HOW OIL PRICES IMPACT THE LABOR MARKET: EMPIRICAL EVIDENCE FROM ALASKA

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THESIS

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Abstract

The present paper uses a linear autoregressive distributed lag (ARDL) approach in order to test for symmetric effects of oil price changes on employment in the oil-industry and employment in non-oil industries in Alaska. The ARDL model allows for the examination of short and long-run effects of employment by changes in crude oil prices, interest rate and personal income. Using quarterly data over the period 1987-2015, the long run results show strong positive correlation of crude oil prices and oil-industry employment and negative correlation between crude oil prices and employment in the non-oil industry in Alaska, supporting the sectoral shift hypothesis. Furthermore, interest rates significantly impact employment in both economic sectors, in the short and in the long run. While a higher interest rate leads to job creation in the oil-industry, it causes job destruction in the non-oil industry.

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Dedicated to my family,

for their unconditional love and support

even in times when supporting me

meant letting me go

to the “other end of the world”.

Danke!

1. Introduction

In January 2016, the West Texas Intermediate (WTI) crude oil price reached the lowest point in over a decade, at only $26.19 per barrel. Only 18 months earlier the price of a barrel of crude oil was over $100 per barrel, about 70% higher than current prices. Although crude oil price volatility mainly originates from international market forces, all economies and regions in the world are impacted by its effects. Consumers in most regions in the world are pleased about the recent decrease in energy prices. Alaskans, however, have ambivalent feelings towards the sudden decline in oil prices. On the one hand, Alaskan consumers and manufactures profit from the decrease in the cost of heating fuel as well as the decline in the price for gasoline. On the other hand, about 30% of the jobs in the state are directly or indirectly connected to the oil industry (Goldsmith, 2008). With oil prices remaining at the current low level, jobs related to the oil and natural gas industry are in danger. Additionally, the state's budget depends on oil revenues unlike most regions of the world. With about 90% of the state's total revenues being attributed to the revenues of the oil and natural gas industry, the state of Alaska faces an estimated budget deficit of about $3.7 billion for the fiscal year 2016 (Alaska Department of Revenue, 2015).

The current budget deficit and hiring freezes in oil companies and governmental agencies due to a sharp fall in oil prices gives rise to the following question: do low oil prices decrease overall employment in the state in the short run, lead to higher unemployment rates in the long run, and are hence bad for the Alaskan economy? This question has motivated the current thesis. To answer it, the thesis empirically examines the dynamic relationship between crude oil prices and the Alaskan labor market. However, it should be emphasized at the onset that, for a careful analysis, it is crucial to divide industries into oil and non-oil industries. In doing so, this thesis can measure the effects of oil price changes on employment in oil and non-oil industries, and overall employment accurately.

The remainder of this thesis is organized as follows. Section 2 discusses the relevant literature. Section 3 introduces an overview of the Alaskan labor market. Section 4 presents the theoretical framework of my work and the empirical model and methods used. Section 5 describes the dataset used for the analysis. In section 6 the empirical results are discussed. Finally, concluding remarks are presented in section 7.

2. Literature Review

Within the theory of the so-called *oil price – macroeconomics nexus*, many studies have sought to investigate the effects of crude oil price changes on employment and unemployment. Examples include Hamilton (1983), Uri (1996), Carruth et al. (1998), Davis and Haltiwanger (2001), Ewing and Yang (2009), Altay et al. (2013), Aminifard and Bahadorkhah (2014) and most recently Senzangakhona and Choga (2015). Most research today is based on the findings from Hamilton (1983) who showed that fluctuation in crude oil prices strongly affect most macroeconomic variables, including unemployment. The Granger causality test, however, indicates that this relationship is unidirectional when analyzing the relation between crude oil prices and unemployment. Crude oil prices strongly impact unemployment but not vice versa. Studies conducted by Uri (1996), Carruth et al. (1998) and Aminifard and Bahadorkhah (2014) support those findings.

