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Whose jobs face transition risk in Alberta? Understanding sectoral employment precarity in an oil-rich Canadian province

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ABSTRACT

Labour markets of oil-exporting regions will be impacted by a global transition to low-carbon energy as oil demand reduces to meet the aims of the Paris Agreement. Together with direct job losses in the oil and gas industry, indirect employment effects on other sectors should also be considered to ensure a just transition. We explore these direct and indirect employment impacts that could result from the low-carbon transition by analysing the effect of oil price fluctuations on the labour market of Alberta, a Canadian province economically reliant on oil sands extraction. We employ a mixed methods approach, contextualizing our quantitative analysis with first-hand experiences of career transitions using interviews with oil sands workers. We estimate a vector autoregression for province-wide insights and explore sector-specific dynamics using time series regressions. We find that the price discount on Canadian oil sands, which is determined by local factors like crude oil quality and pipeline capacity, does not significantly affect employment, while the global oil price does. This finding puts in doubt claims of long-term employment benefits from new pipelines. We find that at a provincial scale, oil price fluctuations lead to employment levels also fluctuating. Our analysis at the sectoral level shows that these job fluctuations extend beyond oil and gas to other sectors, such as construction and some service sectors. These findings suggest that the province's *current* economic dependence on oil creates job precarity because employment in various sectors is sensitive to a volatile oil market. Furthermore, due to this sectoral sensitivity to oil price changes, workers in these sectors may be especially at risk in a low-carbon transition and warrant special attention in the development of provincial and national just transition policies. Transitional assistance can support workers directly, while economic diversification in Alberta can reduce reliance on international oil markets and thereby ensure stable opportunities in existing and new sectors.

Key policy insights:

- Decreased global oil demand is likely to create employment risks for workers in Alberta and other fossil fuel producing regions of the world.
- Current economic dependence on oil sands extraction in Alberta leads to job precarity across sectors, including in those seemingly unrelated to extraction. Proactive economic diversification in anticipation of the low-carbon transition could reduce precarity by mitigating the effects of oil price fluctuations on employment levels in the long term.

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- Workers in sectors with higher oil price sensitivity (i.e. oil and gas, construction, professional services, manufacturing, accommodations, and food services sectors) could be prioritized in coordinated just transition policies at the local, provincial, and national scales.
- The details of career transitions gleaned from our interviews suggest that tripartite social dialogue would contribute meaningfully to just transition policy development.

1. Introduction

1.1. Research context and objectives

The Alberta oil sands in Canada are expansive deposits of bitumen found on the Treaty 6 and 8 territories of the Dene, Cree, and Métis First Nations (Black et al., 2014). Oil sands crude is an unconventional oil that accounts for 63% of Canada's oil production (Natural Resources Canada, 2020). Oil sands extraction, representing 11% of the country's greenhouse gas emissions (Environment Canada, 2020), is a critical factor in achieving national emissions reduction targets. Beyond Canada's national context, if global mean temperatures are to be kept below 2°C compared to pre-industrial levels, 85% of its oil sands deposits must not be exploited (McGlade & Ekins, 2015). To limit warming to 1.5°C, the percentage of exploitable oil sands would decrease further.

Alberta's unconventional oil is not only highly carbon intensive, with only Algeria, Venezuela, and Cameroon having a higher upstream carbon intensity (Masnadi et al., 2018), but also relatively expensive to exploit. Driven by oil sands production, Canadian oil has among the highest production costs per barrel in the world (Ihejirika, 2019). A global low-carbon energy transition is expected to eventually peak and lower oil demand with significant socio-economic consequences for oil exporters (Van de Graaf & Verbruggen, 2015). Canadian oil sands are likely to be among the first resources to suffer devaluations and become stranded assets due to their high cost of extraction (Grant, 2018). Beyond asset stranding caused by changing economic conditions, an equitable allocation of extractable fossil fuel resources would also require wealthy, historically-polluting countries to leave high-cost, carbon intensive fossil fuels unexploited (Lenferna, 2018). Canada, and Alberta in particular, must recognise the climate-related transition risks facing the oil sands.

The stressors that could strand oil sands assets over the coming decades would impact employment in the oil sands and in Alberta more broadly. The number of oil sector jobs in Alberta approximately doubled to 140,000 from the late 1990s to the mid-2000s. As the extraction of unconventional Canadian oil becomes uneconomic sooner than the oil resources of most other exporters, employment dependent on the oil sands is volatile, with oil price crashes leading to widespread job losses. Transition risk is usually framed as a risk to high-carbon firms and regions who may eventually be confronted with regulatory and market changes arising from the low-carbon transition. But transition risk also threatens the livelihoods of workers. Just transition, a term first used by trade unions in the 1980s, focuses on the employment challenges arising from environmental transitions (McCauley & Heffron, 2018). Although its roots are in the labour movement, just transition is often more broadly defined to consider all social impacts of the transition on workers, communities, consumers, small businesses, and citizens (Robins et al., 2021). Mitigating the socio-economic effects of leaving fossil fuel reserves unexploited is essential to a well-managed clean energy transition, especially given the heightened employment precarity during the COVID-19 pandemic and the drastic oil price crash in early 2020. These factors contributed to the unemployment rate in Alberta spiking from 7.2 to 15.5% between February and May 2020 (Alberta Government, 2020).

This paper adopts a mixed method approach including both econometric regression analysis and semi-structured interviews to explore the issue of precarious employment resulting from Alberta's economic oil dependence. We use vector autoregressions (VAR) to quantify the link between the global oil price and province-wide employment and autoregressive distributed lag (ARDL) models to estimate sector-level oil price employment effects. We complement these findings with qualitative insights gained from in-depth interviews with oil sands workers. Given the importance of the oil sands sector to the Albertan economy, an increase in the global oil price would be expected to boost overall employment, as has been documented in various studies on the impact of commodity price booms on local labour markets in resource-rich regions (Marchand & Weber, 2018). Sectoral proximity to the oil industry may increase the sensitivity of jobs to oil price fluctuations compared to sectors more distant from extractive activities. Based on our analysis, we find that just transition policies cannot focus on oil and gas workers alone, since the jobs and livelihoods of people employed in other sectors also face transition risk. We emphasize the need for transitional assistance policies (Green & Gambhir, 2020) to support affected workers in the sectors we identify as at risk, as well as economic diversification to enable resilient employment across sectors.

