	Average annual percent growth in salary and wage income from 1990 to 2000. Measured as the natural log of the ratio of per capita wage and salary income in 1990 to per capita wage and salary income in 2000, times 100 and divided by the number of years in the time period, 10.	BEA
WAGE 1990-2007	1990-2007 version of WAGE 1990-2000	BEA
WAGE 1990-2010	1990-2010 version of WAGE 1990-2000	BEA
WAGE 2000-2007	2000-2007 version of WAGE 1990-2000	BEA
WAGE 2000-2010	2000-2010 version of WAGE 1990-2000	BEA
Independent variables	**Description**	**Source**
OG PCT	Percent of county land area that overlays oil and gas basins	Energy Information Administration (EIA)
FED OG, STATE OG, PRIV OG	Percent of county land area that overlays oil and gas basins and is administered by federal institutions (US Forest Service and BLM), state agencies, or private parties, respectively.	EIA, USGS, PADUS
FED ALL, STATE ALL	Percent of county land area that is administered by federal institutions (US Forest Service and BLM), or state agencies, respectively	
COLLEGE	Percent of county population with a 4 year college degree	U.S. Census
OLD	Percent of county population that is at least 65 years old	U.S. Census
BARTIK 1990-2000	Bartik Instrument for time period 1990-2000: provides a measure of expected annual employment growth due to exogenous labor demand shocks. Measured as the weighted average of national growth rates in the farm, private non-farm, and government sectors, with weights equal to the proportion of county employment in those three sectors.	BEA
BARTIK 1990-2007	1990-2007 version of BARTIK 1990-2000	BEA
BARTIK 1990-2010	1990-2010 version of BARTIK 1990-2000	BEA
BARTIK 2001-2007	2000-2007 version of BARTIK 1990-2000	BEA
BARTIK 2001-2010	2000-2010 version of BARTIK 1990-2000	BEA

spatially coincident with coalbed methane and shale basins. The oil and gas basin data is treated it as a sufficiently exogenous measure of resource abundance as it was produced by federal agencies and its quality is likely independent of local issues. Assessments of economically recoverable reserves of oil and gas are not used to define resource abundance because reserves are a fluid classification which is sensitive to the certainty of geological knowledge and economic and technological conditions (Howe, 1979; Fig. 5). That is, increased geologic knowledge and

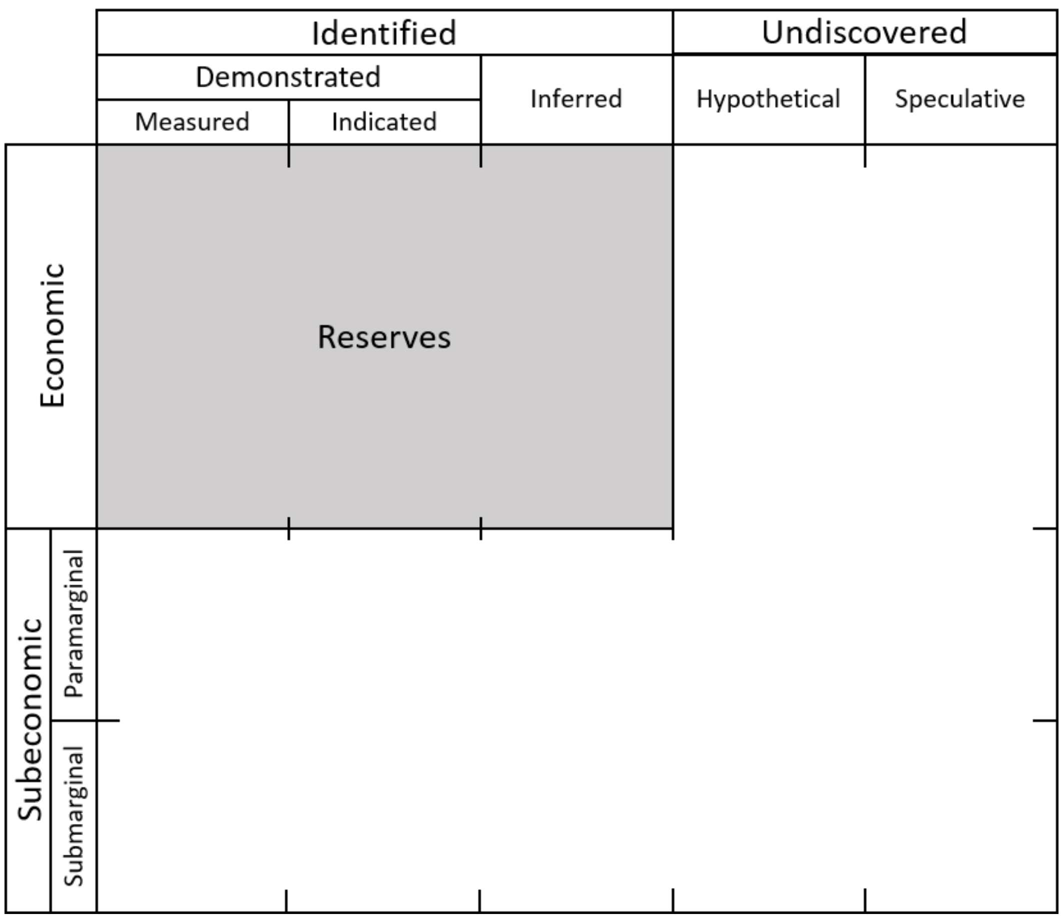

Fig. 5. Classification of resource reserves by economic feasibility and certainty of geologic knowledge. Source: Howe (1979).

improved economic circumstances act to move resources out of the “undiscovered” or “subeconomic” categories of Fig. 5 towards the “reserves” area (Howe 1979).

Land ownership information was acquired from the USGS’s Protected Area Database of the United States (PADUS; USGS, 2012), a GIS database which maps land ownerships nationwide (Fig. 4). The federal ownership variables used in the level and growth regressions were defined based on lands owned by the Forest Service or the BLM. Lands owned by other federal agencies such as the National Park Service, Fish and Wildlife Service, or Departments of Defense and Energy were excluded because they are generally less available for oil and gas development, and comprise a relatively small portion of lands in the sample of counties (4.5%) compared to the BLM (26.8%) and Forest Service (18.4%). Lands not included in PADUS were assigned private land ownership after comparison with another dataset of land ownership in the region (SAGEMAP) indicated that the overwhelming majority (>97%) of lands not included in the PADUS database are private lands. State and private lands comprised 7.2% and 35.5% of the land area of the sample of counties, respectively. All water areas were excluded from oil and gas and institutional ownership variables. The variables FED OG, STATE OG, and PRIV OG were defined as the percent of county oil and gas lands administered by the federal, state, and private categories, respectively. Summary statistics for response, resource, and land ownership variables are presented in Table 2.