In order to test for both short-run dynamics and long-run equilibria, Uri (1996) and Carruth et al. (1998) propose an error correction model (ECM). Uri's findings (1996) are ambiguous: while the results fail to show a correlation between crude oil prices and unemployment rate for U.S. data between 1890 and 1946, the period of 1947-1994 indicates that fluctuations in oil prices have significant and prolonged effects on the unemployment rate. When in disequilibrium, it takes more than three full years before all measurable impacts on the change of unemployment caused by a change in crude oil prices are fully exhausted. Carruth et al. (1998) propose a version of the efficiency wage model with three inputs: capital, labor and the energy input (i.e. oil). The results of the ECM estimation prove integration among unemployment rate, interest rate and oil prices in the United States. The oil price variable is positive and highly significant, suggesting that a positive oil price shock increases unemployment. Using the efficiency wage model of Carruth at al. (1998), Aminifard and Bahadorkhah (2014) investigate the relationship among unemployment rate, crude oil prices and real interest rate in Iran between 1973 and 2012. Applying ECM and a symmetric Autoregressive Distributed Lag (ARDL) model, Aminifard and Bahadorkhah (2014) find long and short-run relationships among all variables. Senzangakhona and Choga (2015) find similar results for unemployment in South Africa between 1990 and 2010. Using vector auto-regression (VAR) methodology, the authors find that crude oil prices impact unemployment in the short and in the long run. While Uri (1996), Carruth et al. (1998), Aminifard and Bahadorkhah (2014) and Senzangakhona and Choga (2015) focus on the relationship between crude oil prices and unemployment within the *oil price –macroeconomics nexus*, Davis and Haltiwanger (2001), Ewing and Yang (2009) and Altay et al. (2013) have sought to investigate relationships between crude oil prices and employment variables. Davis and Haltiwanger (2001), for example, use a VAR model to study the effect of oil price shocks on the creation and destruction of jobs in 20 industries within the manufacturing sector of the United States. The results show that oil price and monetary shocks cause larger response in job destruction than in job creation in most industries. Therefore, the results fail to support the sectoral shift hypothesis that positive and negative shocks should cause the same extent of job reallocation. As continuation of Davis and Haltiwanger's work, Ewing and Yang (2009) compare the effects of a change in crude oil prices on employment in the manufacturing sector and employment in the non-manufacturing sector at the U.S. state level. The results of the Augmented Dickey–Fuller test (ADF) reveal that real crude oil prices and manufacturing employment are strongly cointegrated for most states and on the national level. While the result of the ECM indicate that after an oil price shock oil prices and manufacturing employment in most states slowly revert back to their long-run relationship, the results for Alaska are found to be not statistically significant. Furthermore, only four states show significant results when testing for cointegration between crude oil prices and non-manufacturing employment. Altay et al. (2013) contribute to the research within the *oil price –macroeconomics nexus* by establishing short-run causality between oil prices and output to overall employment in Turkey using vector correction methodology. The results fail to verify the existence of a long-term relationship.

Most countries that have been studied within the *oil price–employment* or the o*il price-unemployment nexus* are oil-dependent countries with oil being one of the major energy input resources for production. In accordance with economic theory, prevalent research shows a positive symmetric relationship between crude oil prices and unemployment and a negative relationship between crude oil prices and employment in various industries. How valid are those findings for an oil producing region like Alaska?

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3. Oil and the Alaskan Labor Market

Only few regions in the world so strongly depend on the oil industry like Alaska. Goldsmith (2011) estimated that without the oil industry, Alaska's economy today would only be half its size. Consequently, low oil prices hurt the whole economy of the state. While in 2014 fiscal funds from oil revenue totaled around \$5.3 billion, the unrestricted revenues decreased to only \$2.2 billion in the fiscal year 2015, leaving a budget deficit of around \$3.7 billion (Alaska Department of Revenue, 2015). The state's total revenue is predicted to be even lower in the fiscal year of 2016. A reason for this tremendous decrease in the state budget, besides low oil prices, is the decline in production numbers. Figure 1 shows the decrease in Alaskan crude oil production and the development of the annual Western Texas Intermediate crude oil price over time.

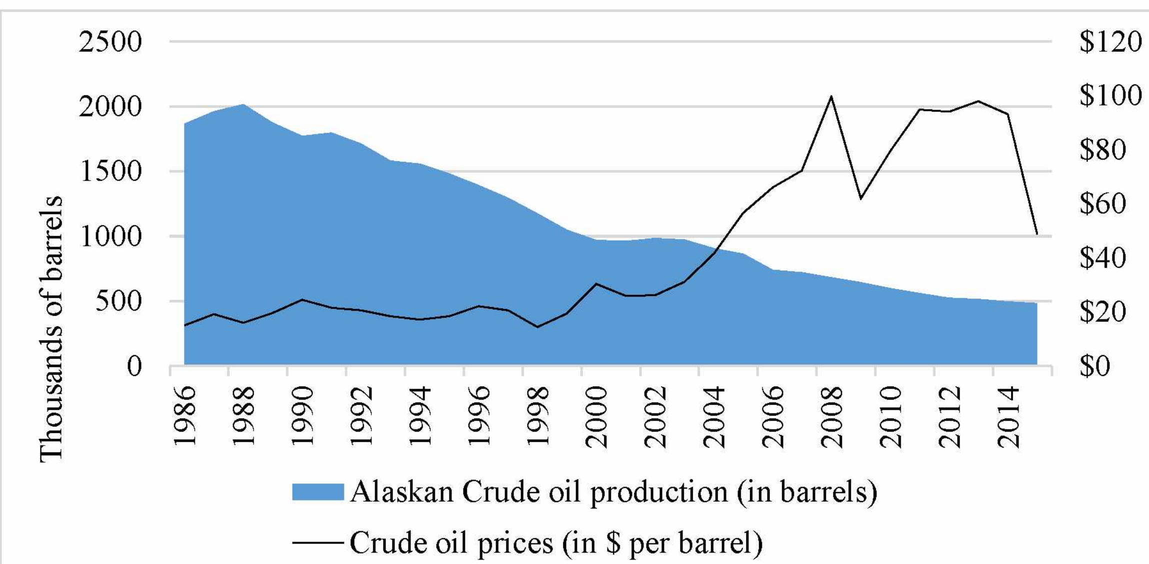

Figure 1: Crude Oil Prices and Crude Oil Production. *Annual crude oil production in Alaska in thousands of barrels and the annual real West Texas Intermediate (WTI) in 2010 U.S dollars per barrel. Data source: U.S. Energy Information Administration (EIA), 2016.*

