USING IMPLAN TO PROPERLY MODEL OIL AND GAS OPERATIONS IN THE ROCKY MOUNTAIN REGION

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Introduction

Challenges associated with modeling oil and gas development center around the observation that most development activities in the Rock Mountain West occur in rural unpopulated areas. These areas often have economies that are very dependent on one or two industries including oil and gas development or other natural resource extraction industries. These circumstances create certain challenges to using IMPLAN as a tool to evaluating oil and gas development. National production functions used within IMPLAN create other challenges to modeling oil and gas operations given the influence of site specific characteristics on cost functions associated with drilling and production. In addition, challenges occur in properly modeling government revenues directly associated with oil and gas production.

The goal of this paper is to investigate different techniques to modify IMPLAN to more accurately reflect oil and gas operations in the Rocky Mountain Region. To accomplish this goal, oil and gas operations in Southwest Wyoming were modeled. This area was chosen as a case study because of the availability of data and information on operations in this area. Techniques to be examined include 1) modeling input costs of operating wells compared to valuing production; and 2) modifying study area data to more accurately reflect local area characteristics. The results are important to upcoming projects within Wyoming associated with oil and gas operations on lands managed by the Bureau of Land Management. In addition, the research can provide important insights to using IMPLAN in other areas to model oil and gas operations.

Oil and Gas Development in Southwest Wyoming

Wyoming has a long history of oil and gas production. Most of the early development focused on oil production. Depending on whom you believe, Mike Murphy completed drilling the first oil well in Wyoming either in 1883 or 1884 at Dallas Dome in Fremont County near Lander. The state's first oil refinery was built in Casper in 1894. During the early 1900s, oil was discovered throughout northern and eastern Wyoming. The Platte Pipeline, carrying 110,000 barrels of oil a day, was completed in 1952.

In the 1960s oil production stagnated and then peaked in the 1970s. However, natural gas production continued to grow in importance. The Arab oil embargo in the 1970's did not significantly affect oil production in Wyoming, but it did stimulate an exploration and development boom for natural gas. As a result new natural gas fields were found in southwestern Wyoming during the 1980s and 1990s. Between 1990 and 2000, natural gas production in the state increased by 76 percent. The four counties in southwest Wyoming accounted for 63 percent of the state's natural gas production in 2000. This growth has caused Wyoming to become one of the major natural gas production states in the nation.

Case Study

In order to model oil and gas operations using IMPLAN, a case study was developed that reflects operations in southwest Wyoming. This particular case focused on the drilling and operating a conventional gas well that would

produce over several years. The case study was used to estimate the impacts of oil and gas production using different approaches using IMPLAN. This includes modeling input costs and modifying study area data. The following section describes the data sources and methods to estimate the necessary inputs.

For this particular area it was assumed that the gas well would be drilled to a depth of 9,000 feet and produce on average 159,690 MCF of dry gas per year with very little byproducts associated with production. Annual average cost to operate a well of this type and size were obtained from the Energy Information Association and are summarized in Table 1. The average costs shown in this table reflect operation of a gas well producing at 8,000 ft within the Rocky Mountain Region and includes operation and maintenance costs.

Table 1
Direct Annual Operating Costs

	Unit Cost	Units	1999$	Percentage of Total Costs
Direct Labor & Overhead			$5,400	3.8%
Fuel, Chemicals & Disposal			$7,600	5.3%
Surface Maintenance			$11,300	7.9%
Subsurface Maintenance			$2,800	2.0%
Electricity	$0.06	5000 KW/month	$3,600	2.5%
Gas Compression Costs	$0.30	MCF	$47,880	33.6%
Gas Transportation Costs	$400	MMCF	$63,840	44.8%
Total Annual Costs			***$142,420***	
Non-Labor Annual Costs			***$137,020***	
Non-Labor Cost Per MCF			***$0.859***	

Source: Energy Information Administration, Cost and Indices for Domestic Oil and Gas Equipment & Production Operations, 1996-1999

Annual gas processing costs were estimated per MCF using data published in the 1997 Economic Census as summarized in Table 2. Average cost per MCF for Wyoming was estimated at $0.092 per Mcf.