Due to spatial autocorrelation in the oil and gas basin and land ownership data, institutional variables are also likely to be correlated, giving rise to concern about multicollinearity in the regression models. Three techniques were used to assess this concern. First, correlations among all of the institutional variables were examined (Table 3). The OG PCT variable is highly correlated with the institutional oil and gas ownership variables. This may be a concern in the alternative institutional model specification (Eq. 7). Otherwise, only the PRIV OG and STATE OG variables (r = 0.64) and the FED ALL and PRIV OG variables (r = -0.52) have

Table 2. Descriptive statistics: response, resource, and land ownership variables.

Response variable	Mean	SD	Minimum	Maximum
WAGE 1990	12360	14658	3436	166725
WAGE 2000	13721	14946	4717	186704
WAGE 2007	16735	21941	5417	246599
WAGE 2010	12066	15568	3785	194610
WAGE 1990-2000	1.209	2.628	-0.005	26.560
WAGE 1990-2007	1.700	1.830	-0.024	15.148
WAGE 1990-2010	-0.157	1.577	-0.007	11.516
WAGE 2000-2007	2.400	2.711	-0.006	15.698
WAGE 2000-2010	-1.523	2.042	-0.019	8.429
Resource or land ownership variable	Mean	SD	Minimum	Maximum
OG PCT	32.9	39.0	0	100
FED OG	9.1	15.9	0	68.5
STATE OG	2.3	4.0	0	34.1
PRIV OG	18.3	27.7	0	96.1
FED ALL	40.4	27.7	0	97.5
STATE ALL	7.0	5.8	0	34.9

Monetary amounts are in 2012 dollars.

Table 3. Correlation among resource and land ownership variables.

	FED OG	STATE OG	PRIV OG	FED ALL	STATE ALL
OG PCT	0.59	0.72	0.84	-0.35	0.03
FED OG		0.37	0.16	0.25	-0.05
STATE OG			0.64	-0.3	0.38
PRIV OG				-0.52	0.06
FED ALL					-0.3

correlation coefficients above 0.4, however the correlation between FED ALL and PRIV OG is not a concern because these two variables are not included together as regressors in any model.

The second collinearity assessment used was an examination of the variance inflation factors (VIF; Davis et al., 1986) for the variables in each model. The VIF technique iteratively regresses each independent variable (IV) in a given regression model on all of the other IVs in the model. If most of the variance of a particular IV can be explained by a linear combination of the other IVs, then multicollinearity may be problem with respect to that IV. The VIF score is calculated as VIF = $1/(1 - R^2)$, where the R^2 value is taken from the regression of the IV in question on all of the other IVs in the model. If the R^2 value is high, the VIF score will be high, indicating collinearity. As a rule of thumb, any VIF value above 10 is cause for concern (Kutner et al., 2004).

The third multicollinearity assessment technique used was the condition index assessment (Belsley et al., 1980). For a given regression model, this technique decomposes the matrix of continuous RHS variables into orthogonal ‘components’ created as linear combinations of the RHS variables, such that the first component explains the most variance in the data, the second component explains the next largest variance, and so on. The variance of each component is called an eigenvalue, and the condition index (CI) score for each component is a simple function of the eigenvalues: $CI_i = \sqrt{\lambda_{max}/\lambda_i}$ where λ is the symbol for an eigenvalue. The largest eigenvalue indicates how much of the total variation in the RHS variables can be explained by a single linear combination of the variables. A very large eigenvalue on the first component would therefore be an indication of possible multicollinearity in the data. While the CI score on the first component will always be equal to one, CI scores on subsequent components will increase proportional to the diminishing amounts of variation in the RHS matrix they explain. A high CI score is therefore indicative of a component which explains very little of the overall variation in the RHS matrix. By examining the proportional contribution of each independent variable to components with high CI scores, the CI technique allows the identification of those variables which, compared to the other RHS variables, are contributing little independent variation in the data and are therefore primary sources of multicollinearity in the model. Belsley et al. (1980) suggest that CI scores greater than 30 are indicative of potentially problematic multicollinearity.

4.2.3 Demographic control variables

County characteristics that may affect growth are controlled for by including variables describing county variation in human capital and demographic characteristics (Table 4). Human capital was measured by the percent of the population with at least a four year college education (COLLEGE). Three variables reflecting demographic characteristics were assessed: the proportion of the population that is under 19 years old (YOUNG), the proportion that is over 65 years old (OLD), and the proportion that is white (WHITE). Bloom et al. (2000) argue that areas with high proportions of young and old people tend to have lower per capita income because young and old people tend to be less productive and are often excluded from the labor force. Similarly, Malmberg (1994) argues that the lower rate of saving among young and old people will tend to depress per capita income levels. The WHITE variable reflects social homogeneity, which may increase productivity through its impact on trust (Zak and Knack, 2001). Values of these covariates for years 1990, 2000 and 2010 were taken from the 2000 and 2010 U.S. censuses. Values for 2007 were taken from the American Community Survey which averages values of the time period 2005 – 2009.

Table 4. Descriptive statistics: control variables.

Variable	Mean	SD	Minimum	Maximum
COLLEGE 1990	10.1	4.9	3.8	37.3
COLLEGE 2000	19.3	9	8.7	60.5
COLLEGE 2007	21	9.4	7.6	63.4
COLLEGE 2010	21.4	9.6	5.3	64
OLD 1990	13.4	4.6	2.3	31.5
OLD 2000	13.7	4.5	3	28.3
OLD 2007	15.2	5.4	4.1	36.5
OLD 2010	16	5	5.6	32.6
BARTIK 1990-2000	1.619	0.288	0.6325	2.118
BARTIK 1990-2007	1.380	0.345	0.1485	1.922
BARTIK 1990-2010	0.978	0.256	0.0473	1.347
BARTIK 2001-2007	1.049	0.374	-0.088	1.586
BARTIK 2001-2010	0.326	0.197	-0.3027	0.6245

Preliminary modeling indicated that the WHITE and YOUNG variables did not have a significant association with wage levels or growth rates. Additionally, CI scores indicated that the WHITE and YOUNG variables were sources of multicollinearity in the data due to their significant contribution to components with CI scores greater than 30 (Belsley et al., 1980). Based on these diagnostics, WHITE and YOUNG were dropped from all models.

