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Modeling Direct and Secondary Employment in the Petroleum Sector in North Dakota

Dean A. Bangsund ■ Nancy M. Hodur

NDSU AGRIBUSINESS AND APPLIED ECONOMICS

North Dakota State University ■ Fargo, ND 58108

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Preface

The research discussed in this report was undertaken by the Department of Agribusiness and Applied Economics at North Dakota State University from requests from stakeholders and community leaders to provide employment forecasts, and ultimately population predictions for western North Dakota. Researchers at NDSU have been assessing the economic impacts of industries in North Dakota for several decades, and have considerable expertise in evaluating how changes in basic-sector industries influence the North Dakota economy. Early in this process, it was found that existing models and analytical frameworks were not accurately reflecting the employment dynamics found in western North Dakota. Compounding this situation, employment forecasts and predictions were being generated and used in the public arena that appeared to contradict those observations.

To address problems of overestimating secondary employment, a new approach to estimating employment change in western North Dakota was needed. Ultimately, the strategy resulted in the development of new methods and new models.

Our first step was to collect information on direct employment in the oil and gas industry. The Oil and Gas Division of the North Dakota Department of Mineral Resource has been estimating employment in the oil and gas industry for several years. We sought their help in identifying key relationships in how jobs have been estimated based on physical measures of industry activity (such as operating wells, drilling rigs, and so on). Lynn Helms, and his staff at the Oil and Gas Division, were very gracious in sharing their labor coefficients and insights on direct employment in the industry. Without the cooperation from Lynn Helms, Alison Ritter, Bruce Hicks, and others in the Oil and Gas Division, our efforts to develop new methods and models would not have been successful. Some people might view our efforts to model direct employment in the industry as competing with modeling done at the Oil and Gas Division. We see both our effort and their insights and modeling to be complementary of each other.

Early in our efforts to construct a model of direct employment, we also sought help from Justin Kringstad with the ND Pipeline Authority. Justin's insights on how to model oil and gas output in the industry, and his tactics to address well drilling and fracing activities in the Williston Basin served as a platform from which we built our petroleum employment model.

We feel very fortunate that key industry experts from the Oil and Gas Division and the ND Pipeline Authority were willing to share their knowledge, insights, perceptions, and ultimately their models to assist in this effort. It is our hope that we can continue to work together with those individuals and agencies to provide employment information on energy development for communities, organizations, stakeholders, officials, legislators, and the general public.

Executive Summary

This report details the methods, procedures and assumptions of a model developed to estimate direct and secondary employment in the petroleum industry in North Dakota. This report also discusses issues associated with the use of historic methods and models to estimate employment associated with expansion in the oil and gas industry. Findings suggest that current employment forecasting techniques do not accurately model conditions in the Williston Basin.

A model to estimate direct employment in the oil and gas industry was constructed from data obtained from the Oil and Gas Division of the North Dakota Department of Mineral Resources. Direct employment was estimated using coefficients for drilling rigs, fracing crews, oil field service, and gathering systems construction. Employment forecasts were scenario driven, and represent potential employment based on measures of physical activity in the industry (e.g., number of rigs, well counts).

Existing input-output models were found to be poor predictors of employment change in the petroleum industry in the Williston Basin. Traditional approaches using input-output models resulted in overestimates of employment. Additional analysis suggests reliance on standard static coefficients may also overestimate employment. Existing models do not control for the effects of a constrained economy, crowding out effects, or a petroleum sector workforce that is heavily comprised of temporary workers and overestimate employment, particularly secondary employment.

The best approach to forecasting future direct employment change is to carefully monitor physical changes in the industry, especially changing expectations for the rate and extent of oil field development. Labor efficiencies particularly those that would affect the long-term permanent workforce should be included in modeling effort. Employment dynamics in the Williston Basin will not likely be static over the next decade making employment forecasting challenging. Findings suggest secondary employment will be constrained in the future. Forecasts will need to adjust those constraints over time as conditions change and new data becomes available. Modeling efforts should also take into consideration differences in the temporary and permanent workforce. The employment model developed in this effort is dynamic and incorporates physical measures of industry activity, incorporates labor efficiencies over time, and takes into consideration workforce characteristics.

Modeling Direct and Secondary Employment in the Petroleum Sector in North Dakota

Dean A. Bangsund and Nancy M. Hodur*

Current expansion of the petroleum sector in North Dakota started in the mid-2000s when drilling in the Bakken formation became the focus of the industry. Initial development was modest, resulting in about 300 wells placed into production annually from 2005 through 2007. However, drilling since that time has expanded rapidly and led to substantial increases in wells, oil and gas output, and employment.

The rate of development in the oil patch has created substantial infrastructure issues from both an industry perspective relating to oil transportation and gas gathering and processing capacities to a local public infrastructure associated with roads, water and sewage treatment, school facilities, housing, and delivery of public services. These problems have created the need for a better understanding of future resource development in the Williston Basin.

Individual communities, as well as the state, are struggling to manage the growth in population and employment associated with oil development in the Williston Basin. A number of assessments and studies have attempted to quantify future housing demand, transportation requirements, workforce needs, and delivery of public services in the oil patch (Bangsund and Leistritz 2010; Ondracek et al. 2010; Renner 2006, 2010; Tolliver and Dybing 2010). Due to the rapid rate of change in the petroleum sector, many of the past assessments are either being updated or have been updated (Rathge et al. 2012). A common thread in all the work that has been done to date is that much of the work lacks a comprehensive understanding of the employment dynamics within the petroleum sector over time as the Bakken/Three Forks formations are developed.

Accurate predictions on drilling, employment, and oil output in North Dakota over a long time scale are nearly impossible. Most policymakers or industry leaders would be skeptical of predictions of precise industry actions 25 to 35 years in the future. Yet decisions are currently being made by state and local governments, many in a reactionary manner, to address service delivery, infrastructure, housing, and transportation issues in western North Dakota. A sound approach to estimating population is critical to understanding potential changes in infrastructure needs, and policy responses to those needs. Unfortunately, because of the rapid expansion of petroleum employment existing demographic tools (e.g., standard co-hort models) are inadequate as the data to properly adjust the type and rate of in-migration in western North Dakota is not available. An alternative approach is to use employment as the mechanism of change to predict population. Employment, and input-output analysis, has been used to evaluate population effects of site-specific projects for decades. Western North Dakota is the site of a very large

* Research scientist and research assistant professor, respectively, Department of Agribusiness and Applied Economics, North Dakota State University, Fargo.

development project, and modeling employment change provides the most reasonable approach to estimating population.