Table 2
Estimated Direct Annual Gas Processing Costs - Wyoming

Total Cost[a]		$129,780,000
Payroll[a]		$37,594,000
Non-Labor Costs		$92,186,000
Total Production (Mcf) for 1999[b]		997,424,673
Non-Labor Cost Per MCF		$0.092

[a] Source: U.S. Bureau of Commerce, Economic Census, 1997.
[b] Source: Wyoming Department of Revenue Annual Report - FY 1998.

Total Industry Output

Secondary data was used to estimate Total Industry Output (TIO) for three industries tied to gas production in southwest Wyoming including:

1. Production (IMPLAN Sector 38)
2. Gas Processing (IMPLAN Sector 39)
3. Oil and Gas Services (IMPLAN Sector 57)

Gas production for 1999 for each of the counties in the study area (Lincoln, Sublette, Sweetwater and Unita) was obtained from the Wyoming Department of Revenue, Annual Report for production year 1999 as summarized in Table 3.

Table 3

Total Gas Production - 1999 (MCF)

Lincoln County	103,118,425
Sublette County	242,364,103
Sweetwater County	203,122,623
Uinta County	179,537,021
Total	**728,142,172**

Total labor for oil and gas operations in southwest Wyoming was estimated with data from two different sources. First, mining employment was obtained from Regional Economic Information System (REIS) database for 1999.[1] This includes oil and gas operations as well as other mining activities. The Annual Report of the State Inspector of Mines of Wyoming was used to determine mining employment for relevant sub-industries such as coal, trona, sand and gravel and miscellaneous, but not oil and gas production. The residual jobs between these two sources were determined to be oil and gas employment (2,674) for southwest Wyoming for 1999. Using the estimated employment for oil and gas operations, total labor income was estimated with information on average earnings per job (AEPJ) from REIS as summarized in Table 4.

Table 4

Labor Income – Oil and Gas for Southwest Wyoming

Employment	2,674
AEPJ	$53,165
Total	$142,163,210

The distribution of employment and income for each of the sectors tied to gas production in southwest Wyoming was estimated as summarized in Table 5. The percentage of employment and income by subsector was estimated using state averages from the Wyoming Department of Employment. These percentages were then applied to the employment and income totals for southwest Wyoming. Employee Compensation and Proprietor Income were estimated using percentages obtained from the U.S. Department of Commerce.

TIO was then estimated for the production and process subsectors as summarized in Table 6 and the service sector as shown in Table 7. For the production and service subsectors, TIO (Cost Basis) was calculated by adding cost of production to employee compensation and proprietor income. Data from the 1997 Economic Census was used to estimate TIO for the service subsector. Total employment for this subsector as estimated in Table 6 was multiplied the value of output per job taken from the census data. This resulted in a TIO of $244 million. Value added was assumed to by 72.8 percent of TIO based on the census data. Other property income (OPI) and indirect business taxes were estimated to be a percentage of value added.

[1] U.S. Department of Commerce, Economics and Statistics Administration, Bureau of Economic Analysis

Table 5

Estimated Study Area Data for Southwest Wyoming - Production, Process, and Services

	Employment			Income				
Industry	Wyoming[a]	Percent	Southwest WY	Wyoming[a]	Percent	Southwest WY	Employee Comp.	Proprietor Income
							@ 65.4%[b]	@ 34.6%[b]
Production	2,463	31.2%	835	$128,825,888	38.7%	$55,056,442	$36,006,913	$19,049,529
Process	111	1.4%	38	$7,477,562	2.2%	$3,195,693	$2,089,983	$1,105,710
Services	5,313	67.4%	1,801	$196,342,488	59.0%	$83,911,075	$54,877,843	$29,033,232
Total	7,887	100.0%	2,674	$332,645,938	100.0%	$142,163,210	$92,974,739	$49,188,471

[a] Source: Wyoming Department of Employment

[b] Source: U.S. Department of Commerce

Table 6

Total Industry Output (Cost Basis)

	Production	Process
Employee Comp	$36,006,913	$2,089,983
Proprietor Income	$19,049,529	$1,105,710
Cost of Production	$625,125,566	$67,297,828
Total Industry Output	$680,182,008	$70,493,521
Cost/MCF	$0.934	$0.097

Table 7

Total Industry Output - Service Subsector

Employment	1,801
Output/Job	$124,416
Total Industry Output	$224,112,259
Value Added @ 72.8%	$163,153,724
Employee Compensation	$54,877,843
Proprietor Income	$29,033,232
Other Property Income	$64,820,487
Indirect Business Taxes	$14,422,162

TIO was also estimated for each sector using a value of production basis for 1999. The value of oil and gas production is shown in Table 8 for the four county study area and was estimated with data from the Wyoming Department of Revenue.