1.2. Literature review

The relationship between the oil price and macroeconomic variables, including labour market statistics, has been studied in oil-importing regions, often using VAR techniques (Hamilton, 1983; Hooker, 1996; Mork, 1989). In these studies, oil is treated as an input to economic activity, with insights suggesting that increases in the oil price tend to lower the employment rate in oil-importing regions (Hamilton, 1983; Hooker, 1996; Mork, 1989). Oil price and employment dynamics have also been disaggregated by sector, for example, in South Africa (Kin et al., 2015).

In addition, there is extensive research examining the labour market effects of oil price on oil-producing regions (Hvinden & Nordbø, 2016; Munasib & Rickman, 2015; Paredes et al., 2015; Weinstein, 2014). Munasib and Rickman (2015) found that earnings and employment in North Dakota's oil and gas and non-oil and gas counties were higher than expected during the state's Bakken boom, a period of high oil extraction from the Bakken oil formation from approximately 2006 to 2014. Paredes et al. (2015) estimated small direct income impacts, but larger employment impacts from the development of the Marcellus Formation in Pennsylvania. Miljkovic and Ripplinger (2016) used a Vector Error Correction Model (VECM) to study the employment impacts of the Bakken oil boom in North Dakota and found that the boom had a positive impact on employment and wages in both the oil and gas sector and the rest of the economy, excluding agriculture. Given the frequent use of VAR models in this context, we follow this literature and use a VAR to analyse the province-wide dynamics between oil price and employment.

Weinstein (2014) found only modest positive employment impacts of the shale boom across the United States from 2001 to 2011, but more sizable earnings growth. The modest increase in jobs estimated by Weinstein counters previous studies that suggest a more optimistic picture of the employment benefits of the shale boom. Furthermore, earnings growth in the resource sector can have negative long-term effects on regional development through disincentivising education by reducing its financial benefits (Weinstein, 2014).

Marchand and Weber (2018) present a detailed review of research on the link between resources and labour markets. All the studies they surveyed, despite using various methods, found positive employment effects and often increased local population from extraction during a boom. Many studies documented positive spillover effects, 'attributing an additional one to two jobs in other sectors of the local economy for every resource sector job created' (Marchand & Weber, 2018, p. 471). High commodity prices and improved technology can incentivise the exploitation of previously uneconomical resource reserves, which in turn requires additional labour. High commodity prices thus create extraction booms with positive employment effects, while lower prices characterize a bust that reduces jobs. Our paper furthers this discussion, highlighting the employment spillovers from the resource sector to the wider economy in the context of the low-carbon transition.

Marchand and Weber (2018) also found that the negative employment effects of the bust are in some cases weaker than the positive effects of the boom, but in others, the bust more than offsets job gains from the boom. While analysing boom-and-bust cycles is useful to manage resource-dependent regions, in cases where demand for that resource is expected to decline, novel angles of analysis are needed. Our paper has ventured in that direction by analysing continuous time series data of employment in a period characterized by oil *busts*, notably those of 2014–2016 and of early 2020.

The relationship between oil resources and labour markets has also been explored in Alberta specifically. The oil price booms of 1971–1981 and 1996–2006 were found to increase jobs in oil and gas, but also in construction, retail, and services with respective job multipliers of 3, 2, and 4.5 for every 10 energy extraction job (Marchand, 2012). Our research complements and extends these results by examining a more recent, high frequency time interval from January 2007 to September 2020, which includes the drastic oil price crashes of 2014 as well as the first few months of the COVID-19 pandemic. Rather than focusing on periods of oil price booms, we analyse continuous monthly time series data, allowing us to show that labour market impacts also occur regularly due to short-term price shifts, making people's livelihoods more precarious. Our econometric analysis enables us to identify the continuous effect that the oil market exerts on the labour market in Alberta, even in the absence of large shocks. We also assess the dependence on or relative independence from favourable oil prices of all economic sectors. In doing so, we examine the long-run, high-resolution relationship between oil price and employment, which could help assess the impacts of a low-carbon transition on Alberta's workers. We follow the existing literature in using oil prices in our analysis rather than oil futures contracts, which indicate expectations on how oil prices will evolve. Further research could consider oil futures in more depth to explore how price expectations could influence labour markets.

From a methodological perspective, our work is unique in several ways. To our knowledge, we construct the first VAR model of the oil price impact on the Albertan labour market. Our analysis also considers a continuous time series, rather than only boom-and-bust cycles. This is additionally the first study to consider the impact of oil price on jobs in all sectors of the Albertan economy. The scope of our analysis is broad as our underlying goal is to evaluate the employment implications of an economy-wide transition and indicate which sectors may require attention in the design of just transition policy. Finally, we complement our quantitative analysis with novel insights drawn from interviews with oil sands workers, who are most likely to be impacted by the transition.

This paper contributes to the just transition literature, which is beginning to engage with quantitative research methods (Snell, 2018). We build on the bourgeoning use of statistical methods to study the labour implications of a global clean energy transition (Castellanos & Heutel, 2019; Dominish et al., 2019; Pollin & Callaci, 2019; Snyder, 2018), while also integrating a worker-focused qualitative analysis. In general, just transition experts have focused on fossil fuel workers, but our paper expands on that foundation to examine the community-wide transition risk workers may face in other economic sectors of an oil-exporting region. Our approach is consistent with macroeconomic theory, which posits that there are direct, indirect, and induced jobs associated with a given economic activity (Bacon & Kojima, 2011). Indeed, labour economists have documented the spillovers of resource extraction on employment in other sectors that have no direct connection to the resource sector (Marchand & Weber, 2018). In this way, our paper bridges the gap between insights from labour economics and the just transition and broadens the scope of whose livelihoods may be affected by the clean energy transition.