Revenues are decreasing, yet oil and natural gas production, oil and gas corporate income and oil and gas property tax accounted for almost 75% of the state's total revenues in 2015 (Alaska Department of Revenue, 2015). In addition to enormous tax revenues contributing to the state's fiscal budget, direct and indirect employment by the petroleum industry is another key factor in Alaska's economy. In 2014, around 15,000 Alaskans were employed in the oil and natural gas industry. The average monthly wage for an employee in this industry has been $11,318, more than 2.5 times the average monthly income in all other industries. Because of the payroll impact of the petroleum industry, Alaska ranks first among all states in the U.S. when comparing median wages (Fried, 2015).

Due to those powerful contributions of the oil industry to the Alaskan economy, both through tax revenues and wages, I suggest to divide the Alaskan economy into two industries: the oil industry and the non-oil industry. About 88% of Alaskan residents are currently employed in an industry other than the oil industry. While the oil industry is solely concerned with the exploration of natural gas and crude oil, it is important to note that even though the non-oil industry in Alaska is not concerned with oil exploration itself, it still has strong ties to exploration companies. Goldsmith (2008) estimates that 75% of all state government employment is linked to the oil and gas industry; 33% of jobs in the finance and real estate sector in Alaska depend on the petroleum industry; and so do 27% of the jobs in the construction industry. Thus, about one-third of all jobs in Alaska are in some way connected to the oil industry. Figure 2 shows the division of the Alaskan labor force into oil-industry employment (4.5%) non-oil industry employment (88.3%), and unemployment (7. 2%) in 2014.

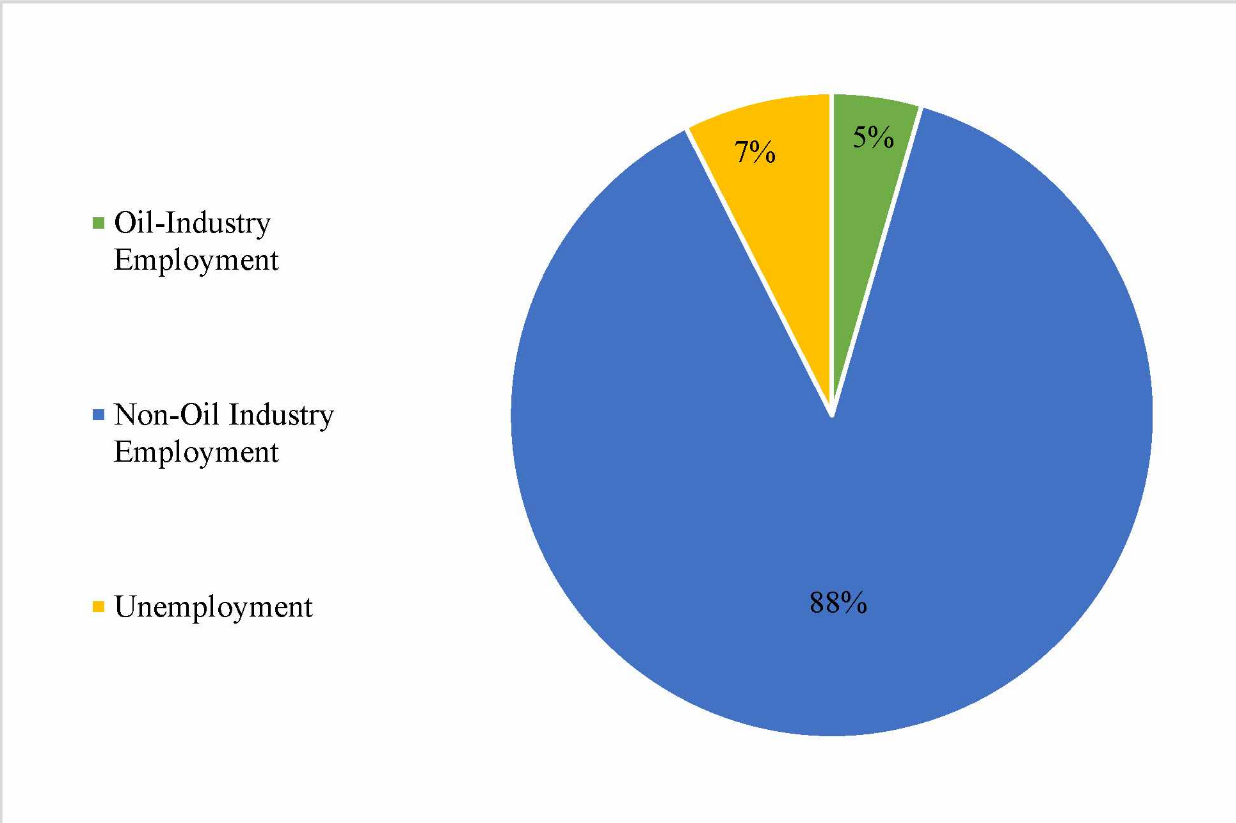

Figure 2: Industry Employment and Unemployment. *2014 Oil industry employment, non-oil industry employment and unemployment as percentage of the sum of total industry employment and unemployment in Alaska. Data Source: Alaskan Department of Labor and Workforce Development, 2016.*

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4. Methodology

4.1 Theoretical Framework

Previous studies sought to investigate transmission channels through which changes in crude oil prices impact employment variables. When allowing for the fact that an economy is composed of different sectors and hence decentralized markets, sectoral shocks have aggregated effects on employment and unemployment (Blanchard and Fischer, 1989). These economic activities can be explained by transmission channels on the micro level and transmission channels on the macro level, namely the efficiency wage model and the sectoral shift hypothesis.