A key component of modeling change in regional employment in western North Dakota is a tool that estimates direct employment in various segments of the oil and gas industry. The oil and gas industry is complex, and involves hundreds of firms in the Williston Basin. Some of the complexity in estimating employment is because jobs associated with the industry are reported in numerous economic sectors (Bangsund and Leistritz 2007, 2009, 2010). For example, employment associated with construction of well pads and pipeline installation and employment in truck transportation. Each represent direct employment in the petroleum sector but are reported in two different economic sectors.

The reporting of direct employment among several economic sectors creates difficulty in relying on standard employment data to track jobs in the oil and gas sector. What is needed is a tool or modeling process that allows direct employment to be estimated across economic sectors, and across various segments or activities within the industry. Further, this tool needs flexibility to address known and anticipated changes within the industry, and be capable of demonstrating how different development scenarios might affect industry employment. Examples of these factors may include changes in oil field size (well counts), rates of development (rig counts over time), and changes in labor efficiencies (adoption of new technologies and practices).

The Oil and Gas Division of the ND Department of Mineral Resources has conducted a thorough and in-depth examination of the labor requirements for various segments of the industry (Oil and Gas Division 2012). That effort produced labor coefficients (FTE requirements) identifying the amount and type of work required for drilling, fracing, construction of oil field gathering systems, and well operations, well maintenance, oil and gas transportation, and associated processing activities. The coefficients developed by the Oil and Gas Division were combined with other employment modeling to produce a model that estimates both direct and secondary employment in the petroleum sector.

Objectives

The primary intent of this work was to develop a tool to estimate direct employment in the oil and gas industry in North Dakota and provide estimates of regional secondary employment associated with direct employment in the industry.

A secondary goal of this work was to design an oil and gas sector employment model that would be compatible with other models used to address development and transportation issues in the Williston Basin.

Methods

This study developed a model to track industry-wide employment and employment in different segments of the industry over time given different future expectations for oil field development in the Williston Basin.

General Model Design and Key Input Variables

Key model inputs and variables are listed in the following sections, along with brief explanations of assumptions associated with those inputs. The model has three main components that divide employment estimates into oil field development, construction of gathering systems, and oil field maintenance and operations.

Rig Counts

Rig counts are a deterministic, annual variable in the model. It is virtually impossible to predict all of the economic, geologic, regulatory, and unforeseen factors that will influence the number of rigs operating in North Dakota in any given year over the next 25 to 35 years. Even discussions and interviews with industry representatives reveal most companies do not have specific long-term drilling plans. Therefore, precise predictions of rig counts will be nearly impossible to forecast. Yet, employment forecasts require that annual estimates of drilling rigs be used in the estimation process.

Several recent studies have relied on a scenario approach to frame a range of possibilities with respect to rig counts over time (Bentek Energy 2012, ND Transmission Authority 2012, Bangsund et al. 2012, Ondracek et al. 2010). The employment model was designed to illustrate effects associated with multiple rig count scenarios. This method is consistent with other analytical approaches to modeling employment and population.

One of the values of using multiple rig count scenarios is that sensitivities of oil and gas employment, regional employment, change in secondary employment, and subsequent effects on housing demand and population can be evaluated quickly and effectively for a variety of assumptions pertaining to the rate of oil field development in the Williston Basin. Considering the acute sensitivities to current demands for infrastructure in western North Dakota, and the difficulty in predicting the exact rate of development, policy makers, community leaders, developers, and other stakeholders can easily visualize how future demands associated with current oil and gas development depend upon changes in rig counts over time.

Well Completions and Wells Drilled

Wells drilled each year of the projection period are a function of rig counts and coefficients predicting wells drilled per year per rig. Well drilling rates are an annual variable in the model, and those rates are modeled to change over time to reflect anticipated efficiencies in well drilling over the course of oil field development in the Williston Basin.

Well completions are modeled to be independent of wells drilled. This provision in the model enables fracing capacity to be equal to, less than, or greater than well drilling capacity over the course of the planning period. The model works through a series of equations that prevent well completions from exceeding wells drilled (plus wells drilled but not completed from previous years) in any particular year of the projection period. Likewise, the model is designed to carry forward wells drilled but not fraced when fracing capacity is less than drilling capacity.

Fracing labor is a function of applying Oil and Gas Division coefficients to the number of wells completed. Drilling labor also is a function of applying Oil and Gas Division labor coefficients to the number of drilling rigs operating each year. Both fracing labor and drilling rig labor have initial values equal to 2012 values obtained from Oil and Gas Division (2012). However, labor requirements are expected to be less in the future as rigs move to drilling multiple-wells per pad (Oil and Gas Division describes this switch as a move from Phase I rigs to Phase II rigs). Labor improvements are modeled to change on an annual basis as the percentage of drilling rigs in the Williston Basin move from Phase I to Phase II rigs.

Well Counts and Well Life

The model's baseline begins with the number of oil producing wells in ND at the end of 2011. Using drilling statistics obtained from the Oil and Gas Division web site, estimates were made of the number of Bakken/Three Forks and all other wells at the of 2011. The model assumes all future wells drilled in the state are part of the Bakken/Three Forks development except wells drilled in the Tyler formation, for which the model tracks rigs and well counts separately. Annual well counts are determined by adding well completions to previous year's well total less wells retired that year.

Well life is variable in the model for both Bakken/Three Forks and other wells in ND. Useful well life for all non-Bakken/Three Forks wells is used to calculate a percentage of wells that are retired annually. Since Bakken/Three Forks wells are tracked separately, those wells can be can be discontinued based on tracking the life of those wells for any given year. For example, Bakken wells drilled in 2011 with a 30-year useful life would be retired in year 2041.

Labor Coefficients

The Oil and Gas Division of the ND Department of Mineral Resources has conducted a thorough and in-depth examination of the labor requirements for various segments of the oil and gas industry (Oil and Gas Division 2012). That effort produced details on the amount and type of labor required for drilling, fracing, construction of oil field gathering systems, well operations, well maintenance, oil and gas transportation, and associated processing activities. These coefficients represent original research by the Oil and Gas Division (2012), and the Oil and Gas Division has used the coefficients to produce a model of direct employment in the oil and gas sector in North Dakota. It should be noted that the Department of Agribusiness and Applied Economics did not generate the coefficients used in this paper, and credit for creating those coefficients rests solely with the Oil and Gas Division of the North Dakota Department of Mineral Resources. Further, the Oil and Gas Division has used the coefficients, combined with oil field spacing, geology, and other factors, to estimate the number of potential future wells by county and generate their own estimates of industry-wide employment.