2. Methodology

We adopt a mixed methods approach, which interweaves diverse research techniques to fill gaps, add context, and provide a sense of both the general and the particular (Cope & Elwood, 2009). We implement the quantitative component as the primary method and we adopt a sequential explanatory design whereby preliminary quantitative results precede the qualitative analysis of interview data (Ivankova et al., 2006). These two methods are integrated in both our results and discussion sections.

2.1. Quantitative analysis

2.1.1. Data and econometric setting

The data used in our analysis is sourced from statistical records of the governments of Alberta (Alberta Government, 2020) and Canada (Statistics Canada, 2020). We use monthly data of the West Texas Intermediate (WTI) and Western Canadian Select (WCS) oil price benchmarks as global and Canadian oil prices, respectively. Our dependent variable is the total number of employees per sector in Alberta.

Our econometric models rest on the assumption of the plausibly weak exogeneity of the Western Texas Intermediate (WTI) oil price, which is used as a proxy for the global oil price. Given the relative insignificance of Albertan oil production as a share of global volume (about 2%) (Alberta Government, 2018) we follow Hiebert and Vansteenkiste (2010) in considering WTI to be exogenous for this regional setting.

Oil sands crude, valued by the WCS benchmark, is sold at a discount relative to WTI due to its lower quality as a heavy sour (i.e. high in sulphur) crude (Millington, 2018). The United States is the destination for 98% of Canadian oil exports (Natural Resources Canada, 2020). Along with the low quality of oil sands crude, constraints on exports to this single market contribute to creating the discount on WCS. Our models include WTI and the discount on WCS (calculated as $WTI - WCS$) to separate the potentially divergent effects of the global oil market represented by WTI and the more local factors represented by the discount.

The time series data considered are almost exclusively non-stationary but cointegrate to I(0) residuals, which allows us to estimate the VAR and ARDL models described below. For each model we consider various lag specifications to account for transitory dynamics and to test the robustness of our results. The VAR model uses a data sample from January 2007 to September 2020, while the ARDL models use a data sample from January 2005 to September 2020.

2.1.2. Province-wide employment: vector autoregression (VAR)

A vector autoregression model (VAR) is a statistical model that captures the relationships between multiple variables lagged over time. Rather than estimating the effect of variables on a single dependent variable, a VAR models the effects of multiple variables on each other by estimating a system of equations. In each equation in this system, the dependent value of another equation is inserted in a lagged form alongside an autoregressive term. In this sense, in a VAR, each dependent variable is modelled by past values of itself, as well as past values of other dependent variables. We estimate an economy-wide four-equation VAR model using the total number of people employed in Alberta alongside the WTI oil price, the discount between WTI and WCS, and the total volume of oil production in Alberta. While the individual time series are non-stationary, a Johansen trace test using the R-package *urca* (Pfaff, 2006) determines that there are two cointegrating relationships, which therefore allows us to consider the VAR in levels. Using various information criteria in a lag structure analysis, all VAR models are estimated as VAR(2) models. To illustrate the effect size of the relevant variables, we present impulse response functions of a one-unit change in the independent variables. The VAR model is estimated according to the following equation:

$$\begin{pmatrix} Employment_t \\ OilProduction_t \\ WTI_t \\ Discount_t \end{pmatrix} = \begin{pmatrix} a_1 \\ a_2 \\ a_3 \\ a_4 \end{pmatrix} + \begin{pmatrix} b_{11}^1 & b_{12}^1 & b_{13}^1 & b_{14}^1 \\ b_{21}^1 & b_{22}^1 & b_{23}^1 & b_{24}^1 \\ b_{31}^1 & b_{32}^1 & b_{33}^1 & b_{34}^1 \\ b_{41}^1 & b_{42}^1 & b_{43}^1 & b_{44}^1 \end{pmatrix} * \begin{pmatrix} Employment_{t-1} \\ OilProduction_{t-1} \\ WTI_{t-1} \\ Discount_{t-1} \end{pmatrix} + \begin{pmatrix} b_{11}^2 & b_{12}^2 & b_{13}^2 & b_{14}^2 \\ b_{21}^2 & b_{22}^2 & b_{23}^2 & b_{24}^2 \\ b_{31}^2 & b_{32}^2 & b_{33}^2 & b_{34}^2 \\ b_{41}^2 & b_{42}^2 & b_{43}^2 & b_{44}^2 \end{pmatrix} * \begin{pmatrix} Employment_{t-2} \\ OilProduction_{t-2} \\ WTI_{t-2} \\ Discount_{t-2} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \end{pmatrix}$$

2.1.3. Sectoral employment: time series ARDL models

We are required to rely solely on aggregated provincial employment statistics in the VAR due to missing covariates at the sectoral level. However, relying solely on aggregated data can mask localised economic phenomena (Snyder, 2018). Therefore, we estimate a series of sectoral autoregressive distributed lag models (ARDL) with the dependent variable corresponding to total employment in each of the 19 North America Industry Classification System (NAICS) sectors and one corresponding to total employment in Alberta. For all sectors, we consider three model specifications to evaluate the results' robustness by varying the number of lags included. In the estimation, we follow the approach set out by Castle and Hendry (2019), which is more formally described by Ericsson (2012), Castle et al. (2015), Johansen and Nielsen (2016), and Pretis et al. (2018b). We formulate a general unrestricted model (GUM) with a one-month autoregressive term, monthly dummies to control for seasonality, and various distributed lag specifications for our socio-economic control variables to account for general economic conditions in Alberta. We use seasonally adjusted retail trade, domestic merchandise exports, and personal and corporate bankruptcy rates as socio-economic control variables. The ARDL models are estimated according to the following equation:

$$Employment_{t,i} = \alpha + \sum_{j=1}^{n} \beta_j Employment_{i,t-j} + \sum_{j=0}^{n} \delta_j \begin{pmatrix} WTI_{t-j} \\ Discount_{t-j} \\ CorpBankruptcy_{t-j} \\ PersonalBankruptcy_{t-j} \\ RetailTrade_{t-j} \\ DomesticExportsMerchandise_{t-j} \end{pmatrix} + \sum_{month=2}^{month=12} \beta_3 D_{month}$$
$$+ SIS_t + IIS_t + \varepsilon_t$$