RESULTS

Before turning to the results of the level and growth regressions, let us consider the general characteristics of the relationship between oil and gas abundance and wages by examining average county wage levels and growth rates by quintiles of OG PCT values (Table 5). In terms of wage levels, there appears to be a positive association with oil and gas abundance only for relatively low levels of oil and gas abundance. While wage levels in the counties of the second quintile exceed those in counties with no oil and gas abundance, wage levels in quintiles three through five exhibit a generally negative trajectory and are usually lower than wage levels in counties with no oil and gas resources. This simple assessment suggests that in small amounts resource abundance may be a blessing but larger endowments of resources may have detrimental effects.

In contrast, the association of oil and gas abundance quintiles with wage growth rates is just the opposite. Compared to counties with no oil and gas resources, those in the second quintile suffer from lower wage growth while well-endowed counties in the third through fifth quintiles enjoy successively higher growth rates that usually exceed those observed in counties with no oil and gas resources.

Table 5. Average wage levels and growth rates by oil and gas abundance quintiles.

OG PCT quintile	1	2	3	4	5
Value range	[0,0]	(0,8.48]	(8.48,50.9]	(50.9,90.3]	(90.3,100]
No. of counties	84	42	41	41	42
WAGE 1990	13202	14046	12092	10743	10827
WAGE 2000	14179	14720	14140	12130	12950
WAGE 2007	17391	17570	16131	15752	16137
WAGE 2010	12871	11960	11217	11352	12088
WAGE 1990 – 2000	1.121	0.65	1.503	1.17	1.696
WAGE 1990 – 2007	1.532	1.187	1.766	1.957	2.232
WAGE 1990 – 2010	-0.337	-0.663	-0.207	0.147	0.461
WAGE 2000 – 2007	2.12	1.953	2.143	3.08	2.997
WAGE 2000 – 2010	-1.795	-1.977	-1.916	-0.876	-0.775

Notably, the distribution of oil and gas resources is not normally distributed among the counties of the region. Instead, oil and gas is distributed in a roughly bimodal distribution across the sample counties (Fig. 6), indicating that there is limited middle ground in terms of oil and gas endowment: a county generally either has a lot of oil and gas lands, or very little. For the 84

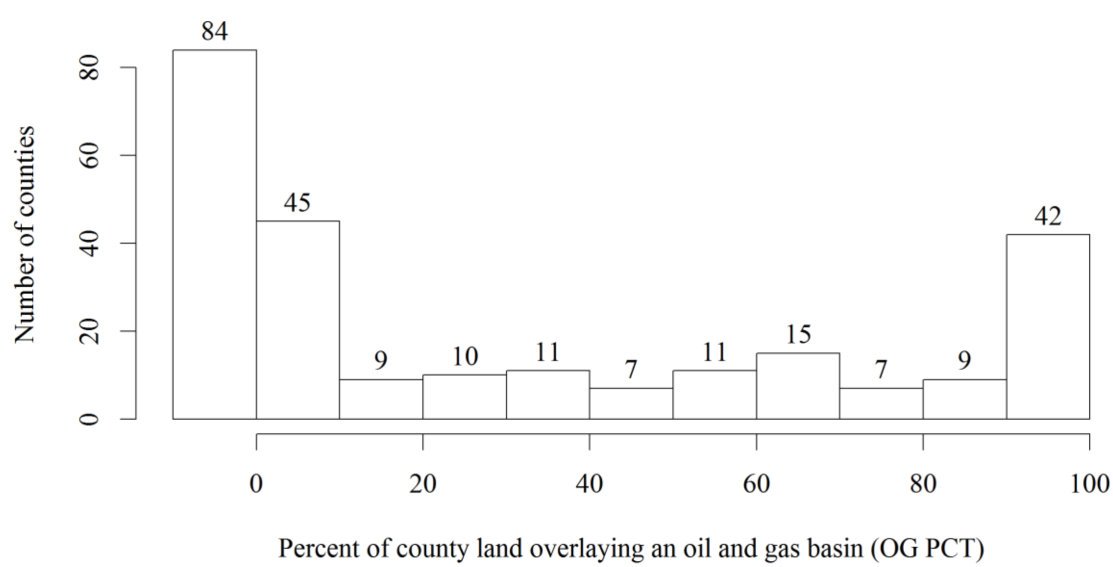

Fig. 6. Distribution of oil and gas abundance across 250 counties in the Intermountain West.

counties that do not overlay an oil and gas basin, the consequences of oil and gas development will likely be of limited practical importance.

5.1 Level regression results

The effects of overall oil and gas abundance on per capita wage levels in 1990, 2000, 2007, and 2010 are presented in Table 6. The coefficient on the percent overlap of county land with an oil and gas basin, OG PCT, is positive and significant at a 5% level in 1990 and at a 1% in level in 2000, 2007, and 2010. The estimated marginal effect on wage levels of each additional percent of county land overlaying an oil and gas basin ranges from 0.17% in 1990 to 0.26% in 2007, at the peak of oil and gas prices. The presence of positive and significant effects of OG PCT in 1990, before the boom in prices and production (Fig. 1), suggests that there are durable beneficial effects associated with oil and gas abundance which are not dependent on a booming resource sector.

An F-test for the equality of state-specific fixed effects strongly rejects the null hypothesis in all time periods, suggesting that state-level policies significantly affect county wage levels. Both of the demographic control variables had significant effects in expected directions. The adjusted R squared values range from 0.256 to 0.325, indicating that the models do a reasonable job of explaining the variation in county wage levels. Taken together, these results indicate well specified models and suggest that oil and gas abundance has been a blessing for wage levels in the counties of the Intermountain West, not a curse.

In all level regressions (Tables 6, 7, and 8), VIF scores for all variables were less than 6 and component CI scores were never larger than 17, indicating that these models did not suffer from severe multicollinearity problems.

Table 6. OLS results: Level effects of oil and gas abundance on county salaries and wages in 1990, 2000, 2007, and 2010.