Each labor coefficient is treated as an annual variable in the model. Those annually adjusted coefficients are multiplied by the corresponding metric (i.e., appropriate units) to arrive at total labor requirements for various activities in the oil and gas sector. For example, the labor coefficient for drilling rigs is multiplied by the number of rigs operating each year in the 25-year period. Similar approaches are used with well counts for service labor and well completions for fracing labor. The coefficients represent an annual input that can be easily adjusted over time for known and anticipated efficiencies in labor requirements.

Direct Employment

The model was designed to make several delineations in employment in the petroleum industry. Those categories included direct and secondary employment, permanent and temporary workforce, and estimates of direct and secondary employment by economic sector. Direct employment is defined as jobs that are part of the industry, such as a tool pusher on an oil drilling rig, or an employee working at a natural gas processing plant. Secondary employment would be jobs supported in other economic sectors that exist as a result of the jobs/business activity in the oil and gas industry, and examples of those type of jobs include nurses, department store clerks, auto repair technicians, loan officers, school teachers, and so on.

Direct Employment within the Industry

The petroleum sector or industry was divided into three primary segments; oil field development, oil field service, and gathering systems construction. Oil field development includes well drilling and fracing operations. Oil field service includes oil well operation, maintenance, infrastructure maintenance, gas processing, and transportation of oil and gas from production to collection points. Oil field gathering systems pertaining to pipelines and other infrastructure to collect and distribute oil, gas, and water in the oil fields.

Labor Efficiency over Time

Labor coefficients, either directly or indirectly, were adjusted over time to account for changes in efficiency within the industry. For example, as the industry moves predominately to drilling multiple wells per pad in the future, labor requirements associated with drilling rigs used on multiple-wells pads are expected to be reduced. Also, future labor requirements for oil field service with respect to truck transportation are expected to be lower than current requirements as the industry moves to the use of collection systems within the oil fields. The model is flexible in that adjustments for efficiency can be based on mathematic relationships (e.g., economies of scale that exhibit logarithmic changes over time) or deterministic values. Also, static coefficients can be modeled over the 25-year period.

Temporary and Permanent Workforce

The terms ‘temporary’ and ‘permanent’ have different connotations for labor in the petroleum sector. As natural resource development for oil and gas goes through its various stages, duration of labor requirements in each stage varies. Much of the issue between the two workforces can be a described as a function of time (more specifically job duration in a specific region) or a function of job design (type of work). Jobs which will be more lasting in nature and not subject to short term economic conditions tend to be thought of as permanent jobs. After development of an oil field, wells, pipelines, and processing activities tend to require labor at a consistent rate over the life of those investments or over the operating life of an oil field. Contrast to those jobs are workers, whose job, by design, can easily end or be re-assigned with changing economic factors. Jobs associated with drilling and fracing operations tend to be much more temporary with respect to location and duration. For example, recent shifts by major petroleum companies from gas development to oil development have resulted in substantial amounts of workforce shifting to different regions of the country.

A delineation for temporary and permanent workers within the oil and gas industry was created separately for drilling, fracing, gathering systems, and oil field service. A key aspect to understanding the future labor characteristics and the implications of a changing labor dynamic within the industry is to identify and quantify the amount of short-term labor and long-term labor requirements within the industry. Workforce characteristics also play an important role in estimating secondary employment, and have substantial implications related to short-term and long-term housing needs.

Most drilling and fracing employment can be considered part of the industry's temporary workforce. However, the Williston Basin will likely have drilling and fracing operations for a considerable period (i.e., out 25 to 35 years) so the model estimates a portion of the long-term drilling and fracing employment to represent permanent employment. All drilling and fracing employment above the estimated long-term presence of drilling and fracing employment was considering temporary. Levels of drilling and fracing activity differ depending upon assumptions and conditions in projections of rig counts (Oil and Gas Division 2012b, BenTek 2012). Therefore, based on the primary assumptions of any particular scenario, different levels of temporary and permanent employment could be estimated. All construction employment for oil field gathering systems was treated as temporary employment, whereas, all oil field service employment was considered permanent employment.

Employment by Economic Sector

Labor coefficients, obtained from the Oil and Gas Division of the North Dakota Department of Mineral Resources (Oil and Gas Division 2012), were placed into North American Industrial Classification System (NAICS) codes (North American Industrial Classification System 2012) (Table 1). Because many direct jobs within the industry actually get reported as jobs in other sectors (Bangsund and Leistritz 2007, 2009, 2010), it was necessary to make employment projections consistent with how industry employment is tracked by state and federal agencies (Job Service North Dakota 2012).

Additional advantages to estimating oil and gas industry employment using commonly accepted definitions of economic sectors is that output from the model can be directly used by other models that require employment inputs broken into 2-digit NAICS codes. Examples include various input-output models (e.g., IMPLAN, RIMS II), transportation models, and community planning models. Further, placing industry direct and secondary employment into NAICS codes facilitated the use of Quarterly Census of Employment and Wage (QCEW) data to estimate change in employment in counties and multi-county regions heavily impacted by oil field development. In essence, the model is standardized to match how employment data is tracked by government agencies, community planners, transportation systems, and developers who rely on 2-digit NAICS codes for analysis.

Table 1. Percentage of Petroleum Sector Employment within Drilling, Fracing, Gathering Systems, and Oil Field Service Segments, by North American Industrial Classification System Codes, North Dakota, 2012

Industry Segment	NAICS code	Percentage of Labor	Sector Name
Drilling Employment	21	51.5	Oil and Gas
	23	2.2	Construction
	31-33	7.6	Manufacturing
	42	0.7	Wholesale Trade
	48-49	36.7	Transportation & Warehousing
	54	0.6	Professional, Scientific, & Technical Services
	92	0.7	Government
Fracing Employment	21	100	Oil and Gas
Development of Gathering Systems	23	100	Construction
Oil Field Service Employment	21	49.9	Oil and Gas
	31-33	11.7	Manufacturing
	42	1.5	Wholesale Trade
	48-49	35.7	Transportation & Warehousing
	92	1.3	Government

<u>Secondary Employment</u>

Economists primarily use Input-Output analysis to estimate changes in employment associated with changes in revenues or expenditures with an industry. Those techniques are widely used and accepted within the profession and have been refined over the past 40-50 years (Leistritz 1998, 1994). However, current data would suggest a methodology relying on historic productivity ratios or employment multipliers, either linked to sales volume (sales to final demand) or industry spending (in-state expenditures), would currently overestimate total employment from the petroleum sector in North Dakota.

Current data suggests disproportionately less secondary employment has been added to the region outside of the definition of direct employment within the petroleum industry. Part of the issue is that the definition of direct employment used in previous economic assessments of the industry (Bangsund and Leistritz 2007, 2009, 2010) and the coefficients associated with labor requirements in the industry (Oil and Gas Division 2012), potentially hide some secondary employment in various sectors. The *Construction, Manufacturing, Transportation and Warehousing*, and *Wholesale Trade* sectors in western North Dakota contain considerable employment associated with current development in the petroleum industry. However, observed changes in employment in the retail trade, personal service, business service, social service, and other sectors of the regional economy are less than expected with current input-output analysis.