Following Kaufmann (2020) who uses indicator saturation in an oil price application, we use step indicator saturation (SIS) and impulse indicator saturation (IIS) to account for step shifts and outlying observations respectively and use 0.01% as our accepted level of retaining false-positive indicators (Castle & Hendry, 2019; Hendry et al., 2008). For more information on SIS and IIS, see the Supplementary Materials. We then employ automatic general-to-specific model selection (gets) using the *gets* R-package (Pretis et al., 2018a) to select relevant covariates and formulate a specific model. Linear combination of coefficient estimates was carried out using the *multcomp* R-package (Hothorn et al., 2008).

While employment and oil price data are available from 1990, essential control variables are only available from 2005 to 2020. As an additional robustness check, we conduct a secondary set of time series models that exclude control variables and therefore cover a wider historical time span, albeit in a simpler specification. The results of this secondary set of models are presented in the Supplementary Materials.

2.2. Qualitative analysis

We complement our primary quantitative methodology with interviews conducted in July 2019 with six current or former oil sands workers from various sub-sectors of the Albertan oil sands industry. These interviews are included to explore the *perceived* impact of oil price on employment, which has complementary significance to our statistical results as perceptions often shape the decisions of workers, employers, and policymakers. Individuals' expectations, motivations, and the conditions that influence them provide a richness of detail to support arguments about economic phenomena. The diverse and detailed stories of workers and their working life challenge 'the notion of labour as an undifferentiated homogeneous social group' (Dutta, 2016). Information from the interviews is not intended to provide generalizable insights into the opinions of *all* oil sands workers but rather, by including qualitative interview material, we seek to supplement the econometric analysis with an understanding of the lived experiences of oil sands workers. A semi-structured interview format was used to allow additional insights to emerge beyond the interview questions (Bryman, 2012). The interview questions and interviewees' professional profiles can be found in the Supplementary Materials.

Interview participants were workers who had either transitioned out of work in the oil sands or who were seeking to transition to another sector. Their professions, which ranged widely between individuals and within each of their careers, include steel fabricator, electrical engineer, seam fitter, plumber, construction worker, lab technologist, journalist, and electrician. Participants were contacted through the network of *Iron & Earth*, an organization that advocates for the upskilling of oil sands workers towards jobs in renewable energy. The focus on workers who have sought or are seeking to transition their careers offers insights into micro-scale considerations relating to the energy transition. This limits the applicability of participants' perspectives to other Albertans, however, as we are not seeking generalisability of these data, the interviews are valuable for contextualizing our quantitative analysis.

We conducted a thematic analysis of the interview material (Maguire & Delahunt, 2017), the findings of which were then juxtaposed with the key takeaways of our econometric analysis. The thematic analytical method involves identifying patterns and latent themes in qualitative data (in our case written transcripts of interviews) with the aim of examining the underlying ideas and conceptualisations of participants. Thematic analysis, as with interviewing as a research method, is considered a flexible qualitative method (see, for example, Hitchings & Latham, 2020), enabling the qualitative insights to be better integrated with our quantitative findings.

3. Results

Our econometric analysis sheds light on the relationship between oil price fluctuations and employment in Alberta. Insights from interview participants are presented alongside the quantitative results to deepen our understanding of these results.

3.1. Province-wide results

To facilitate the interpretation of our four-equation VAR model results, we present impulse response functions in Figure 1, which illustrate the effects over time of a one-unit increase in the WTI oil price. The impulse response functions show that a higher global oil price is associated with a long-term increase in total employment, such that a one dollar increase in WTI oil price boosts total employment by nearly 20,000 jobs with a four-month adjustment period. A WTI decrease, which we use to proxy future oil demand reductions associated with more stringent climate change mitigation, is therefore expected to result in employment losses. These estimates are robust to varying model specifications like seasonality and the inclusion of a constant or a trend in the cointegrating relationships.

The evidence is far less conclusive regarding the impact of the WCS discount on total employment (Figure 2). Although there are possible transitory effects, they do not exhibit statistically significant relationships. With respect to jobs in Alberta, the exogenous factors that determine the WTI oil price (i.e. global oil supply and demand) seem more important as determinants of employment levels than the local factors that are understood to contribute to the discount on the WCS oil price, such as pipeline capacity.