A revised version of the shirking efficiency wage model first established by Sharpio and Stiglitz (1984) is able to explain unemployment on a micro level: during a recession wages would need to fall to account for the decrease in labor demand. Since wages are rigid and firms are not able to renegotiate wages repeatedly, wages do not fall enough and hence unemployment rises. Furthermore, artificial restrictions like trade union monopoly power and minimum wage legislations hold wages above the efficiency wage (Snowdon and Vane, 2005). Carruth et al. (1998) modify the model presented by Sharpio and Stiglitz (1984) by including nonlabor input prices, such as real oil prices and interest rate into the equation. The former assume that labor l, capital k and energy x are the inputs needed to produce a single output with wages w, interest rate r and the exogenous given price of crude oil p^o as prices for the input goods, respectively.

Assuming a constant returns to scale technology, where y $f(...)$ is homogenous of degree one and μ measures neutral technical progress, output y is generated through

$$y = \mu f(l, k, x) \tag{1}$$

and hence the minimum cost function C is defined as:

$$C = \frac{1}{\mu} c(w, r, p^o) \tag{2}$$

Assuming a market with perfect competition, profits are eliminated in equilibrium so p-C=0 where p is the price the output good is sold at. Hence, with an increase of the price of a nonlabor input such as oil, the profit margin erodes. In order to restore equilibrium one other variable needs to adjust. Given that interest cannot be controlled at the individual level but interest rates are controlled by central banks and international markets, the price for labor w must adjust. Since wages are rigid, however, firms need to decrease the overall labor costs by reducing employment in oil-depending industries such as manufacturing. Therefore unemployment rises in the short run. In the long run, workers accept lower wages and voluntary unemployment decreases again.

The version of the efficiency wage model proposed by Carruth et al. (1998) will be used as theoretical framework in order to capture employment changes in the non-oil industry in Alaska. However, in order to understand changes in employment in the Alaskan oil industry, it is important to notice that the single production good produced in the oil industry is crude oil. Therefore, with a change in the exogenous crude oil prices p^o, the price p for the crude oil produced simultaneously increases and hence not only costs but also profits increase. For a perfect competitive oil producing firm, the following equation can be derived:

$$py = wl + rk + p^o x \tag{3}$$

To simplify things, I assume that input prices for crude oil p^o and output prices p are approximately the same ($p \cong p^o$), leading to:

$$p(y - x) = wl + rk \tag{4}$$

The interest rate is exogenous defined as assumed by Carruth et al. (1998) in the equation for the non-oil industry and $y>x$, since an oil producing firm produces more crude oil than it needs as an input good for the exploration. Based on the sticky wage assumption of the efficiency wage model established by Carruth et al. (1998), labor demand will increase. Therefore, the efficiency wage model predicts a positive relationship between crude oil prices and employment in the oil producing industry in the short run.

According to theory, a change in crude oil leads to job creation in the oil industry while it causes job destruction in the non-oil industry. The impact on unemployment depends on the magnitude of those two opposing movements. In the long run, wages adjust or people find higher paying job in another industry. According to the so-called sectoral shift hypothesis, this change reallocates labor across sectors and opens up the possibility of short-run unemployment. Due to the crude oil price shock, the relative demand for labor in one sector increases while the demand for labor in the other sector decreases. Labor, however, is immobile in the short run, but considered fully mobile in the long run (Blanchard and Fischer, 1989). In the short run, employees being laid off in a negatively affected sector cannot instantaneously be reallocated into a positively impacted sector. Due to specific skill sets, time consuming job search and immobility in the short run, aggregated employment decreases. In the long run, however, workers receive industry specific training and are considered fully mobile across sectors (Blanchard and Fischer, 1989). Hence, unemployment is expected to decrease and aggregated employment is expected to return to equilibrium.