Potential Constraints to Secondary Job Growth

> Western North Dakota has several substantial constraints to expanded employment in many sectors of the economy. Local and regional businesses have difficulty adding employment due to wage competition, labor shortages, lack of housing, inability to physically expand operations (e.g., shortage of construction capacity), or other constraints (e.g., lack of daycare).
>
> Excess capacity may have existed in the regional economy at the start of oil field development. If there was initially excess capacity (i.e., number of workers or ability to add sales with existing labor pool) that would explain how regional businesses could absorb increases in economic activity without requiring proportional increases in employment.
>
> Technological changes have altered the amount of sales per unit of labor for some sectors. Examples include pay-at-the-pump, internet orders, and potentially other adjustments that generate improvements in output per unit of labor.
>
> Employment decisions by local and regional businesses have lagged or curtailed due to perceptions or beliefs that current activity would conform to historic short-term boom&bust cycles. The sting from the past bust of the 1980s still resonates with many leaders and businesses in western North Dakota. A failure to recognize the difference between the current expansion and past short-term expansions/contractions would result in delays in reacting to the increase in economic activity.
>
> Some normal supply chains for various goods and services are not conforming to normal channels or behavior. For example, crew camps by-pass many of the normal supply and service purchases compared to traditional housing. Food supply is contracted for large deliveries to the crew camps, eliminating the process where a worker would purchase groceries at a local grocery store and prepare their own meals. Similarly, the need for personal items such as recreation, furniture, appliances, decor, among others would be less when living in a crew camp, camper, or trailer than a traditional apartment or home. Also, services for home maintenance, upkeep, landscaping, and other home ownership requirements would be mostly forgone, as well as the supply of utilities and other services (e.g., electricity, cable TV, internet).

There is likely considerable economic leakage associated with non-local workers who move some portion of their wages/salaries to other states. It is suspected that a high percentage of the oil and gas workers in North Dakota have not become North Dakota residents, have family residing in other states, or have outstanding financial obligations in other states. Further, probably only a small portion of the private mineral royalties accruing to North Dakota residents is being injected into the regional economy. After initial upgrades to homes, vehicles, and other personal belongings, much of the royalty stream is likely invested or secured in various forms of financial instruments, not all of which would provide financial stimuli in ND. Further, some economic models (e.g., Regional Economic Models, Inc. [REMI]) suggest personal spending and capital expenditures have non-linear responses, and that predictions of economic activity based on linear relationships overestimate regional economic activity. Current economic conditions in western North Dakota would certainty fit with those hypotheses.

Workforce labor arrangements allow for workers to have several weeks of constant employment in the oil field followed by equal or similar periods of non-employment (e.g., two-weeks on, one-week off). These work arrangements act to reduce the level of personal spending in western North Dakota compared to workers who permanently reside in the region. These work arrangements contribute heavily to economic leakage, as workers likely spend much of their disposable income at their permanent residence. Individuals who work every day for two weeks, then leave the oil field, travel back to their normal residence, will spend a majority of their disposable income in their home location (e.g., utilities, home maintenance, vehicle purchases, child expenses, health care, personal banking and investments, and perhaps other consumables such as clothing, recreational goods, groceries, house supplies, and so on…..). Workers working in one area and living elsewhere contribute to a reduction in the demand for personal services, retail goods, and other traditional demands for non-basic sectors in North Dakota. Those leakages reduce the metrics for secondary employment associated with gross employment levels.

The net result of these and other factors is that secondary employment, in non-oil related sectors, has largely been inelastic with respect to changes in petroleum sector expansion. This inelasticity is likely to become less prevalent over time as some of the wage and housing constraints are alleviated. Also, as the permanent population in western trade centers increases with change from temporary to permanent workforce, jobs more closely linked to population (as opposed to the purchase of industry inputs), such as induced employment associated with consumer spending, are likely to increase.

Anecdotal evidence suggests secondary employment is on the rise in the Williston Basin. Increases have been observed with teachers, home construction workers, medical personal, and some retail trade employment. Quantitative data showing employment response lags actual occurrence making it difficult to model current changes to regional employment. What is being observed at this stage of the development of the shale plays in the Williston Basin is just the beginning of local and regional responses to adding additional workforce. How those responses play out in the long-run is unknown. Not only is the degree of response unknown, but it is likely that the response will be uneven across economic sectors. For example, the region has undergone tremendous increases in taxable sales and purchases, yet employment in those sectors has not increased proportionally to the change in sales. If the current business volume remains high but does not increase it is plausible that proportional responses in labor in the retail trade sector will not be observed in the future. Will these trends continue in the service-based sectors of the economy as population levels remain high over time? One postulation is that the response in secondary employment is lagged, and that additional employment will occur, albeit not proportional to observed past relationships. If so, existing employment multipliers/productivity ratios will over state near-term employment response and potentially over-state total employment in longer periods.

Observations and Output from Existing Models

In developing projections of employment, the initial versions of the petroleum employment model generated forecasts of industry spending and gross sales of oil and gas. Estimates of petroleum sector expenditures were tied to physical measures of output using financial metrics from previous economic assessments (Bangsund and Leistritz 2007, 2009, 2010) and modified for expected labor efficiencies and economies of scale. Physical measures of output for the industry included wells drilled, wells serviced, volume of gas processed, and volume of oil shipped. In addition to industry spending, estimates of the gross value of oil and gas sales were generated using forecasted prices and estimates of expected crude oil and gas production with different development scenarios. These data were used with several approaches to evaluate the applicability of various methodologies to estimate secondary employment in western North Dakota.

A: Industry-wide Expenditures

The first approach used traditional estimates of direct industry spending and applied those spending estimates to the North Dakota Input-Output (I-O) Model (Coon et al. 1985; Coon et al. 2012). Secondary business volume and employment productivity ratios, by economic sector, were used to generate estimates of secondary employment. This approach produced estimates of future secondary employment that appeared to be in conflict with observed employment change in the region and within the state. Even after accounting for expected future changes in productivity ratios the estimates were in conflict with observed changes in employment.

A second approach used estimates of industry expenditures, be economic sector, with employment multipliers from the Regional Input-Output Modeling System (RIMS II) (Bureau of Economic Analysis 2011). Since productivity ratios for western North Dakota have increased substantially since the beginning of the 2000s (Coon et al. 2012), adjustments to employment multipliers were performed in an attempt to reflect increases in business volume per unit labor. These adjustments were based on changes in inflation-adjusted productivity ratios from the ND Economic Base data set (Coon et al. 2012). The results from this modeling also produced unrealistic estimates of total future employment in the Williston Basin. Because of the results of that approach, past estimates of spending and actual employment were used with the model to test how model output matched observed changes over the period.