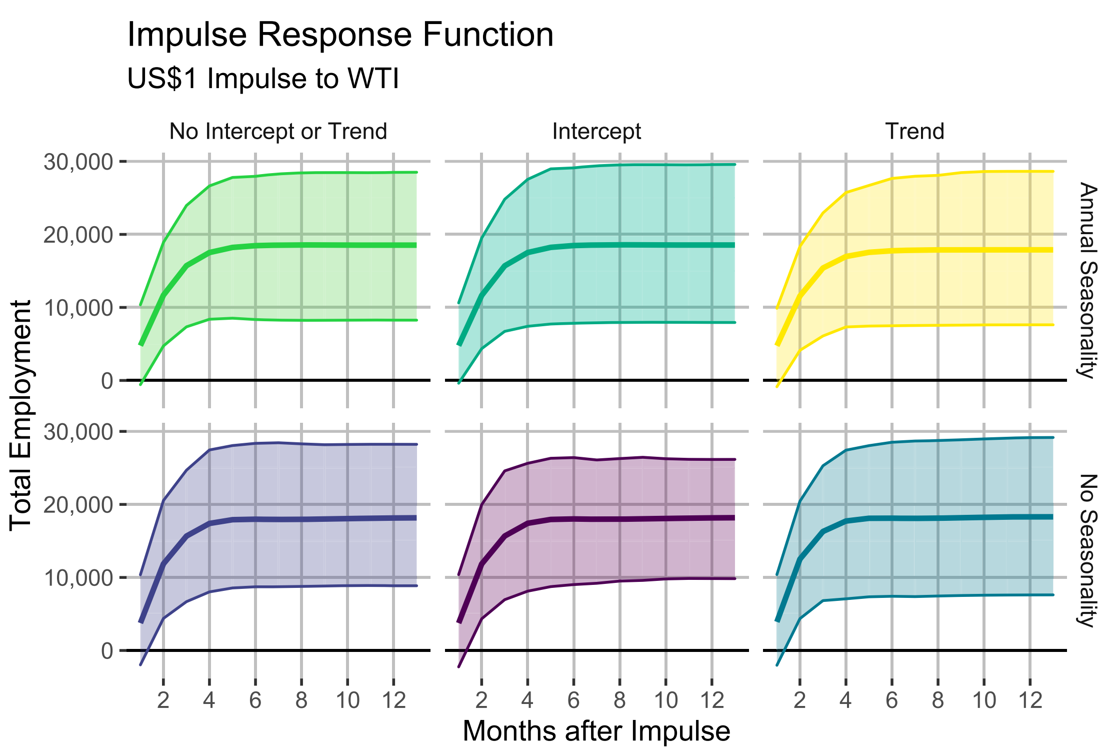

Figure 1. Impulse response functions for an impulse (i.e. one unit increase) in WTI on total provincial employment under different specifications. Uncertainty bands represent a bootstrapped 95% confidence interval.

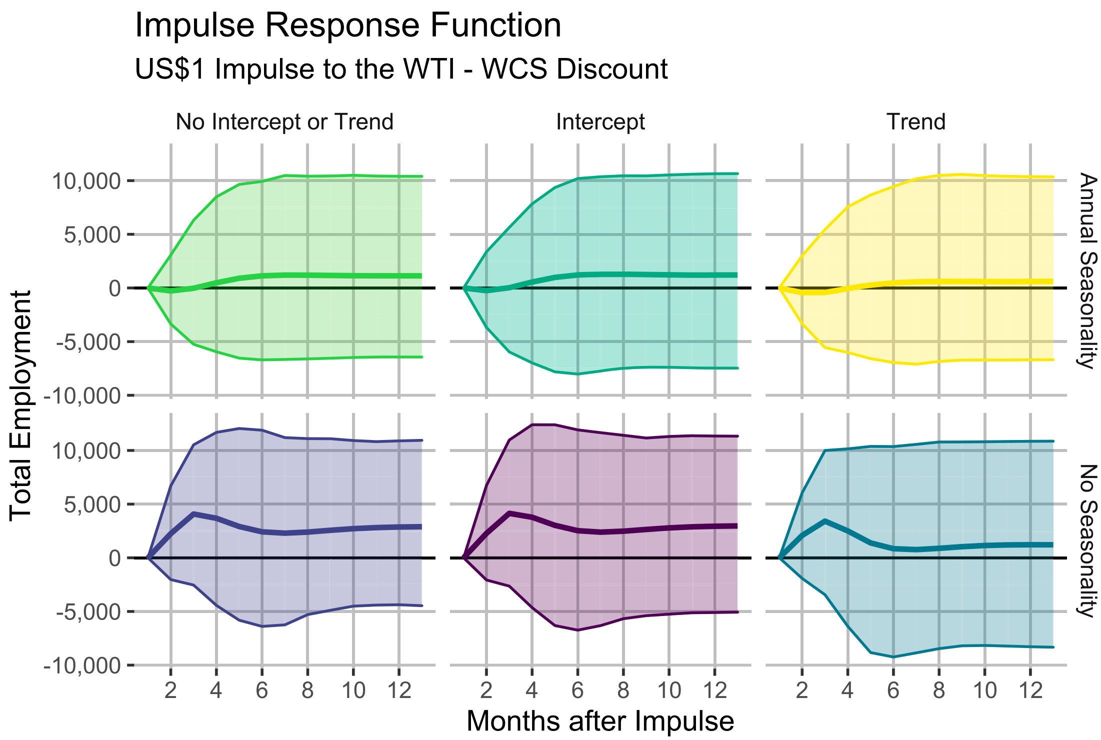

Figure 2. Impulse response functions for an impulse in the discount on total provincial employment under different specifications.

The monthly sensitivity of jobs to oil price changes is a quantitative indication of labour precarity because transmission between oil market shocks and the labour market are rapid. Precarity, however, is not simply the risk of losing one's job, which is the only quantitative measure we use in our econometric analysis. Further components of precarity include low or unreliable wages, unavailable full-time work, and limited opportunities for career progression. While these factors are beyond the scope of our quantitative analysis, our interviews highlighted that the reality of resource jobs means that workers shift frequently from employer to employer on short-term contracts. For example, the boom-and-bust cycle of oil dependence interrupts normal career progression. In the bust, people are laid off or demoted and forced to rebuild their careers. One interviewee, Teresa,[1] elaborated on this: '*If I could've continued and slowly gone up like in any other industry, then I would've been set for life a long time ago*'. She also shared the experience of a colleague: '*he was my project manager […] but he's gone to being a surveyor. He was a manager and then basically a labourer*'.

While facing precarity because of the province's oil dependence, workers employ diverse tactics to prepare for oil crashes when they expect their jobs to be at risk. Beyond saving their earnings, several interviewees also invested in diversifying their skill sets. Peter listed his numerous qualifications: '*I'm an electronics technician and production engineer as well as red seal electrician. I have all these things under my belt, but otherwise I'd be up shit's creek without a paddle*'. Josh noted that workers should be supported so they can '*transition to something they can do without being burdened with the cost of going back to school*'. Workers' preparedness to shift into other sectors, if economic conditions change, is an adaptation to transition at the individual level. Understanding which sectors may be resilient to oil price changes and a clean energy transition is key to making these decisions.