	Dependent variable:			
	ln(WAGE 1990)	ln(WAGE 2000)	ln(WAGE 2007)	ln(WAGE 2010)
	(1)	(2)	(3)	(4)
Constant	9.4467***	9.2573***	9.3680***	9.2510***
	(0.1594)	(0.1573)	(0.1383)	(0.1567)
OG PCT	0.0017**	0.0019***	0.0026***	0.0024***
	(0.0007)	(0.0007)	(0.0007)	(0.0007)
COLLEGE	0.0258***	0.0199***	0.0193***	0.0142***
	(0.0085)	(0.0045)	(0.0039)	(0.0040)
YOUNG	-0.0298***	-0.0182***	-0.0160***	-0.0243***
	(0.0058)	(0.0058)	(0.0053)	(0.0053)
F statistic: State FEs	8.421***	7.373***	6.442***	5.956***
Observations	250	250	250	250
Adjusted R^2	0.3247	0.3156	0.2845	0.2559
F Statistic (df = 12; 237)	12.9714***	12.4820***	10.9014***	9.5612***

Heteroskedasticity-consistent standard errors are in parentheses. *p<0.1; **p<0.05; ***p<0.01

When oil and gas abundance is disaggregated by institutional ownership type, positive and significant effects on county wage levels are estimated for both federal and state ownerships (Table 7). The results are particularly striking for the STATE OG variable, which has large effects on wage levels in all years. For every additional percent of county land owned by the state and overlaying an oil and gas basin, county wage levels were 1% higher in 1990; 1.6% higher in 2000; 1.4% higher in 2007 and 1.5% higher in 2010. In 1990 the STATE OG effects were significant at a 5% level; in 2000, 2007, and 2010 the effects were significant at a 1% level. In contrast, the parameter estimates on the FED OG variable, while positive at all time periods and significant in three of the four, are of a magnitude one-third to one-ninth the size of the STATE OG effect. The difference in magnitude between the FED OG and STATE OG effects is significant at a 1% level in the 2000 and 2010 regressions; the differences are not quite significant in the 1990 and 2007 regressions (t statistic p-values of 0.161 and 0.106, respectively). These results show that state ownership of oil and gas resources consistently produces greater positive effects on county wage levels than federal ownership. The coefficient on private oil and gas ownership, PRIV OG, is insignificant in all time periods, and its positive parameter estimate is usually an order of magnitude smaller than the FED OG parameter estimate. This is a somewhat surprising result given the consistently positive results of other resource variables. The effects of state dummy variables and demographic covariates remain largely unchanged from the previous level regression on overall oil and gas abundance.

Table 7. OLS results: Level effects of institutional ownerships of oil and gas lands on county salaries and wages in 1990, 2000, 2007, and 2010.

	Dependent variable:			
	ln(WAGE 1990)	ln(WAGE 2000)	ln(WAGE 2007)	ln(WAGE 2010)
	(1)	(2)	(3)	(4)
Constant	9.4548***	9.2691***	9.3897***	9.2667***
	(0.1595)	(0.1566)	(0.1382)	(0.1549)
FED OG	0.0032**	0.0019	0.0043**	0.0030*
	(0.0015)	(0.0014)	(0.0018)	(0.0017)
STATE OG	0.0099**	0.0163***	0.0142***	0.0145***
	(0.0043)	(0.0042)	(0.0050)	(0.0045)
PRIV OG	0.0002	0.0001	0.0005	0.0008
	(0.0012)	(0.0011)	(0.0012)	(0.0013)
COLLEGE	0.0247***	0.0197***	0.0186***	0.0138***
	(0.0087)	(0.0045)	(0.0039)	(0.0041)
OLD	-0.0298***	-0.0188***	-0.0166***	-0.0249***
	(0.0059)	(0.0059)	(0.0052)	(0.0053)
F statistic: State FEs	8.32***	7.064***	5.749***	5.595***
t statistic: FED OG = STATE OG	1.347	2.943***	1.629	2.145**
Observations	250	250	250	250
Adjusted R^2	0.3259	0.3174	0.2884	0.2569
F Statistic (df = 14; 235)	11.0296***	10.6493***	9.4115***	8.1719***

Heteroskedasticity-consistent standard errors are in parentheses. *p<0.1; **p<0.05; ***p<0.01

In the alternative institutional model specification (Table 8), the STATE OG variable has a positive and significant effect in three of the four time periods, and is statistically different from FED OG in two of these periods, while FED OG is not significant in any time period. The only other land ownership variable that has a significant effect on wage levels is the overall amount of

Table 8. OLS results: Level effects of institutional land ownerships on county salaries and wages in 1990, 2000, 2007, and 2010.

	Dependent variable:			
	ln(WAGE 1990)	ln(WAGE 2000)	ln(WAGE 2007)	ln(WAGE 2010)
Constant	9.3122***	9.1941***	9.3415***	9.2236***
	(0.1722)	(0.1683)	(0.1459)	(0.1634)
FED ALL	0.0028**	0.0013	0.0015	0.0014
	(0.0013)	(0.0013)	(0.0013)	(0.0014)
FED OG	-0.00004	0.0002	0.0019	0.0006
	(0.0022)	(0.0022)	(0.0025)	(0.0024)
STATE ALL	0.0028	0.0026	-0.0032	-0.0021
	(0.0063)	(0.0060)	(0.0065)	(0.0075)
STATE OG	0.0064	0.0120*	0.0152**	0.0156**
	(0.0064)	(0.0063)	(0.0073)	(0.0077)
OG PCT	0.0017	0.0012	0.0012	0.0013
	(0.0013)	(0.0012)	(0.0013)	(0.0013)
COLLEGE	0.0229**	0.0195***	0.0179***	0.0131***
	(0.0092)	(0.0046)	(0.0039)	(0.0041)
OLD	-0.0295***	-0.0190***	-0.0163***	-0.0248***
	(0.0062)	(0.0063)	(0.0055)	(0.0056)
F statistic: State FEs	7.443***	6.76***	5.439***	5.446***
F statistic: Equivalence of federal and state oil and gas effects	1.78	7.65***	2.33	5.48**
Observations	250	250	250	250
Adjusted R^2	0.3303	0.3145	0.2875	0.2540
F Statistic (df = 14; 235)	9.7737***	9.1583***	8.1779***	7.0565***

Heteroskedasticity-consistent standard errors are in parentheses. *p<0.1; **p<0.05; ***p<0.01

federal land, FED ALL, which has a positive and significant parameter estimate on 1990 wage levels. The FED ALL effects are usually larger than the FED OG effects, suggesting that federal lands with oil and gas deposits do not contribute to faster wage growth than do federal lands with no oil and gas resources. On the other hand, STATE ALL effects are much smaller than STATE OG effects in all time periods, suggesting that state lands with oil and gas deposits do contribute to faster wage growth than do state lands with no oil and gas resources. Taken together, these results provide additional support for the beneficial effect of state oil and gas ownership as well as its comparatively beneficial effect compared to federal oil and gas ownership.