The change in statewide industry spending from 2005 to 2010 was used to estimate the increase in FTE employment using RIMS II multipliers. An examination of total QCEW employment change in the state (across all sectors and all industries) revealed less employment change that what the model suggested. Actual employment change was only about 60 percent of the estimated total change in employment produced by RIMS II employment multipliers. The use of RIMS II employment multipliers suggested that North Dakota would have added between 74,000 to 80,000 total jobs from 2005 to 2010 based on the dollar volume of industry expenditures. Employment change included both direct and secondary jobs associated only with the change in petroleum sector activity from 2005 through 2010. In reality, the state added a total of 49,000 jobs over the period (Job Service North Dakota 2012).

Some of the short fall in expected employment may be due to the fact that Job Service QCEW does not report sole proprietors. Any new sole proprietorship over the period would not be included. Also, QCEW data was comprehensive for all industries in the state, not just the petroleum sector. In other words, the potential overestimation could be even more exaggerated if there was positive net growth in direct employment or secondary employment in other industries in the state. If net employment in all other industries in the state remained constant over that period (which is unlikely) then RIMS II would have overestimated employment by 25,000 to 31,000 jobs, or by 51 to 61 percent of the actual employment change.

Using an expenditure-based approach, with RIMS II and the ND I-O model, to forecast secondary employment resulted in estimates of future employment that conflicted with observed data on employment change in western North Dakota. Accordingly, an expenditure-based approach would not be appropriate to project future secondary employment associated with the industry.

B: Sales to Final Demand Approach

A third approach to forecasting secondary employment was to use estimates of the future value of oil and gas sales and apply sales values to the Oil and Gas Extraction sector (NAICS 21) of two recognized and widely accepted input-output models. The use of gross industry sales, also known as sales to final demand, is common in applications of input-output analysis to show economic effects of changes in industry output.

Applying future estimates of oil and gas sales to RIMS II employment multipliers in some development scenarios produced large estimates of total (direct and secondary) employment in the state. Estimates of total state employment, based on expected future value of oil and gas sales in ND became extremely large several years into the projection period. Using this approach, total future employment statewide in ND was projected to be nearly equivalent to half the current total employment in the entire state. Clearly, such levels of employment change are not plausible. These results lead to an examination of how well the models performed when using historical data and observing the difference between model output and measured employment (QCEW data).

The use of future value of oil and gas sales to predict secondary employment was not adopted for obvious reasons. Accurately predicting future oil and gas prices is extremely problematic, and that process would impart a level of subjectivity to the forecasting process that would not remove uncertainty with future estimates of employment[1]. Further, as explained below, model performance also did not appear to track well with past employment observations.

Average annual price received for crude oil and natural gas were used with estimates of barrels of crude oil sold and mcf (1000 cubic feet) of natural gas sold to estimate gross value of oil and gas sales from 2005 through 2010 (Strombeck 2012, Energy Information Administration 2012, Oil and Gas Division 2011). Previous estimates of the gross value of oil and gas sales going back to 1970 in North Dakota also have been documented by Bangsund and Leistritz (2007, 2009, 2010). The change in oil and gas sales from 2005 to 2010 was used to gauge how accurately current I-O models were measuring observed employment change over the same period, and to perhaps provide insights on predictability of using a sales to final demand methodology to predict future employment change. Alternatively, did predicted employment change match observed employment change from 2005 to 2010.

(1) Regional Input-Output Modeling System (RIMS II)

The values of the change in oil and gas sales were applied to the Oil and Gas Extraction sector (NAICS 21) of the RIMS II model. Output from that analysis revealed RIMS II predicted a total statewide employment change of 35,200 jobs over the period. That predicted level of employment change was plausible, given that total change in covered employment over the same period was about 49,000 jobs (Job Service North Dakota 2012). However, the predicted change in direct employment associated only with the change in oil and gas sales was estimated at over 20,000 jobs. By contrast, an analysis using Oil and Gas Division employment coefficients with the change in the number of producing wells in the state over the same period showed a change in direct employment around 2,000 FTE jobs.

Clearly, that magnitude of change suggested the RIMS II model using sales to final demand was not observed with respect to the production segment of the oil and gas industry. It is important to recognize that employment output by RIMS II did not involve modeling the employment change associated with the development segment of oil and gas industry (i.e., drilling, fracing, and construction). Those changes would not be contained in the estimates as modeled, but rather would represent another analysis.

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[1]In addition to the inherent issues with predicting future oil and gas prices, small changes in prices produced substantial swings in gross sales given the magnitude of predicted oil and gas output. Large swings in gross sales then translated into large swings in employment, and substantial employment change was not considered realistic based solely on annual or short-term changes in oil and gas prices.

(2) IMPLAN

IMPLAN is perhaps the most widely employed and accepted regional economic analysis software for predicting economic impacts. Given its widespread use, IMPLAN also was tested to measure the amount of statewide employment change from 2005 through 2010 associated with the change in oil and gas sales. IMPLAN also produced total statewide employment estimates that were substantially larger than observed employment change in the state over the same period.

IMPLAN estimated that the statewide employment change should have been 57,600 FTE jobs. As noted above, the state, across all industries, had net gains of employment totaling 49,000 jobs from 2005 through 2010. Even if all employment change in the state was solely due to changes in the production of oil and gas (a highly unlikely assumption), IMPLAN overestimated employment by 18,600 jobs or by 38 percent. Estimates of direct employment associated with the change in the value of oil and gas sales over the period was estimated at 37,100 jobs–a level that greatly exceeds estimates of the change in direct employment in that segment of the industry over that period.

Summary of Observations and Approaches

All of the methods and models used in the aforementioned analyses contained serious problems for predicting future change in both direct and secondary employment in the oil and gas industry in North Dakota. Using estimates of future industry in-state spending would require considerable effort to predict. Further, when applying predictions of future industry expenditures to existing models, employment predictions became excessively large. Using estimates of the future predicted value of oil and gas sales would be equally difficult to predict, also creating unrealistic projections.

To validate the observations that those models, as currently calibrated, have poor predictive capacities, past data was run through the models and compared to observed changes in statewide employment. In this context, direct employment appeared to be greatly overestimated, and as a result, total employment also was not consistent with existing employment data. While estimates of secondary employment were reasonable compared to the relative size of direct employment, estimates of secondary employment appeared also to be overestimated.