3.2. Sectoral results

The results of the sectoral autoregressive distributed lag (ARDL) models are shown in Figure 3. Acknowledging the statistical issues arising from multiple hypothesis testing of our ARDL models, we limit our illustration of the

Figure 3. Sectoral results of ARDL regressions. Green indicates a positive effect; red indicates a negative effect; white indicates insignificant linear combinations (i.e. positive and negative lags cancelling out); and grey indicates that no term was retained by model selection.

sectoral results to the direction of the influence and its statistical significance. The magnitude of the effect and model results can be considered in the Supplementary Material. As expected, our results indicate that a higher WTI price has a positive effect on employment in the oil sector, which is robust across most model specifications. Our ARDL results also show a positive relationship between WTI and jobs in accommodation and food services, agriculture, construction, manufacturing, professional, and other services. Notably, construction and professional services are the third and fourth biggest employers in Alberta.

Employment in sectors with a positive relationship with oil price can be categorized as follows: direct jobs in the oil sector, indirect jobs, and induced jobs (Bacon & Kojima, 2011). Employment in construction, and to some extent in professional services and manufacturing, may be directly or indirectly linked to oil extraction. Various scientific and technical jobs are needed to service oil and gas exploration and extraction. Also, the manufacturing sector of Red Deer, a region of Alberta, manufactures a variety of components used in the oil and gas industry, including metal fabrication, petrochemicals, and drilling equipment (City of Red Deer, 2019). Finally, employment in accommodation and food services are *induced* by oil extraction: revenue is gained, and employees are hired due to the spending of people working directly in resource extraction or indirectly in the sectors that support it.

Sectors whose employment levels have a positive relationship with oil price depend on the success of the oil industry and can be expected to suffer most in a clean energy transition. Sectors with a negative relationship with oil price may be more resilient to oil price crashes and by extension to the transition. A policy-based, albeit subjective, explanation for the negative relationships in healthcare and education was offered by Farooq: '*The NDP had a good way of handling unemployment by creating and sustaining public sector work. The current [Conservative] government has other ideas*'. Indeed, the left-leaning New Democratic Party (NDP) government increased spending on public services during the 2014–2016 oil price crash (Mason, 2018). Furthermore, schooling decisions are affected when high-paid, low-skilled extraction jobs encourage young people to leave their studies early (Weinstein, 2014). Drop-out rates rose in American counties with drilling activity during the shale boom (Zuo et al., 2019). This mechanism could lead to a decrease in the demand for education jobs during resource booms, which may be partially responsible for the observed negative relationship between the number of employees in this sector and the oil price. The dominance of oil in Alberta, especially during oil booms, may thus inhibit skills development and educational attainment among its workforce, which are critical if the province is to adapt to a low-carbon transition. Sectors like education and healthcare that have a negative relationship with oil price may exhibit resilience to a transition, but this depends on public spending decisions.

For most other sectors, a clear picture does not emerge across estimation methods and specifications. For example, in the finance and insurance sector, different models show positive and negative relationships between oil price and jobs. The forestry sector has positive and negative relationships with oil price at different monthly lags, which cancel out, indicating that the effects of the WTI oil price may be only transitory. Sectors with no clear, statistically significant oil price relationship may be somewhat unaffected by the volatility of oil price and its drastic crashes over the period under study. However, it is unclear whether these other sectors would be resilient or at risk in a transition that lowers Alberta's oil production permanently. These sectors may in fact experience both positive and negative pressures from an increase in oil price leading to a net neutral impact. Job losses in these sectors may nonetheless result from oil price volatility, but they are hidden by the sectoral aggregation.

Interview participants confirmed the result that oil price effects on employment are not limited to jobs in the oil sector. Understanding the interconnectedness of the resource-dependent economy, Josh explained, '*Most of the industries in Alberta are built around supporting the oil industry*'. These observations are based on how oil price crashes visibly affect many sectors, since the month-to-month job precarity demonstrated in our statistical analysis cannot easily be perceived. In this way our quantitative and qualitative methods approach precarity from different angles and provide complementary information. We also learned from interviewees that there is further heterogeneity in the impacts of oil price within at-risk sectors like oil and construction. For example, labourers tend to face higher job precarity than managers, an issue that is beyond the scope of our econometric analysis but should be considered during just transition policy development.

In discussing the sectors that face transition risk, the transferability of skills is important to consider. When at-risk sectors make layoffs, those affected need alternatives, which often turn out to be closed to them. The wealth of resource jobs is a magnet that is hard to escape; Alberta's undiversified economy retains people in this work because transitioning is challenging even with a varied skill set. Meanwhile, the volatility of the oil price also means that oil workers face challenges when seeking employment in other sectors. Josh explained, '*I talked to people outside my industry that looked at my resume and they said that they don't hire oil and gas people, because when oil goes back up, they all leave, and they wasted time training them and have to hire someone new [… .] My resume shows oil and gas, what else am I going to put on it?*'. Teresa echoed this experience. In this way, the volatility of oil price amplifies job precarity even when workers are attempting to move away from the oil sector.

Interviewees proposed diverse solutions to address different components of the employment problem in Alberta. George suggested that instant qualification for employment insurance would allow the '*freedom to change jobs and start something new at any time, which is very good for an economy*'. Other interviewees suggested solutions ranging from doubling down on oil by building both pipelines and refineries to aligning with a clean energy transition through diversification and retraining programmes. Lliam advocated for a national upskilling initiative: '*There will be more and more jobs in renewable energy by 2050. I believe in a prosperous transition for workers. It can be achieved through proactively training our workforces*'. Social dialogue with workers in Alberta and consultations with potentially affected communities are needed to understand how just transition policies and initiatives might work in practice.