5.2 Growth regression results

The parameter estimates in the growth regressions can be interpreted as expected percentage point adjustments to county wage growth rates. For example, the 0.0074 parameter estimate on the OG PCT variable in the 1990-2000 growth regressions (Table 9) suggests that a resource-rich county in which 100% of the land area overlays an oil and gas basin would experience annual wage growth 0.74 percentage points higher than an otherwise identical but resource-poor county with no oil and gas land. Turning to the rest of the results in Table 9, parameter estimates on the OG PCT variable are positive and significant in all time periods analyzed. In the 1990-2007 period annual growth rates in the hypothetical resource-rich and resource-poor counties would diverge by 0.92 percentage points; in the 1990-2010, 2000-2007, and 2000-2010 periods the growth rate divergence would be 0.80, 1.2, and 0.83 percentage points, respectively.

In comparison with average growth rates in the sample of counties, these differences represent large and quite consistent effects. For example, a 0.74 percentage point effect in the 1990-2000 period represents a 66% increase over the period mean of 1.121%; the 0.92 percentage point effect in the 1990-2007 period represents a 60% increase over the period mean of 1.532%;

and the 1.2 percentage point effect in the 2000-2007 period represents a 57% increase over the period mean of 2.12%.

The effects of the demographic covariates in the growth regressions presented in Table 9 are less consistent than they were in the level regression results. The COLLEGE variable continues to have a positive and significant effect on wages in most time periods, although in the 2000-2007 period the effect is insignificant. The negative parameter estimate on COLLEGE in

Table 9. OLS results: Effects of oil and gas abundance on annual growth rates of county salaries and wages.

	Dependent variable:				
	WAGE 1990-2000	WAGE 1990-2007	WAGE 1990-2010	WAGE 2000-2007	WAGE 2000-2010
	(1)	(2)	(3)	(4)	(5)
Constant	24.2311***	15.3636***	10.6081**	5.8195	-1.1287
	(8.1623)	(5.9518)	(5.2353)	(6.4026)	(4.9239)
ln(initial WAGE)	-2.9668***	-1.6800**	-1.3167**	-0.3848	-0.0212
	(0.9737)	(0.6904)	(0.6087)	(0.7376)	(0.5605)
OG PCT	0.0074*	0.0092***	0.0080***	0.0120**	0.0083**
	(0.0039)	(0.0030)	(0.0026)	(0.0056)	(0.0038)
BARTIK	1.5372**	0.4274	0.3075	0.0509	-0.5459
	(0.7341)	(0.4293)	(0.5272)	(0.5040)	(0.6807)
COLLEGE	0.2070***	0.1285***	0.0798***	0.0049	-0.0316*
	(0.0441)	(0.0298)	(0.0264)	(0.0242)	(0.0191)
OLD	-0.0066	-0.0069	0.0012	-0.0195	-0.0037
	(0.0384)	(0.0264)	(0.0228)	(0.0353)	(0.0288)
F statistic: State FEs	2.579**	1.818*	1.27	2.057**	3.485***
Observations	250	250	250	250	250
Adjusted R^2	0.3184	0.2196	0.1886	0.0375	0.1096
F Statistic (df = 13; 236)	10.6936***	6.8384***	5.8216***	1.8095**	3.5545***

Heteroskedasticity-consistent standard errors are in parentheses. *p<0.1; **p<0.05; ***p<0.01

the 2000-2010 period may be attributable to the onset of the Great Recession in 2008. The negative sign on the OLD variable is expected, and insignificant in all time periods. Initial wage levels are always negative and usually significant, indicating a convergence of wage levels across the sample counties. Finally, the F test for the equality of state fixed effects indicates that these variables are jointly significant only in the 2000-2007 and 2000-2010 periods, suggesting that differences in state policies had little effect on wage growth in the earlier time periods. The R-squared values are substantially lower than those of the level regressions, suggesting that the effects of resources on wages may be better estimated using levels as the response.

In the growth regressions multicollinearity is more of a concern than it was in the level regressions. While VIF scores for all variables in all growth regressions (Tables 9, 10, and 11) were less than 6, CI scores indicated that muticollinearity may be an issue. The largest CI scores in the growth regressions ranged from 70 to 89, and were associated with components mostly defined by the intercept and initial income terms. The next highest CI scores in the growth models ranged from 13 to 25 and were associated with components mostly defined by linear combinations of the BARTIK and OLD variables.

In the first institutional growth regression specification (Table 10), wage growth effects of the institutional oil and gas ownership variables are shown to be less consistent than their level effects. While the parameter estimates on the FED OG and STATE OG variables are still mostly positive, they are each only significant in one of the five time periods. The effect of state ownership is larger than that of federal ownership in four of the five time periods. During the period 1990-2000 FED OG has a negative effect while each additional unit of STATE OG is associated with a 0.0571 percentage point increase in wage growth; an almost significant difference (t statistic p-value: 0.112). Over the period 1990-2007 the marginal effect of STATE OG is almost four times that of FED OG (t statistic p-value: 0.29); in 1990-2010 the factor difference is 36 (T statistic p-value: 0.104); and in 2000-2010 the two estimates are of similar magnitude. The time period 2000-2007 is something of an anomaly in the results, with the FED OG effect much larger than the negative STATE OG effect; however, the two effects are not significantly different (T statistic p-value: 0.322). Parameter estimates for the third institutional

Table 10. OLS results: Effects of institutional ownerships of oil and gas lands on annual growth rates of county salaries and wages.