4.2 Econometric Models

To examine the *oil-price employment nexus* in Alaska, I followed the studies reviewed in section 3. The following reduced-form equations specify the long-run relationship between oil prices and employment in the oil and gas industry and employment in the non-oil industry, respectively, as follows:

$$OL_t = \propto_0 + \propto_1 OP_t + \propto_2 IR_t + \propto_3 PI_t + \varepsilon_t \quad (5)$$

$$NOL_t = \beta_0 + \beta_1 OP_t + \beta_2 IR_t + \beta_3 PI_t + u_t \quad (6)$$

where OL_t and NOL_t are the logarithms of oil industry employment and employment outside of the oil industry in Alaska, respectively, each as ratio of the overall Alaskan labor force; $OP_t$is the logarithm of crude oil prices, $IR_t$is the interest rate; $PI_t$is the real personal income in Alaska, ε_t and u_t are error terms representing other causes for employment in the respective sectors. As discussed in 4.1, an increase in oil prices could cause the employment in the oil industry to increase while employment outside of the oil industry could decrease, hence the estimates on $\propto_1$and β_1 are expected to be positive and negative, respectively. Even though the oil sector is a powerful determinant of the Alaskan economy due to its wage and tax contributions, the non-oil sector is much larger. Thus, the impact of oil price changes on aggregated employment is uncertain. Since the oil industry is very capital intensive, an increase in interest rate could lead to higher exploration costs and fewer investment spending and therefore reduced employment, hence the estimate of $\propto_2$ could be negative. Same holds for the non-oil sector, thus β_2 is expected to be negative. Finally, if a strong Alaskan economy leads to growth in personal income and hence high employment in both sectors and low unemployment, $\propto_3$ and β_3 are expected to be positive.

In order to examine short and long-run effects of oil price changes on employment in the two sectors, ARDL methodology developed by Pesaran et al. (2001) is used. This allows the variables in each model to be a combination of stationary I(0) and non-stationary I(1) variables when estimating uni-directional relationships. Furthermore, the ARDL approach is capable of estimating short-run and long-run coefficients in a single step. The model is autoregressive, since the dependend variables can be partially explained by the lagged values of itself. To incorporate short-run dynamic adjustments into the estimation procedure, Eq. (5) and (6) are transformed, as proposed by Pesaran et al. (2001), respectively as follows:

$$\Delta OL_t = \propto_0 + \sum_{i=1}^{n1} \propto_1 \Delta OL_{t-1} + \sum_{i=1}^{n2} \propto_2 \Delta OP_{t-1} + \sum_{i=1}^{n3} \propto_3 \Delta IR_{t-1} + \sum_{i=1}^{n4} \propto_4 \Delta PI_{t-1} + \delta_0 OL_{t-1} + \delta_1 OP_{t-1} + \delta_2 IR_{t-1} + \delta_3 PI_{t-1} + \varepsilon_t \quad (7)$$

$$\Delta NOL_t = \beta_0 + \sum_{i=1}^{n1} \beta_1 \Delta NOL_{t-1} + \sum_{i=1}^{n2} \beta_2 \Delta OP_{t-1} + \sum_{i=1}^{n3} \beta_3 \Delta IR_{t-1} + \sum_{i=1}^{n4} \beta_4 \Delta PI_{t-1} + \vartheta_0 NOL_{t-1} + \vartheta_1 OP_{t-1} + \vartheta_2 IR_{t-1} + \vartheta_3 PI_{t-1} + u_t \quad (8)$$

where all variables are the same as previously defined, Δ is the difference operator estimating the short run effects of each explanatory variable and n the number of lags, selected by the Akaike Information Criterion (AIC). This error correction model suggests that the relationship between variables is subordinated to the deviation from long-run effects and changes among other independent variables. The long-run effects, on the other hand, are represented by the lagged level variables with the estimates of δ_1-δ_3 and ϑ_1-ϑ_3 being normalized by δ_0 and ϑ_0, respectively, to form a cointegrating vector. In order to establish joint significance of lagged level variables as evidence of cointegration, Pesaran et al. (2001) recommend using the F-test. Table 1 shows the null hypotheses and their alternatives for the F-tests of the two models used.

Table 1: Null Hypotheses of F-Tests

	Joint insignificance (no cointegration)	**Joint significance (cointegration)**
Model 1: Employment in oil-industry, **Eq. (7).**	$H_0: \delta_0 = \delta_1 = \delta_2 = \delta_3$	$H_1: \delta_0 \neq \delta_1 \neq \delta_2 \neq \delta_3$
Model 2: Employment in non-oil industry, **Eq. (8).**	$H_0: \vartheta_0 = \vartheta_1 = \vartheta_2 = \vartheta_3$	$H_1: \vartheta_0 \neq \vartheta_1 \neq \vartheta_2 \neq \vartheta_3$

Since the asymptotic distributions of the F-statistics are not standardly distributed under the null hypotheses, standard critical values are invalid. However, Pesaran et al. (2001) develop two new sets of critical value which incorporate the properties of the variables. If the obtained F-statistic is greater than the upper critical value, the null hypothesis of joint insignificance can be rejected in favor of the alternative, cointegration.

5. Data

To estimate Eq. (7) and (8), quarterly data covering 1987III to 2015III is used. From 1987-2000, data for the oil industry employment is classified using the Standard Industrial Classification (SIC) 13 and retrieved from the U.S. Bureau of Labor Statistics (BLS). Oil industry employment data from 2001-2015 is classified under the North American Industry Classification System (NAICS) 211000, adjusted for the change in classification system occurring in 2001 and provided by the Alaskan Department of Labor and Workforce Development. The oil industry employment rate is defined as total number of people employed in the oil and natural gas industry in Alaska as percent of the labor force. Data for the total Alaskan labor is obtained from the Alaska Department of Labor and Workforce Development. The non-oil industry employment rate, Eq. (8), is defined as the number of people that are neither employed in the oil industry nor unemployed as percentage of the overall labor force. Unemployed are those who were not employed during the reference week but were available for work except for temporary illness, and had tried to find employment some time during the four-week period ending with the reference period. It is important to note, that due to missing data, self-employed individuals, fishers, unpaid family help, domestics and most individuals engaged in agriculture are not included in industry specific employment data and hence, could not be accounted for in this paper.