4. Discussion

4.1. Interpretation of results and policy implications

We estimate a mean effect on employment of nearly 20,000 additional jobs following a WTI oil price unit increase. This province-wide figure is notable, considering the occasionally large monthly swings in oil price of up to 15 USD, but it is consistent with the literature in terms of the effects' direction (Marchand & Weber, 2018). Our interviewees shared details of additional facets of precarity including limited opportunities for career progression. This evidence highlights the need for a provincial just transition plan to mitigate the precarity caused by oil market changes and the job losses in Alberta that would be caused by a global energy transition over the coming decades.

At both the provincial and sectoral levels, we found the WCS discount, which is mainly determined by factors like crude oil quality and local export capacity, to be insignificant as a determinant of employment levels, unlike the WTI global oil price. The contrasting importance of local and international factors that influence oil price has implications for pipeline construction in North America. The cancellation of the Keystone XL pipeline from Alberta to Nebraska has been criticized by Canadian politicians, who cite lost employment opportunities from the failure to expand Alberta's oil export capacity. However, based on our analysis, there is little evidence of job creation from an expansion in export capacity, specifically through its effect on reducing the discount on WCS. As such, the transition risk faced by Alberta with respect to employment is dominated by factors outside of the province's control (i.e. the international oil market) rather than factors like pipeline construction, which are in part within its control. The increase in oil exports from additional pipeline capacity could, however, contribute to increased oil production, revenues, and government royalties, which may also indirectly support job creation, but this mechanism is outside the scope of our analysis.

Our sectoral breakdown of employment sensitivities to oil price indicates priority areas for worker-focused just transition policies and confirms existing research, which has attributed additional jobs in other sectors for each resource sector job created (Marchand & Weber, 2018). Based on our analysis, worker-focused just transition policies could be targeted first at workers in the oil and gas and construction sectors. We note that our analysis does not consider wealth and income levels, which are crucial factors in designing effective just transition policies that prioritize those most in need of assistance. Policymakers can draw on a toolbox of transitional assistance policies, including early retirement benefits, worker transfer schemes, relocation support, and subsidized training, as well as more indirect support for workers by requiring corporate-led retraining programmes, and for affected communities through public investment (Green & Gambhir, 2020). Retraining programmes for oil and gas workers could prioritize skills relevant for renewable energy, energy efficiency projects, and transition minerals mining. A review of potential pandemic recovery policies found that policies aimed directly at workers have large economic multipliers (Hepburn et al., 2020). Worker-focused support should form part of a planned domestic transition as well as any urgent relief policies in the case of unexpectedly drastic advances in the global energy transition.

Our qualitative evidence suggests that oil and gas workers seeking employment in non-extractive sectors face high scrutiny from employers, who fear they will return to the oil sector once oil prices rise. Actions to mitigate this effect are required, particularly in the short term, to overcome biases and to provide some security to employers while also enabling workers to transition out of the sector long term. A similar issue emerges when long periods of unemployment in a candidate's work history lead employers to assume that their skills have atrophied (Hvinden & Nordbø, 2016). To both uphold worker rights and support employer needs, tripartite social dialogue is needed between government, employers, and labour unions or other worker representatives (ILO, 2015). Provincial and national governments are in the best position to initiate such dialogue and facilitate lasting solutions through just transition policy development.

Targeted sector-specific assistance like retraining programmes, however, are insufficient to entirely resolve the employment precarity resulting from Alberta's dependence on fossil fuels: we have identified various other sectors that are also affected by oil price shifts. Construction workers might not need to re-skill or transition into other sectors, but they require employment opportunities that do not rely on a booming oil industry. Retraining may also not be appropriate to support those employed in the professional, scientific, and technical services and the accommodations and food services sectors. The North American Industry Classification System category of professional, scientific, and technical services includes a broad range of jobs in businesses that rely on human capital, like legal, accounting, engineering, surveying, design, and architectural services. Some employees in this sector category, such as those employed as surveyors for oil and gas exploration, may benefit from re-skilling programmes to transition into geothermal surveying, for example. However, re-skilling accounting or customer service employees may not be as relevant. The overall provincial economy's reliance on oil extraction makes these workers' livelihoods precarious, most importantly affecting those with lower wages in the accommodations and food services sector. Economic diversification policies could fill this gap, shifting the entire economy so that workers across sectors have stable employment opportunities.

Our results suggest that proactive economic diversification could accomplish two aims. First, irrespective of the low-carbon transition, a more diversified economy would lessen how strongly the volatile global oil market causes job precarity across Alberta's sectors. Second, economic diversification would reduce the province's transition risk by lessening the relative economic importance of extracting and selling carbon-intensive oil to a progressively decarbonizing global economy. Alberta has a fraught political history of largely failed attempts at government-led economic diversification (Morton & McDonald, 2015). Horizontal diversification policies that benefit all businesses, such as low tax rates, have often further strengthened the position of oil companies in the province (Hawkins, 2017). By demonstrating the extent to which the oil sands industry currently creates unstable employment as a result of oil price changes, this paper presents evidence alongside other research that encourages economic diversification as a strategy for oil-rich countries to adapt to a global clean energy transition (Fattouh et al., 2018; Van de Graaf & Verbruggen, 2015). A renewed examination of how to diversify Alberta's economy is necessary for a just transition that would protect workers in all economic sectors.

4.2. Future areas of analysis

Additional routes of inquiry could deepen the research presented here. Marchand (2012) found that the 1981–1991 oil price bust did not offset the employment and wage gains from the preceding oil price boom. However, given the vastly different global oil market of the recent decade, this asymmetry may no longer hold or may even be skewed in the other direction, whereby oil price crashes lead to more job losses than were gained during the boom. This is a pattern observed by our interviewees, who highlighted the role of automation in making many oil jobs redundant even after oil prices recovered. The potential for technological unemployment (i.e. through automation of specific tasks) adds another layer of uncertainty to the future of work in extractive sectors (see, for example, Focacci, 2021). Further quantitative analysis is needed to better understand the potential asymmetry between the employment gains from a resource boom and the losses from a bust. This could be coupled with qualitative engagement with workers and employers to further interrogate the potential drivers of this asymmetry, such as automation.