Another factor to consider in the current job situation in western North Dakota is that none of the additional economic stimuli associated with oil and gas infrastructure development and well drilling and fracing operations was directly included in the aforementioned analyses. The overestimation of employment did not include the additional employment that the models would have produced if industry activities associated with infrastructure and well drilling activities were modeled.

This process of discovery concluded that an over reliance on one method/approach, or one model, was not sufficient to predict future employment change in the oil and gas industry in western North Dakota. Rather than relying on financial metrics (e.g., sales to final demand, in-state expenditures), an alternative approach was developed based on the relationships between direct employment and secondary employment, and the use of restrictions and constraints to reflect economic conditions in western North Dakota.

Secondary Employment Estimates

Three methods that rely on either sales to final demand or industry spending were evaluated for applicability in estimating secondary employment. The basic premise of those economic analyses is that estimates of employment can be estimated using business activity (i.e., industry spending or sales to final demand). Employment as function of business volume is a fundamental component of input-output analysis. However, a more direct approach to estimating secondary employment based on changes in petroleum sector activity was adopted that used the relationship between employment in basic-sectors (industries that bring money into a region) and non-basic sectors (industries that provide support and service to basic-sector industries). Using the ND Economic Base data set (Coon et al. 2012), estimates of direct employment in basic sector industries were estimated for western North Dakota and for the state. By definition, subtracting basic-sector employment from total employment would yield secondary or non-basic sector employment. An overall relationship (ratio) based on employment between basic-sector and non-basic sectors was developed. The basic-sector to non-basic-sector employment ratio could be further refined if employment was pro-rated by an industry's percentage of the region's economic base.

Using an approach that examined changes in observed employment in western North Dakota produced two results. First, the overall relationship between number of basic sector jobs and non-basic sector jobs revealed job creation by basic sector industries to be much less than expenditure-based or sales to final demand-based approaches. Second, on the margin, additional basic-sector employment in recent years has not added employment at a rate equal to the overall ratio. For example, in 2005, oil producing counties in western North Dakota had an estimated 11,600 basic-sector FTE jobs, total FTE employment of 34,600, and non-basic sector employment of 23,000 (34,600-11,600). These estimates produced a ratio of about 2 non-basic sector jobs per 1 basic sector job. In 2010, that ratio was down to 1.4 non-basic sector jobs per 1 basic sector job. Therefore, recent ratios of basic-sector to non-basic sector employment are lower than previously observed. For example, the change in basic sector employment from 2009 to 2010 in the oil producing counties was estimated at 4,338 FTE jobs; however, total employment only increased by 6,526 FTE jobs. So, from 2009 to 2010, western North Dakota added 4,338 basic-sector jobs and added 2,188 non-basic sector jobs (6,526-4,338). On the margin, each additional basic sector job equaled 0.5 secondary jobs. Further, examination of the economic base (dollars flowing into the region) showed a 187 percent increase in real terms from 2005 to 2010. The economy has increased substantially as measured by business volume, yet those increases in business volume have not produced proportional changes in employment.

Re-calibration of an input-output model to match the current conditions in the oil patch with respect to creation of secondary employment would be clearly beyond the scope of this project. And, future projections based on existing models and coefficients clearly appear to overestimate secondary employment. Estimates of secondary employment were therefore based on using separate coefficients for secondary employment for associated with temporary and permanent workforce in the petroleum sector.

Temporary and Permanent Employment

The rationale for treating temporary and permanent workforce differently was that the characteristics of each type of workforce result in different demand for goods and services in the economy. Service requirements for a permanent worker who owns a house, has a family, and purchases nearly all of his goods and services in the regional economy are clearly different than a temporary or non-resident worker who potentially sends a portion of his personal income to another state, leaves the state during his off-work time, or lives in temporary housing arrangements. The two types of workers have different demands for goods and services while living and working in western North Dakota.

Another rationale for treating temporary and permanent workforce differently is that it is expected that employment in the oil patch will transition to a more permanent workforce over the next decade. Also, it is expected that housing and other constraints to adding employment in the region would lesson over those same periods. As constraints are lessened, and as the workforce transitions to more permanent workers, the expectation is that secondary employment would more closely resemble long-term relationships between basic-sector employment and non-basic sector employment, or potentially reflect the relationships observed with current I-O models. Currently, overall employment in the petroleum sector is dominated by temporary workforce. Considering the constraints to expanding employment (e.g., housing, wages, labor supply) near-term estimates of regional secondary employment from the industry will be more reflective of the lower coefficient associated with a higher percentage of workforce representing temporary workers. Over the next decade, estimates of secondary employment from the petroleum sector will be more reflective of the higher coefficient associated with a larger permanent workforce. If those dynamics hold, the coefficient for secondary employment (averaged across all petroleum sector employment) will change over time. Because of the expected changes in workforce, secondary employment modeling must be dynamic, and not rely on static coefficients.

Comparing Direct Employment Coefficients with Total Employment Multipliers

One of the ways to gauge the potential employment output of existing models is to calculate ratios of direct to secondary employment. That assessment was conducted for both RIMS II and IMPLAN, and although the methods to derive the ratios were different, results were somewhat similar between the models. Also, estimates of measured secondary employment with the ND I-O model were examined.

RIMS II

Another approach to determining an appropriate coefficient for secondary job creation was to examine the matrix of RIMS II total employment multipliers (on an FTE basis) by economic sector and subtract Oil and Gas Division (2012) direct labor coefficients (on an FTE basis) to determine the net gain in secondary employment.

State-level type II RIMS II final demand employment multipliers[2] were examined for several sectors that contain direct employment in the petroleum industry in North Dakota. The sectors that contained substantial direct employment in the Oil and Gas Division coefficients included Oil and Gas Extraction (NAICS 21), Support Activities for Mining (NAICS 21), Petroleum and Coal Products Manufacturing (NAICS 31-33), Construction (NAICS 23), and Transportation (NAICS 48-49). The sectors of Government (NAICS 92) and Professional Services (NAICS 54) were omitted from the analysis due to relatively low levels of direct employment in the Oil and Gas Division coefficients.

The employment matrix for RIMS II for Oil and Gas Extraction, Support Activities for Mining, Petroleum and Coal Products Manufacturing, Construction, and Transportation sectors was examined to first estimate the FTE coefficient for secondary employment per unit of direct employment. That coefficient (or ratio) was estimated by subtracting direct employment coefficients from the matrix of total employment coefficients (i.e., summed across all 2-digit NAICS codes). Next, Oil and Gas Division (2012) labor coefficients were adjusted to match the above RIMS II economic sectors. For example, the other direct labor requirements on a FTE basis (values divided by NAICS 21) were estimated for drilling, fracing, and well servicing, and when appropriate, direct employment coefficients were put into the most applicable RIMS II sector. The gas processing coefficient, part of the well servicing labor requirement, was placed into the Petroleum and Coal Products Manufacturing RIMS II sector and labor for movement of oil and gas, also part of the well serving labor requirement, was placed in the Transportation sector. This process was repeated for Oil and Gas Division (2012) coefficients for drilling and fracing employment and construction employment associated with gathering systems.