Table 8

Total Industry Output (Value of Production Basis)

County	Gas (MCF)	Oil (Barrel)	Total
Lincoln	103,118,425	840,374	
Sublette	242,364,103	2,705,264	
Sweetwater	203,122,623	4,478,687	
Uinta	179,537,021	4,646,759	
Total	728,142,172	12,671,084	
Price/Unit	$2.06	16.44	
Value of Production	$1,499,972,874	$208,312,621	$1,708,285,495

Value of production was then used to estimate value added components for the three subsectors for the study area as shown in Table 9. For the production subsector total value added was estimated by subtracting the cost of production, calculated in Table 7 from total industry output. OPI and IBT were then estimated as a percentage of total value added. For the processing sector, total industry output was assumed to be twice total value added which is equal to cost of production. OPI and IBT were then estimated as a percentage of total value added.

Table 9

Value Added for Production, Processing and Services - SW Wyoming

VALUE ADDED	Production	Processing	Services
Employee Comp	$36,006,913	$2,089,983	$54,877,843
Proprietor Income	$19,049,529	$1,105,710	$29,033,232
Other Prop Income	$865,663,136	$53,973,998	$64,820,487
IBT	$162,440,351	$10,128,137	$14,422,162
Total Value Added	$1,083,159,929	$67,297,828	$163,153,724
TIO	$1,708,285,495	$134,595,656	$224,112,259
Employment	835	38	1,801

Modeling Oil and Gas Operations Using IMPLAN

Potential impacts of drilling and operating oil and gas wells in southwest Wyoming were estimated by examining the results of several IMPLAN model runs. For each event impacts were estimated as $1 million in expenditures for the oil and gas production (38), natural gas liquids (39) and services (57). For each of these sectors two IMPLAN model runs were completed. The first run used IMPLAN without making any adjustments to the study area data. The second run for each event modified IMPLAN to reflect local area data as described in the previous section.

In addition, the modified IMPLAN model was used to examine impacts if modeled from a cost basis. For this event, the costs to operate a well were estimated as follows. In Table 10, the total costs of production were distributed within several cost categories as shown in the first column. Labor income was assumed to be the sum of employee compensation and proprietors income as estimated in Table 10 for production. All other costs were estimated as a percentage of total cost of production with the percentages estimated in Table 1 from EIA data. Column 4 shows the gross inputs per $1 million in expenditures as estimated by multiplying $1 million by the percentage of costs shown in column 3. These costs were then distributed to appropriate IMPLAN sectors as summarized in column 5 that results in the regional inputs by category in column 6. The results of each model run are summarized in Table 11.

Table 10

Regional Inputs for Gas Well in Southwest Wyoming

Cost Category	Total Cost of Production by Cost Category	Percent of Costs	Gross Inputs per $1 Million in Expenditures	IMPLAN Sector	Regional Inputs
(1)	(2)	(3)	(4)	(5)	(6)
Labor Income	$55,056,442	8.1%	$32,229	66.7% -10008	$21,497
Fuel, Chemicals, Disposal	$34,673,437	5.1%	$20,297	2/3(M) - 447 & 1/3 57	$8,791
Surface Maintenance	$51,553,926	7.6%	$30,179	90% - 57	$27,161
Subsurface Maintenance	$12,774,424	1.9%	$7,478	90% - 57	$6,730
Electricity	$16,424,260	2.4%	$9,614	443	$9,614
Gas Compression	$218,442,652	32.1%	$127,873	90% - 57	$115,085
Gas Transportation	$291,256,869	42.8%	$170,497	92% - 444	$156,857
Total	**$680,182,008**	**100.0%**	**$398,167**		**$345,736**