The West Texas Intermediate (WTI) spot price, measured in U.S dollar per barrel, is used as a proxy for world crude oil prices and taken form the U.S. Energy Information Administration.

The effective federal funds rate, obtained from the Board of Governors of the Federal Reserve System, is used as a proxy for the cost of capital. Alaska's personal income in levels, measured in thousands of U.S dollars, is used as a proxy for the economic strength of the state and comes from the U.S. Bureau of Economic Analysis (BEA), Department of Commerce (DOC). Crude oil prices and income are deflated by the consumer price index (2010=100) taken from the Organization for Economic Co-operation and Development (OECD). All variables but the interest rate are in logarithms.[1] Table 2 displays a summary of statistic for all data being used in real prices and their leveled values.

Table 2: Summary of Statistics

Variable	Mean	Std. Dev.	Min	Max
OP	$49.83	26.33	$17.18	$125.226
OL	3.18%	0.51%	2.28%	4.16%
NOL	89.52%	1.21%	86.12%	92.21%
UR	7.29%	1.06%	5.38%	10.53%
IR	3.67%	2.71	0.07%	9.73%
PI	$2.65e+07	4923215	$1.98e+07	$3.69e+07

[1] This model specification outperforms an alternative model in which the interest rate is in logarithm in terms of expected signs and number of significant coefficient for all three equations estimated.

6. Empirical Results

In order to use ARDL methodology, all variables should not be I(2) or above and hence have to be either I(0) or I(1). The former have a mean and tend to return to the mean value over time. I(1) processes, on the other hand, will wander widely and only return to an earlier value in infinite time (Granger, 1991). The results of the Dickey Fuller-Generalized Least Squares (DF-GLS) unit root test with time trend are presented in Table 3. The appropriate lag size is determined using the Schwert criterion.

Table 3: Results of Unit Root Test with Time Trend

Variable	Level	First difference	Decision
Oil price	-1.744 (2)	-4.296*** (2)	I(1)
Oil Employment	-1.701 (1)	-5.756*** (1)	I(1)
Non-Oil Employment	-1.737 (1)	-5.965*** (1)	I(1)
Interest rate	-3.589*** (1)		I(0)
Income	-1.202 (1)	-8.663*** (1)	I(1)

*Notes: Lag lengths are determined using the Schwert criterion. *** denotes rejection of null hypothesis at the 1% level.*

The findings show that I fail to reject the null hypothesis of a unit root in levels for all variables but interest rate. Hence the results suggest interest rate is stationary and thus a I(0) variables, while oil price, oil employment, non-oil employment and income are not stationary. When using first differences I reject the null hypothesis at the 1% significance level that the data is not I(1). This suggests that the variables are I(1), non-stationary. Hence, all variables fulfill the requirements to be either I(0) or I(1) and therefore ARDL methodology can be used. It should be noted, that the results of the DF-GLS test with constant term present the same results, namely that all variables are either I(0) or I(1).

The ARDL approach includes three steps: (1) the F-test has to be conducted in order to determine whether the variables are cointegrated, (2) the long-run relationship has to be estimated, and (3) the short-run relationship has to be determined. In order to measure long and short-run relationships, a maximum lag length of four is imposed on all equations. The findings for both equations will be discussed separately in the following sections.

6.1 Results of Oil Price Impacts on Oil Industry Employment

The key results of Eq. (7) are reported in Table 4, where Panels A, B and C show the short-run estimates, long-run estimates and the diagnostic statistics.

Table 4: Full Information Estimate of ARDL Eq. (7)

Panel A: Short-Run Coefficient Estimates			
Lag order	**0**	**1**	
Δ(Oil price)	-0.042 (-1.970)*	-0.072 (-2.969)***	
Δ(Interest rate)	0.009 (4.444)***		
Δ(Income)	0.056 (1.111)		
Panel B: Long-Run Coefficient Estimates			
Constant	Oil price	Interest Rate	Income
-10.786 (-1.153)	0.5 (3.678)***	0.092 (3.052)***	0.569 (1.02)
Panel C: Diagnostic Statistics			
F-statistic	EC_{t-1}	LM	RESET
12.915	-0.098 (-4.341)***	2.006	0.458

Notes: Numbers inside the parentheses are t-statistics. The upper critical bound value of the F-statistic at the 5% significance level is 4.4468, which is computed by stochastic simulations using 20,000 replications. LM and RESET are the Lagrange multiplier test of serial correlation. EC_{t-1} *represents an error-correction term. *** and * denote significance at the 1% and 10% levels, respectively.*

The F- statistic is with 12.915 greater than the upper critical value at the 5% level (4.447) which has been computed by Pesaran et al. (2001) by stochastic simulations using 20,000 replications. Thus, the null hypothesis that *OL, OP, IR* and PI and not cointegrated can be rejected in favor of H_1(cointegration), as previously presented in Table 1. This supports the theory of a long-term relationship among the variables indicating that even though the variables might deviate in the short run, they are expected to return to their mean values in the long run (Granger, 1991). A key assumption made by Pesaran et al. (2001) is that the errors of Eq. (7) have to be serially uncorrelated. The results of the Lagrange Multiplier (LM) test of residual serial correlation (p-value = 0.735) and Ramsey's RESET (p-value 0.766) shown in Table 4, Panel C indicate that I fail to reject the null hypothesis of no serial correlation, suggesting that Eq.(7) is well specified with no evidence of serial correlation.