Next, the other direct labor coefficients (estimated on an FTE basis to employment in NAICS 21) were subtracted from the RIMS II coefficient to represent the ratio of secondary to direct (on an FTE basis) employment. This process was repeated across the other economic sectors. The result of this analysis produced a net gain in secondary employment associated with direct employment (on an FTE basis) in that sector (remember, the RIMS II sectors were aligned with specific labor needs in the petroleum industry).

The last part of the analysis was to provide the proper weighting across all the sectors. Total employment in the petroleum sector in 2011 was divided into *Oil and Gas Extraction*, *Support Activities for Mining*, *Petroleum and Coal Products Manufacturing*, *Construction*, and

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[2] Type II coefficients include both indirect and induced employment. Indirect is employment supported and created through the acquisition of goods and services associated with business operations. Induced is employment created through the consumption of goods and services of direct labor in an industry and from consumption of goods and services associated with increases in indirect labor. In regional impact assessment, impacts from induced consumption can be of greater magnitude than indirect impacts. These conditions can be especially noticeable in rural, less developed regions where the production-related purchases associated with indirect consumption are likely to result in acquisition of inputs from outside the region. These conditions are also more prevalent when regional changes in employment are derived from high wage industries. The above conditions describing observed economic impacts reflect current conditions in many regions of western North Dakota and the greater Williston Basin.

Transportation using rig counts, well counts, and the Oil and Gas Division (2012) labor coefficients. The percentage of direct employment in those sectors was multiplied by the secondary coefficient from the RIMS II analysis for those same sectors to arrive at a weighted average for the petroleum industry. This approach accounted for some employment being measured as direct employment in the industry that would, in many input-output models, be considered as secondary employment.

Multiplying traditional secondary job coefficients (i.e., on an FTE ratio to direct jobs) by estimates of direct labor (on an FTE basis) in the petroleum industry will overstate secondary job creation because some secondary job creation is by definition already been included in the coefficients for direct labor. For example, the coefficient for direct employment associated with oil field service includes jobs in manufacturing (gas plant jobs) and jobs in transportation (pipeline jobs). Jobs in manufacturing and pipeline operation are part of the estimate of secondary employment in the employment matrix for RIMS II. The use of unadjusted secondary coefficients would result in double counting.

An examination of RIMS II Type I versus Type II final demand employment multipliers revealed that a greater portion of employment was due to induced effects than indirect effects. This pattern is consistent with high wage industries operating in less developed, rural economies.

IMPLAN

Access to IMPLAN was limited for this assessment, but a comparison of model predictions for direct employment and secondary employment (induced and indirect) was conducted for output from NAICS code 211. IMPLAN estimated that for every 1 FTE in direct employment an additional 0.55 FTE in secondary employment was generated. Induced employment was twice the rate of indirect job creation, similar to the observations found with RIMS II multipliers. However, the petroleum industry did not add direct employment at the rate suggested by IMPLAN. Therefore, it is likely that the level of induced employment growth would also be overestimated as much of the induced employment change would be derived from an exceedingly overestimated level of direct employment. In other words, the model produced induced employment based largely on the personal spending associated with a change in the direct employment workforce equal to 37,000 workers. Using Oil and Gas Division labor coefficients with a change in well counts, it was estimated that the state added about 2,000 jobs associated with the sale of oil and gas over the period. Removing the personal spending associated with 35,000 jobs is likely to substantially reduced predicted levels of induced employment.

ND Input-Output Model

The North Dakota Input-Output Model (I-O) does not produce separate estimates of indirect and induced business volume, but rather reports both effects as one estimate for each sector of the model based on assignment of direct impacts in a given economic sector. The model uses interdependent coefficients, similar to other input-output models, to provide estimates of gross receipts per sector. The sum of the gross receipts is termed gross business volume. Sector-specific secondary business activity is estimated by subtracting sector-specific direct impacts (inputs to the model) from gross receipts per sector. The modeling process relies on productivity ratios to estimate secondary economic employment from those estimates of secondary business volume (gross receipts less direct impacts). Productivity ratios represent a measure of the amount of business activity needed in an economic sector to support one full-time job. To estimate productivity ratios, gross business volume for the entire state and for various regions are estimated using data from the Economic Base Data set. North Dakota's economic base is estimated independently. Output from the model is then used with employment data to estimate productivity ratios. These productivity ratios become the metric used to estimate secondary employment for various projects, programs, activities, or industries in North Dakota when changes in business volume are estimated using the ND I-O Model. Thus, the North Dakota I-O Model both requires, and contributes, to the Economic Base Data set.

Since the North Dakota I-O Model uses industry expenditures to examine economic impacts in North Dakota, a direct comparison of the ND I-O Model using the same oil and gas sales figure used with RIMS II and IMPLAN would not work without translating sales volume into industry expenditures. Instead, an alternative assessment would be to examine output from the model from previous industry assessments.

In 2011, methods used to estimate secondary employment underwent revision as a result of comparing expected changes in estimates of secondary employment to observed changes in employment overtime within the state, and indirect comparisons of secondary employment estimates from other I-O models. Studies with the most recent methodology show that ratios of secondary employment to direct employment in different industries vary from 1:1 with information-based industries (Bangsund et al. 2010, Coon et al. 2012a) to ratios about 2-2.5:1 for capital-intensive industries (Coon et al. 2012b, Bangsund and Leistritz 2010). Informational-based industries would be similar to the North Dakota University System (i.e., higher education), and examples of capital-based industries would be the ND Lignite Industry and the Petroleum Industry.

While the ND I-O model uses a different methodology to estimate secondary employment compared to other I-O models discussed in this report, like other I-O models, it is not calibrated to accurately reflect the employment dynamics in western North Dakota. As such, the ND I-O model also would over estimate likely changes in secondary employment associated with the constrained economic conditions in the Williston Basin.

Literature Review

The impacts of energy development have been examined at great length and in great detail for as long as fossil fuels have served as the primary source of energy in the United States. A brief examination of literature was conducted to gain insight on the issues examined in this report. Recent shale gas plays appear to be the most relevant to current energy development in the Williston Basin.