	Dependent variable:				
	WAGE 1990-2000	WAGE 1990-2007	WAGE 1990-2010	WAGE 2000-2007	WAGE 2000-2010
	(1)	(2)	(3)	(4)	(5)
Constant	24.1591***	15.5761***	10.7511**	5.8124	-0.9839
	(8.1440)	(5.9968)	(5.2570)	(6.4698)	(5.0052)
ln(initial WAGE)	-2.9606***	-1.6861**	-1.3228**	-0.3474	-0.0254
	(0.9704)	(0.6943)	(0.6102)	(0.7449)	(0.5686)
FED OG	-0.0112	0.0090	0.0011	0.0360**	0.0125
	(0.0091)	(0.0084)	(0.0066)	(0.0158)	(0.0092)
STATE OG	0.0571	0.0320	0.0398*	-0.0079	0.0138
	(0.0367)	(0.0237)	(0.0204)	(0.0585)	(0.0386)
PRIV OG	0.0068	0.0062	0.0063	0.0069	0.0067
	(0.0062)	(0.0049)	(0.0044)	(0.0094)	(0.0069)
BARTIK	1.6692**	0.4084	0.3664	-0.1877	-0.5784
	(0.7354)	(0.4343)	(0.5333)	(0.5403)	(0.7261)
COLLEGE	0.2033***	0.1238***	0.0759***	0.0017	-0.0336*
	(0.0448)	(0.0304)	(0.0267)	(0.0247)	(0.0193)
OLD	-0.0184	-0.0138	-0.0069	-0.0238	-0.0086
	(0.0374)	(0.0267)	(0.0231)	(0.0354)	(0.0289)
F statistic: State FEs	2.827***	1.335	1.238	2.001*	3.451***
t statistic: FED OG = STATE OG	1.596	0.798	1.638	0.653	0.032
Observations	250	250	250	250	250
Adjusted R^2	0.3215	0.2121	0.1845	0.0480	0.1032
F Statistic (df = 15; 234)	9.4264***	5.7869***	5.0244***	1.8964**	3.0468***

Heteroskedasticity-consistent standard errors are in parentheses. *p<0.1; **p<0.05; ***p<0.01

ownership category, private ownership, remain consistently small and insignificant in all regressions.

In the alternative institutional model specification (Table 11), parameter estimates on the STATE OG and FED OG variables are positive in all time periods. Although the effects are statistically insignificant, this suggests that public lands with oil and gas deposits contribute to faster wage growth than do public lands with no oil and gas resources. A similar effect is seen in the private land category, where positive, albeit small and statistically insignificant, parameter estimates on the OG PCT variable indicate that oil and gas abundance on private lands contributes to faster wage growth than does private land ownership without oil and gas resources. While the magnitudes of STATE OG effects are at least three times larger than the FED OG effects in four of the five periods, the differences between the effects are insignificant, although in the 1990-2000 and 1990-2010 periods they are almost significant (p-values of 0.112 and 0.104, respectively). In the 2000-2007 period, the STATE OG effect is slightly larger than the FED OG effect, in contrast to the anomalous result for this time period from the first institutional growth regression (Table 11), where FED OG outperformed STATE OG. Finally, the overall amount of public land in a county, whether federal or state, is shown to have a generally negative effect on wage growth in most time periods, with the FED ALL variable having a significant negative effect in the 1990-2000, 1990-2007, and 1990-2010 periods.

Table 11. OLS results: Effects of institutional land ownerships on annual growth rates of county salaries and wages.

	Dependent variable:				
	WAGE 1990-2000	WAGE 1990-2007	WAGE 1990-2010	WAGE 2000-2007	WAGE 2000-2010
	(1)	(2)	(3)	(4)	(5)
Constant	23.9553***	15.5802***	10.7392**	5.9611	-0.7986
	(8.0871)	(5.9428)	(5.1963)	(6.5099)	(4.9866)
ln(initial WAGE)	-2.9112***	-1.6500**	-1.2871**	-0.3323	-0.0165
	(0.9799)	(0.6956)	(0.6102)	(0.7378)	(0.5592)
FED ALL	-0.0195***	-0.0116**	-0.0112**	-0.0019	-0.0041
	(0.0069)	(0.0059)	(0.0052)	(0.0144)	(0.0103)
FED OG	0.0003	0.0139	0.0055	0.0319	0.0100
	(0.0099)	(0.0105)	(0.0085)	(0.0220)	(0.0145)
STATE ALL	0.0072	-0.0186	-0.0149	-0.0494	-0.0364
	(0.0409)	(0.0286)	(0.0271)	(0.0425)	(0.0360)
STATE OG	0.0362	0.0415	0.0460*	0.0408	0.0451
	(0.0376)	(0.0307)	(0.0276)	(0.0693)	(0.0503)
OG PCT	0.0005	0.0005	0.0010	0.0010	0.0018
	(0.0058)	(0.0052)	(0.0044)	(0.0113)	(0.0077)
BARTIK	1.9451***	0.5148	0.5008	-0.2177	-0.5628
	(0.7512)	(0.4496)	(0.5466)	(0.6448)	(0.8124)
COLLEGE	0.2202***	0.1330***	0.0853***	-0.0002	-0.0334
	(0.0459)	(0.0315)	(0.0275)	(0.0260)	(0.0205)
OLD	-0.0119	-0.0044	0.0019	-0.0121	0.0021
	(0.0437)	(0.0299)	(0.0262)	(0.0378)	(0.0310)
F statistic: State FEs	3.522***	1.49	1.13	2.017*	2.896***
F statistic: Equivalence of federal and state oil and gas effects	2.55	0.54	2.66	0.41	0.01
Observations	250	250	250	250	250
Adjusted R^2	0.3380	0.2209	0.1970	0.0444	0.1011
F Statistic (df = 16; 233)	8.9454***	5.4127***	4.8183***	1.7232**	2.7507***

Heteroskedasticity-consistent standard errors are in parentheses. *p<0.1; **p<0.05; ***p<0.01

DISCUSSION

The results indicate that oil and gas abundance is associated with higher wage levels and faster wage growth in the counties of the Intermountain West. These findings are similar to other studies that have measured oil and gas abundance exogenously, notably Michaels' (2010) study of oil abundance on the counties of the southern United States and Weber's (2012) study of the recent natural gas boom on the counties of Colorado, Wyoming, and Texas. In each case these authors found that resource abundance had positive effects on local incomes. The regional scale results reported here are also consistent with Alexeev and Conrad's (2009) use of level regressions in a cross-country study which found significant positive effects of exogenously measured resource abundance on income levels.