Panel A provides the short-run coefficient estimates of changes in oil prices, interest rate and income on oil industry employment. The optimal lag lengths according to the Akaike Information Criterion (AIC) is found to be two. The variable OP_t carries two negative coefficients (-0.042 and – 0.072), significant at the 10% and 1% level, respectively. The findings suggest that in the short run an increase in oil prices leads to a decrease in the oil industry employment rate. In the long run, however, the estimated effect of oil prices on employment in the oil industry is positive and highly significant at the 1% level, as shown in Panel B. That implies that even though oil price changes might have negative effects on oil-industry employment in the short run, in the long run an increase in oil prices leads to an increase in the oil-industry employment ratio. Those long-run findings agree with economic theory presented in section 4.1. The estimation predicts that a 1% increase (decrease) in oil prices, would lead to 0.5% increase (decrease) in employment in the oil industry in the long run. This suggests that if oil prices were to stay as low as $33 per barrel as in February 2016 and thus about 66% less than previous prices, the long-run employment in the Alaskan oil and gas industry would decrease by 33% in comparison to total oil industry employment in 2014.

The estimated impact of the interest rate on oil-industry employment is expected to be positive and is significant at the 1% level in the short run and in the long run, suggesting that an 1% increase in interest rate leads to an 0.9% increase in employment in the oil and natural gas industry in the short run and a 9.2% increase in the long run. This finding disagrees with economic theory presented in 4.2 but could be viewed as evidence supporting the so-called Hotelling principle: as interest rates increase, oil producers have an incentive to increase oil extraction in an effort to maximize the rents of extraction that can receive a higher interest rate, which could lead to strong growth of oil and gas employment (Bocklet and Baek, in press).

As of the estimated effects of income, I find that Alaska's income carries positive coefficient in the short run (0.056) and in the long run (0.569). Since wages in the Alaskan oil industry are significantly higher than in the non-oil industry, as discussed in section 3, the positive coefficients agree with economic theory, indicating a positive relationship between oil-industry employment and state income. However, the estimated impacts are found to be insignificant, both in the short and in the long run.

While the variables drift away from equilibrium in the short run, over time they return to their long-run equilibrium. A significant negative coefficient for EC_{t-1} reflects the adjustment towards this long-run equilibrium and the absolute value of the coefficient implies the speed of adjustment. Hence, the very significant coefficient of the error correction term in Panel C (-0.098) implies that approximately 9.8% of the adjustment takes place in one quarter; in other words, it takes over two and half years (1/0.098 = 10.2 quarters) to eliminate the disequilibrium in oil industry employment.

6.2 Results of Oil Price Impacts on Non-Oil Industry Employment

Table 5 displays the short-run coefficients, long-run coefficients and diagnostic statistics on employment in the non-oil industry in Alaska. The optimal lag length of 2 is selected by the Akaike Information Criterion.

Table 5: Full Information Estimate of ARDL Eq. (8)

Panel A: Short-Run Coefficient Estimates			
Lag order	**0**	**1**	
Δ(Oil price)	0.001 (2.102)**	0.002 (2.868)***	
Δ(Interest rate)	-0.003 (-4.409)***		
Δ(Income)	-0.002 (-1.206)		
Panel B: Long-Run Coefficient Estimates			
Constant	Oil price	Interest Rate	Income
0.384 (1.24)	-0.016 (-3.604)***	-0.03 (-3.002)***	-0.02 (-1.095)
Panel C: Diagnostic Statistics			
F-statistic	EC_{t-1}	LM	RESET
12.762	-0.094 (-4.2425)***	0.962	0.218

*Notes: Numbers inside the parentheses are t-statistics. The upper critical bound value of the F-statistic at the 5% significance level is 4.4468, which is computed by stochastic simulations using 20,000 replications. LM and RESET are the Lagrange multiplier test of serial correlation. EC_{t-1} represents an error-correction term. *** and ** denote significance at the 1% and 5% levels, respectively.*

Given the 5% upper critical value of 4.447 developed by Pesaran et al. (2001), the calculated F-statistic of 12.762 is statically significant, supporting the existence of a long-run relationship through joint significance. The Lagrange Multiplier (0.962) and Ramsey' RESET (0.218) tests, implemented to check serial correlation and functional misspecification, suggest statistical insignificance and thus show that the model is well specified with no evidence of serial correlation. The adjustment speed, captured in the coefficient for EC_{t-1}, is -0.094. This indicates that it takes about 2.6 years (1/0.095=10.6 quarters) to move from disequilibrium back to equilibrium.