Table 11

Comparison of IMPLAN Model Runs for Oil and Gas Sectors

	Production			Natural Gas Liquids		O&G Services	
Direct Impacts	**1999 IMPLAN**	**Modified IMPLAN**	**Cost Basis**	**1999 IMPLAN**	**Modified IMPLAN**	**1999 IMPLAN**	**Modified IMPLAN**
Employee Comp.	$78.443	$36.007		$4.533	$2.090	$19.324	$54.878
Proprietor Income	$36.676	$19.049		$2.003	$1.106	$10.153	$29.033
Other Property Income	$168.182	$865.663		$29.185	$53.974	$13.479	$64.820
Indirect Business Taxes	$31.482	$162.440		$5.463	$10.128	$2.991	$14.422
Value Added	$314.783	$1,083.159		$41.184	$67.298	$45.947	$163.153
Employment	1,563	835		63	38	651	1,801
Total Industry Output	$467.261	$1,708.285		$79.102	$134.596	$87.493	$224.112
Per Worker:							
Output	$299,022	$2,045,850		$1,265,539	$3,542,000	$134,488	$124,438
Earnings	$73,670	$65,935		$104,581	$84,105	$45,309	$46,591
Impacts Per $1MM							
Direct Output	$1,000,000	$1,000,000	$383,179	$1,000,000	$1,000,000	$1,000,000	$1,000,000
Total Output	$1,396,988	$1,324,049	$562,872	$1,484,631	$1,435,906	$1,350,617	$1,246,453
Multiplier	1.397	1.324	1.469	1.485	1.436	1.351	1.246
Direct Employment	3.3	0.5	0.5	0.8	0.3	7.4	8.0
Total Employment	7.4	2.9	4.0	5.0	3.5	12.6	12.0
Multiplier	2.242	5.800	8.000	6.250	11.667	1.703	1.500
Direct Labor Income	$246,369	$32,229	$32,229	$82,637	$23,745	$336,902	$374,415
Total Labor Income	$360,853	$109,003	$160,016	$218,775	$126,396	$453,005	$456,452
Multiplier	1.465	3.382	4.965	2.647	5.323	1.345	1.219
AEPJ	$48,764	$37,587	$40,004	$43,755	$36,113	$35,953	$38,038

Analysis and Conclusions

In comparing the results for these model runs, several observations are apparent.

- Study area data in the unmodified IMPLAN model varies significantly for two of the three sectors (38 and 39) related to oil and gas operations in Southwest Wyoming as compared to estimates derived from secondary data sources.
- Impacts estimated with the unmodified IMPLAN model tended to be greater than those estimated with the modified IMPLAN model for production and natural gas liquids.
- Impacts estimated with the modified IMPLAN model using the value of production and cost basis produced similar impact results, especially when compared to the impacts estimated with the unmodified IMPLAN model.
- Impacts associated with the oil & gas services sectors were similar using the two IMPLAN models.

One goal of this paper was to evaluate the implications for modeling the value of gas production as compared to modeling the cost of operating and maintaining a conventional oil and gas well. The results of the model runs presented above indicate that modifying study area data to reflect local conditions will likely improve the results whether using a value of production or cost basis approach. For example, the model based on the original IMPLAN data estimates 5,637 direct jobs in oil and gas production based on the 1999 production levels for the four-counties. However, REIS indicates only 5,664 total mining jobs in the four-county area. Total mining jobs would include coal mining, trona mining, sand and gravel operations, natural gas liquids, oil and gas field services, and miscellaneous mining. Based on the original IMPLAN estimates these other mining activities support only 27 jobs in the region. This result is clearly at odds with the level of other mining activity present in the region and over 6.5 times greater than the employment estimated with the modified model.

However, an important question remains on which approach produces the most accurate results (value of production vs. input costs). For rural areas such as southwest Wyoming, it is likely that much of the income generated from oil and gas production leaves the area. This is important due to the fact that many of the large and medium sized companies are headquartered outside of the economic study area.

Given this observation, it appears more accurate to model cost of operating and maintaining these wells than actual production. This has two benefits. First, it appears to more accurately reflect total value added and employment impacts for rural areas. Second, it reduces the uncertainty in estimating the value of oil and gas production in any given year due to great variations in commodity prices. For example, in 2001 the monthly average price of natural gas at the Opal hub in southwest Wyoming ranged from $8.75 per mcf in January to $1.25 per mcf in October. While variations in price can affect both drilling operations and production levels, it is likely that changes to operations are not proportional to changes in price. Therefore, some level of operations (and costs) will be incurred even with variations in oil and gas prices. However, a cost basis approach presents problems associated with obtaining accurate cost data for operations in different basins throughout the Rocky Mountain West.