The results are strikingly consistent with respect to the positive level and growth effects of overall resource abundance on county wages, and provide support for Boyce and Emery's (2011) hypothesis that resource production without market failures or poor institutions should result in increased incomes. Given that resource prices and production were generally increasing (Fig. 1) in the periods analyzed, the results showing a strong positive effect of resource abundance on growth rates also provide support for Boyce and Emery's hypothesis regarding the expected relative growth rates of resource and non-resource sectors. The divergent institutional ownership effects found in the level and growth regressions can be usefully framed by another observation from Boyce and Emery: that the positive income effects of resources are a function of resource *production*. Because oil and gas production is likely sensitive to costs associated with the institutional permitting process and the royalty interest charged by mineral owners, these two concerns frame the discussion below of the divergent institutional effects reported between federal and state oil and gas ownership variables.

The federal and state permitting process for oil and gas drilling differ substantially. The BLM oversees permitting for all federal lands and recent studies of the permitting process at the BLM reveal long wait times, understaffing, and a lack of oversight and accountability (U.S. Department of the Interior Office of the Inspector General, 2014; Humphries, 2015). These indicators of bureaucratic inefficiency are reminiscent of the institutional quality index used by Mehlum (2006a), which included, among other metrics, an index of bureaucratic quality. The permitting process to drill for oil and gas on state lands is significantly faster. A 2014 report by the U.S. Department of the Interior Office of the Inspector General found that state governments claim an average of 80 days to process and approve an 'application for permit to drill' (APD), whereas the BLM reported an average of 228 days, or 7.5 months, to process an APD on federal lands. This BLM processing time was an improvement from the average 307 day processing time in 2011 (Humphries, 2015). While the BLM approves 99 percent of all APDs received, only 6 percent are processed within 30 days; the lack of accountability and oversight results in a process that "is essentially open ended" (U.S. Department of the Interior Office of the Inspector General, 2014). The uncertainty regarding permitting times and costs is a disincentive for oil and gas companies to drill on federal lands. One reason for the streamlined permitting process on state lands is that states are not required to perform the often lengthy environmental review process demanded by the National Environmental Policy Act (NEPA), which only applies to proposed actions on federal lands and accounts for most of the APD processing time at the BLM (U.S. Department of the Interior Office of the Inspector General, 2014).

The royalty rates for drilling on state versus federal land are also significantly different. From a producer's perspective, a 12.5% royalty rate for drilling on federal land is more attractive than the 16.67% (the rate in Utah, Montana, Colorado, and Wyoming) or 18.75% (New Mexico) rates for drilling on state lands. The results suggest that production decisions are likely more sensitive to the differences in the permitting process than they are to differences in royalty rates between federal and state lands. However, the final destination of royalty payments does have an impact on the local outcomes of resource development. After royalties are collected on federal lands, 50% is returned to the state of origin, 40% goes to the Bureau of Reclamation, and 10% goes to the U.S. Treasury (U.S. Department of the Interior, 2013). The state has some discretion over their share of federal royalties and often invests in roads and other public works in the communities where oil and gas extraction took place. In return for drilling on federal lands, then, local communities would benefit from royalties equal to or less than half of 12.5% of the value of production. When oil and gas is extracted from state lands, in contrast, royalty rates are higher (at least 16.67% in the study area) and the federal government does not take a 50% share, resulting in significantly increased royalties retained by the state.

Deeper institutional characteristics also help explain the differing permitting processes and royalty rates at the federal and state levels. First, state agencies are part of a bureaucracy whose decision makers are accountable to local and state constituencies to a far greater degree than are federal agencies, who are accountable to federal overseers in Washington D.C. Second, state governments are contractually bound to maximize revenue from state trust lands (Souder and Fairfax, 1996) while federal agencies are constrained by their multiple use mandate. Finally, state governments arguably have a greater urgency to generate revenue from oil and gas resources since states have to balance their budgets every year, while the federal government does not.

One would presume that the final institutional variable, private ownership of oil and gas resources, would be associated with higher production levels, so its insignificant relationship with local wages is something of a surprise. A simple explanation for the lack of effect of private ownership is that oil and gas royalties from these lands are not being reinvested in local communities. Two recent studies suggest the plausibility of this explanation and indicate the relatively large scale of private versus federal or state oil and gas development. Fitzgerald (2014) analyzed a substantial collection of mineral leases in the five major oil and gas producing states in the study area. He matched the reported address of the grantors of drilling leases, that is, the mineral owners, to lease locations and created summaries of the proportion of ownership addresses that were within the same county and the same state as the lease. To estimate the proportion of total oil and gas revenue that came from private lands, Fitzgerald and Rucker (2014) collected data on aggregate, federal, and state oil and gas production, and estimated the quantity of private production as the residual amount after accounting for federal and state production.

The results of these studies, shown in Table 12, clearly show that only a small minority of mineral owners live in the same county as the oil or gas lease locations; frequently they live in another state. Moreover, the proportion of total oil and gas revenue from private lands is very substantial. While information on private royalty rates is generally unavailable, the state of Montana does publish private royalty rate information. Fitzgerald and Rucker (2014) report that for the five year period 2008-2012 royalties for oil and gas production on private lands in that state averaged 13.5% for oil and 11.8% for gas. These rates are similar to the federal rate of 12.5% and provide a reasonable estimate of private royalty rates. Given the large share of overall production from private lands and a royalty rate comparable to the federal rate, the effect of private land ownership on county incomes may be significant if the royalties flowed back to the local communities. However, the results in Table 12 indicate that royalties from oil and gas production on private lands are likely flowing to locations remote from the county where the resource production takes place. In such a scenario one would not expect to see large positive effects of private land ownership on local wages. Even if private royalties stayed in the county where production took place, if they concentrate in only a few hands and are not spent or invested locally it is unlikely that a positive county-level effect on wages would result. In contrast, resource revenues that accrue to a responsible governmental body would likely have broader positive effects by increasing public services and investment and/or lowering tax rates (Weber

2012). This is a reason why some states are considering raising their severance, or production, taxes on private oil and gas production: to divert more of the resource rents to the communities located where the resources are extracted (Fitzgerald and Rucker, 2014).