An impact on communities and regional economies from a rapid influx of workers is a key and reoccurring theme associated with rapid natural resource development. These impacts have been categorized into distinct periods that coincide with the type and focus of industry activities (Jacquet 2009, Macke and Gardner 2012). Others have described these effects more generally in terms of how they translate into community-level impacts (Leistritz et al. 1982, Seifert 2010, Putz et al. 2011).

Generally, rapid natural resource development resulted in wage escalation, labor force shortages, housing shortages, increased cost of living, and strain on local private and public resources. Effects have both short and long-term consequences of those effects.

In the short-term, local economies are disrupted as effects of rapid population and employment growth strain local infrastructures. These conditions result in shortages for housing, labor, and regional resources (Macke and Gardner 2012, Jacquet 2009, Putz et al. 2011, Seifert 2010). The competition for resources also prevents local economies from adding employment in other sectors of the economy especially those that rely on lower wage employment (e.g., retail trade, lodging, consumer services). Conditions constrain or restrict employment in other sectors of the local and regional economy preventing other sectors of the economy from expanding and may even lead to contractions in other sectors. Current conditions in the Williston Basin are consistence with a constrained economy.

Competition for labor, housing, and regional resources are long term effects associated with a decline in the overall economic health of other industries (Macke and Gardner 2012, Farren et al. 2012, Putz et al. 2011, Headwaters Economics 2008, Humphreys 2007). These effects have been referred to as resource curse, crowding out and Dutch Disease. Regardless of the name, local and regional economies that experience rapid growth have less diversity, less resiliency, and are more likely to have reduced economic output in the long run. New industries are frequently stifled (Seifert 2010).

Crowding out effects can also be illustrated by evaluating changes in basic-sector employment relative to non-basic sector employment. An assessment by Seifert (2010), using QCEW data from Job Service North Dakota, revealed that employment is becoming less diverse in the Williston Basin as the regional economy experiences substantial growth in oil and gas industry employment. Observations from the North Dakota Input-Output Model Database reveal a similar trend as the ratio of basic-sector employment to non-basic sector employment is increasing in the Williston Basin (Coon et al. 2012). [See discussion on page 14 regarding the North Dakota I-O Model database analysis].

The effects of rapid resource development can vary dramatically among affected communities (Jacquet 2009, Putz et al. 2011). Observations in the Williston Basin would confirm that the effects of rapid development have not been shared equally between the region's major trade centers of Williston, Dickinson, and Minot.

Some of the factors discussed in previous sections describing constraints to job creation [See discussion on pages 8-9] are consistent with observations of crowding out effects during the development phase of oil and gas resources. Employment is becoming less diverse in the Williston Basin which may affect the long-term viability of existing industries in areas experiencing rapid development of natural resources.

A brief examination of literature pertaining to employment effects associated with rapid development of natural resources reveals that local and regional economies often experience negative short-term and long-term consequences as a result of competition for labor, housing, services, and other resources necessary to support development. These effects are being observed in the Williston Basin, and require careful consideration when developing employment forecasts.

Summary and Implications

The primary objective of this study was to document the methodology used to estimate direct employment in the oil and gas industry using physical measures of industry activity (e.g., rig counts, well counts) and examine the applicability of using traditional methods to estimate secondary job creation. The model was used to produce employment estimates that would be compatible with planning and forecasting tools and model that require employment delineated into various economic sectors. Existing models assume labor is largely dominated by a permanent workforce in an unconstrained economy.

Labor coefficients obtained from Oil and Gas Division of the North Dakota Department of Mineral Resources were used to construct a model to estimate direct employment in the industry based physical changes in sector activity. Per-unit labor requirements were adjusted over time to reflect new technologies and practices that would reduce future labor requirements. Finally, the model used Oil and Gas Division data to track employment across various economic sectors thereby addressing shortcomings associated with standard employment data to track jobs in the oil and gas industry.

The applicability of various methods to estimate secondary job creation was evaluated in two phases. The first phase examined how accurately currently accepted input-output models (ND Input-Output Model, IMPLAN and RIMS II) estimated changes in direct employment in the industry using traditional inputs. IMPLAN suggested that the change in the volume of oil and gas sales for North Dakota from 2005 through 2010 would require 37,000 direct jobs in the oil and gas industry. A corresponding figure for RIMS II using the same approach was estimated to be slightly over 20,000 FTE direct employment. Oil and Gas Division employment coefficients and the change in the number of producing wells in the state over the period produced a change in direct employment of around 2,000 FTE jobs.

The second phase of the assessment examined secondary job creation. Secondary employment was estimated using the ND Input-Output Model, IMPLAN and RIMS II. Next, estimates of secondary jobs were placed on a per-FTE basis (ratio to direct employment). Finally, estimates of employment change from the various models were compared to observed changes reported by the North Dakota Economic Base Data set. The analysis revealed that, on an FTE-basis, the ratios of direct to secondary employment produced relatively consistent results.

While secondary job creation on a FTE-basis, was consistent among the models, the approach had substantial problems. Existing coefficients (ratios) come from models that are poorly calibrated for the economic conditions in the Williston Basin. The current workforce is currently dominated by temporary workers which makes using labor coefficients that were based on economic responses in an unconstrained economic environment problematic.[3] A key assumption of input-output models related to estimates of secondary employment

[3]An implicit assumption of input-output models is that supplies to raw materials and labor are only limited by demand.

(induced jobs) is that an expansion in direct employment leads to an increase in personal consumption.

What is clear is that forecasts of petroleum sector employment in the Williston Basin cannot use traditional models and approaches and expect realistic results. Traditional models likely overestimate both direct and total employment. Traditional inputs (oil and gas sales) used with the I-O models produced estimates of direct employment that directly correspond to permanent workforce in the industry. Permanent employment largely consists of jobs associated with oil and gas output–well maintenance, oil field service, and oil and gas processing. Since permanent employment is the one metric used to most closely predict future long-term demand for services and infrastructure associated with resource development, it is the most critical component of any planning process. Overestimating direct employment can lead to overestimating secondary employment. Inflated estimates of secondary employment estimates can lead to overblown population estimates which are especially problematic when those figures are used to develop plans and policies to accommodate those population changes.

The best approach to forecasting future direct employment change is to carefully monitor physical changes in the industry, and adjust for changing expectations for the rate and extent of oil field development. It is also important to adjust labor efficiencies in direct employment, particularly those that would affect long-term permanent workforce. Finally, the employment situation in the Williston Basin is rife with change, and employment dynamics will likely continue to make employment forecasting challenging in the next decade. Findings of the study suggest secondary employment will be constrained, however those constraints must be adjusted over time. Modeling efforts should also take into consideration the differences between temporary and permanent workforce. The approach adopted here is dynamic uses of measures of physical industry activity, adjusts labor efficiencies over time, and incorporates a current understanding of workforce characteristics.

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