Both coefficients on crude oil prices presented in Table 5, Panel A, are positive (0.001 and 0.002) in the short run and significant at the 5% and 1% significance level, respectively. Those findings suggest that a 1% increase in crude oil prices leads to a cumulative increase of 0.003% in non-oil industry in the short run. Given the size of the respective coefficient, the short-run impacts of oil prices on non-oil industry employment appear to be small. As for the long-run results, Panel B shows that the variable OP_t carries a negative coefficient, which is strongly significant at the 1% level. This indicates a negative relationship between crude oil prices and non-oil industry employment as proposed in the efficiency wage hypothesis in 4.1.

The estimated coefficient on interest rate is negative and significant at the 1% level in the short run and carries over and increases in sizes in the long run. The results predict a 3% decrease in the non-oil industry employment rate when the interest rate increases by 1%. This suggest that when the cost of capital increases and thence the overall production costs rise, fewer people will be employed in the non-oil industry. This agrees with the economic theory previously presented within the framework of the efficiency wage model.

As of the sign of the income variable, I find a negative relation between personal income and employment in the non-oil industry, suggesting that improved economic conditions in the state do not increase the ratio of people working in the non-oil industry. However, the estimated coefficients, in both short and long run are not statistically significant.

In sum, the results displayed in Table 4 and Table 5 suggest opposing effects of changes in oil prices, interest rate and personal income on the Alaskan labor market, in the short run as well as in the long run. The adjustment speed, when in disequilibrium, is about the same for both industries. Table 6 presents a summary of the main findings obtained from Eqs. (7) and (8).

Table 6: Summary of Major Findings on the Effects of Oil Prices on Oil Industry and Non-Oil Industry Employment

	Employment in Oil Industry	Employment in Non-Oil Industry
Short run		
Oil price	-	+
Interest Rate	+	-
Income	(+)	(-)
Long run		
Oil price	+	-
Interest Rate	+	-
Income	(+)	(-)

Notes: A minus sign "-" indicates a negative relationship between the variable and the respective industry employment; a positive sign "+" indicates a positive relationship between the variable and the respective industry employment. Signs in brackets indicate the respective coefficient is not statistically significant at the 10% significance level.

The table shows the oppositional effects of changes in the variables on the two industrial sectors. It is important to note that the size of the coefficient on oil industry employment exceeds the size of the non-oil industry employment coefficients without exception. Due to the difference in total employment numbers, however, the results fail to provide an accurate answer to the question if the changes in variable cause overall job destruction or creation in the state.

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7. Conclusion

In this thesis, I examined the impact of oil prices on the labor force for an oil producing region, i.e. Alaska. Previous literature suggested dividing the labor force into manufacturing and non-manufacturing industry and failed to establish a long-run equilibrium between crude oil prices and employment in Alaska. Recognizing opposing roles of crude oil in the Alaskan economy, not only as an input good for manufacturing and transportation in the non-oil industry but mainly as output product in the Alaskan oil industry, I separate the Alaskan economy into oil producing and oil consuming industries. Adopting a linear ARDL model for the analysis, this paper captures highly significant long-run and short-run relationships between oil prices and employment in both economic sectors. More specifically, in the long run an oil price increase tends to increase employment in the oil industry and decreases employment in the non-oil industry. Those findings support the sectoral shift hypothesis proposing that in the long run jobs transition from a negatively affected sector to a positively affected industrial sector. While in the short run unemployment rises in order to account for the time needed for the transition from one job to another, in the long run unemployment is not affected. The significant short-run coefficient and the insignificant long-run coefficients of oil prices on unemployment support this theory. However, I fail to prove the existence of cointegration among the independent variables and unemployment.

The existence of cointegration among the selected variables, namely crude oil prices, interest rate and income, and employment in both industries, however, has been proofed. Interest rate and employment in the oil industry are positively related in the short and in the long run supporting the hoteling principle. In the non-oil industry, an increase in the cost for capital leads to job destruction in the short and in the long run. Income appears to be not statistically significant when looking at the distribution of labor in the state of Alaska. Finally, when in disequilibrium, employment in both industries adjusts at about the same speed.

The findings show the ambivalent effects of oil price changes on the Alaskan labor market. Even though about 30% of all jobs in the state are connected to the oil industry, not all sectors of the economy profit from high oil prices. The positive impact of low crude oil prices on employment in oil consuming industries do not completely offset the negative effects of low oil prices on employment in the oil industry. However, the results show that low oil prices are not necessarily bad for the whole Alaskan economy. While the current budget deficit of the state of Alaska suggest a dismal outlook for the state if oil prices were to remain low, the findings suggest that promoting oil consuming industries as well as industries that do not depend on crude oil prices could be the key in order to keep employment rates high. Furthermore, the results of this paper show that in the long run employees will find a job in another industrial sector, supporting the sectoral shift hypothesis. In order to keep unemployment low and income high it is therefore necessary to reduce the time between jobs. To minimize structural unemployment in the state, strong policies need to be implemented providing adequate training for workers to bridge a potential skill gap. Additionally, providing an economic climate in the state that supports businesses and corporations outside of the oil industry should be a first step in reducing the state's dependence on world crude oil prices.

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