Table 12. Absentee ownership of substantial private oil and gas revenues in the major oil and gas producing states of the region. The addresses of grantors of private oil and gas leases are often remote from the county or state of lease locations.

	Private owner address[a]		Private oil and gas revenue share (%)[b]
	In-state	In-county	
Colorado	61.17	34.52	81.2
Montana	47.73	25.16	78.9
New Mexico	36.51	18.96	29.5
Utah	64.1	12.39	49.7
Wyoming	41.35	29.35	30.0

[a] Source: Fitzgerald (2014)
[b] Source: Fitzgerald and Rucker (2014).

The empirical results allow an assessment of the potential effects of a transfer of federal lands to the states, such as has been called for by several state legislatures in the region. The level effects estimated for the STATE OG and FED OG variables imply that a transfer of federally owned oil and gas land to the states would contribute to significantly higher county wage levels. Using the results of the 2010 level regression in Table 7, the implications of such a transfer are presented in Table 13. Two land transfer levels are considered: one percent of county land, and five percent of county land. The assumption in each case is that the land in question overlays an oil and gas basin. Effects are estimated for the top 20 counties by oil and gas production in 2010 measured in BTUs (Low et al., 2014), with at least 5% federal oil and gas land. On average, transfers of one and five percent of county land imply annual wage level increases of $150 and $766, respectively. The amount of land at issue in such scenarios is a function of county land area; for the twenty counties 1% and 5% land transfers would consist of, on average, 31,700 and 158,500 acres.

Table 13. Wage level effects of a transfer of federal oil and gas lands to state ownership. Two hypothetical transfer amounts are considered: 1% of county land, and 5% of county land.

	Pre – transfer levels				FED OG transfer effect: 1% of county land		FED OG transfer effect: 5% of county land	
County	Wage level ($)	FED OG (%)	STATE OG (%)	OG PCT (%)	Acres (1000s)	Wage effect ($)	Acres (1000s)	Wage effect ($)
Lea, NM	15772	15.2	34.1	100	28.1	184	140.6	942
Eddy, NM	19152	57.1	19.1	100	26.8	156	133.8	797
Duchesne, UT	14473	25.8	7.7	81	20.8	124	103.8	637
Campbell, WY	29089	13.4	6.8	100	30.8	203	153.8	1040
Sublette, WY	26751	50.2	3	69.7	31.3	197	156.6	1006
Sweetwater, WY	24331	67	3.9	99.9	66.9	204	334.3	1042
Park, WY	15003	9.3	1.8	25.3	44.4	151	222.1	774
Uintah, UT	15354	49.2	8.7	89	28.7	136	143.4	697
Fallon, MT	20870	11.2	7	100	10.4	105	51.9	539
Fremont, WY	13237	15.4	2.4	31.1	58.9	156	294.4	796
San Juan, UT	8115	45	4.5	77	50.3	125	251.4	640
Hot Springs, WY	12436	25	2.5	37	12.8	126	64.2	643
Sevier, UT	10228	27.9	1.5	33.6	12.2	103	61.2	529
Garfield, CO	15928	37.8	0.9	73.9	18.9	142	94.4	725
Converse, WY	15558	14.1	10	97.2	27.3	178	136.4	909
Chaves, NM	8991	15.1	10.2	52.1	38.9	122	194.4	623
Big Horn, WY	11372	30.2	1.7	44	20.1	143	100.5	733
Carbon, WY	15101	23.4	4.1	45.3	50.6	161	253	823
Crook, WY	10215	15.1	7.1	100	18.3	169	91.3	867
Rio Arriba, NM	7053	16.5	1.6	42.4	37.5	107	187.7	548
Average	15451	28.2	6.9	69.9	31.7	150	158.5	766

Note: Results shown for 2010 salary and wage levels for the top 20 counties by oil and gas production in 2010 measured in BTUs (Low et al., 2014), with at least 5% federal oil and gas land, ordered by 2010 BTU production.

Also notable is that the mean wage level for these top oil and gas producing counties is higher than the average for all counties in the study area ($15,451 vs $12,066), and that only six of the top producing counties have a below-average wage level. Moreover, the single county with the highest STATE OG value (34.1), Lea County, New Mexico, and the county with the third highest STATE OG value (19.1), Eddy County, New Mexico, are the top two oil and gas producers of the sample of 250 counties in each year from 2000-2010 with the exception of 2006 (Low et al., 2014). This anecdotal evidence provides additional support for the level regression results.

CONCLUSION

Oil and gas abundance in the counties of the Intermountain West has had a consistently positive effect on county wage levels and growth rates. Moreover, state ownership of oil and gas lands has had significantly larger positive effects on local wages than federal ownership. The discrepancy in effects between the institutional land ownership types is likely attributable to significant differences in permitting processes, royalty rates, and institutional mandates and constituencies. Private ownership, meanwhile, has no significant positive effect on local wages, likely due to extensive absentee ownership.

To the best of my knowledge, this study is the first to systematically assess the ownership effects of oil and gas resources on economic outcomes at a county level. There are several possible areas for improvement. First, the analysis assumes that surface land ownership implies subsurface ownership of minerals including oil and gas. This assumption does not hold in a "split estate" context, when subsurface minerals are owned by a party other than the surface owner. While this concern is legitimate I do not have the data to account for it in the empirical models. Even with such data, the findings may be little changed since the permitting and environmental review processes would presumably still be strongly influenced by surface ownership. Second, spatial effects could be incorporated in the models. This would help account for labor and income effects of oil and gas abundance that cross county lines, for example by oil and gas operations attracting workers from neighboring counties. Third, additional covariates that leverage geospatial datasets could be used to develop reasonable measures of the accessibility and topographic suitability of oil and gas lands. Additionally, this research did not consider non-market values of oil and gas lands or the distribution of wage benefits across the income spectrum.

Given the strongly positive results of state ownership of oil and gas resources on local economic outcomes, the findings presented here suggest that research exploring the effects of governmental scale – that is, assessing whether 'Small is Beautiful' (Schumacher, 1971) when it comes to governmental organization – may be fruitful. Finally, this analysis lends a modicum of empirical support to the proposals of the state legislatures of the western states calling for the transfer of federal lands to the states. However, the present analysis addresses only one small aspect of that charged political debate, which raises broad concerns not only about economic issues but also about public land access and use, environmental protection, and the role of government.

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