This paper has certain limitations, which suggest further research questions. First, our analysis of labour precarity in Alberta was constrained to employment levels and did not include other dimensions of labour precarity relevant to a just transition. Examining precarity more broadly could involve analysing the impacts of a global clean energy transition on wages (as has been done, albeit without a transition lens, in much of the labour market and resource literature), access to full-time working hours, employee benefits, and career progression opportunities. Second, we did not consider inter-provincial or international migration, which is of interest because workers may join and exit Alberta's labour force in line with oil production. The role of migration in driving the relationship between oil price and employment was also highlighted by interviewees. Third, examining the link between employment and futures contracts for oil, which we do not undertake in this study, could be of interest in future research. Finally, we use oil price changes to highlight the negative employment impacts of oil price volatility but mainly to proxy a future clean energy transition. However, the energy transition is likely to be driven by both falling oil demand and regulatory pressures, which together will not necessarily lower oil prices. Further analysis on how to quantify transition risk with the aim of estimating employment impacts would benefit the just transition literature.

Although our paper is specific to Alberta, our conclusions could apply to labour markets in other resource-dependent regions. For example, Alberta's diversification attempts have been suggested as a source of policy transfer for Kazakhstan (Howie, 2018). Successful economic diversification policies in Alberta include establishing effective intellectual property rights systems, strengthening links between industries to favour innovation, and promoting human capital development in the disciplines of science, technology, engineering, and mathematics. Vertical diversification policies that attempted to lift sectors unrelated to the province's comparative advantage in oil extraction have historically been unsuccessful, but 'diversifying within [fossil fuel-based] energy' only (Howie, 2018), without shifting towards alternative economic activities, would not be prudent in the context of a clean energy transition. Supporting the oil sector and related industries may have been a good economic strategy in Alberta's recent past. However, transition risk presents the possibility that oil demand will peak and decline, leaving oil exporting countries with stranded assets and underdeveloped alternatives unless they diversify their economies and help their workforces transition.

We specify sectors whose employment levels may be most at risk due to a low-carbon energy transition; further research to identify areas for employment growth is also needed. Job opportunities over the next decade in renewable energy, energy efficiency, sustainable transport, and oil and gas clean-up projects in Alberta have been estimated at 67,200 jobs (Kaddoura et al., 2020). These areas, which reduce emissions and could provide stable work, require investment and favourable policies including pricing pollution, creating efficiency standards, and designing community renewable energy programmes (Kaddoura et al., 2020). It should be noted that a renewable energy boom would create many construction jobs in the short-term especially, while creating fewer permanent jobs in operations and maintenance in the longer term. However, work in these sectors over both the short and long term would not suffer from the precarity induced by oil price volatility. The urgency of policies that could boost sustainable employment opportunities has increased in the current context. The pandemic, coupled with an oil price war, led to a historic oil price drop in March 2020, illustrating how unexpected oil price shocks affect employment in Alberta. Policies addressing transition, relief, and recovery can play important roles in the current crisis, in future shocks, and in building resilience to a global clean energy transition.

5. Conclusion

Our paper has contributed to deepening the understanding of Alberta's dependence on oil sands and the potential employment impacts of a clean energy transition, offering insights to countries and regions that may also eventually have to transition away from a dependence on exporting fossil fuels.

We show that higher global oil prices boost Albertan employment, whereas the local oil price determinants, represented by the oil sands' WCS price discount, have no clear influence on local employment. This suggests that international factors outside of Alberta's control have a more significant impact on employment levels compared to the local factors that influence the WCS oil price. Although we did not explicitly examine changes in export capacity, this result casts doubt on the long-term employment benefits of new pipelines and other export opportunities.

At a provincial scale, global oil price changes cause employment levels to fluctuate. This result suggests that the province's *current* economic dependence on oil creates job precarity because employment is sensitive to a volatile oil market. It also highlights that lower oil demand resulting from the low-carbon transition could lead to job losses in Alberta unless appropriate just transition policies are implemented. This relationship between fossil fuel commodity prices and employment is likely also a driver of both current job precarity and future transition risk for workers in other countries and regions that depend economically on fossil fuel extraction.

Beyond the province-wide level, labour dynamics resulting from oil price volatility are heterogeneous between the province's economic sectors. Employment in oil and gas, construction, professional services, and accommodations and food services is sensitive to oil price fluctuations and, therefore, may face higher risk in a clean energy transition. Transitional assistance policies can support workers in the sectors we have identified as high risk, while economic diversification measures can ensure that retrained Albertans find stable opportunities in existing and new sectors that do not rely on international oil markets. Observations about employer biases and other challenges in career transitions raised by interviewees are relevant to ensuring effective just transition policy. Tripartite social dialogue led by governments would ensure that such details are considered in the policy development process. The foundation of social dialogue and the dual approach to just transition, whereby worker-focused support is complemented by economy-wide diversification measures, are generalizable to other fossil fuel-dependent regions.

Given the need to transition away from oil-dependence, and the high carbon intensity of oil sands extraction, it is imperative that meaningful and swift action is taken by a range of stakeholders, including policymakers. The justification for supporting extractive industries because they provide local jobs overlooks the multi-scalar interactions between global oil prices, local oil extraction, and sector-specific employment. Understanding the complex geographies of the transition and its effects on workers will help policymakers design more effective policies which protect local livelihoods as part of a just transition.

Note

1. All names are pseudonyms that preserve the gender and language family of the interviewee's name, except for Lliam Hildebrand, the co-founder of *Iron & Earth*, who opted not to be anonymous.

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Additional remarks

Further explanations of the econometric results as well as the interview questions and anonymised interviewee profiles can be found in the Supplementary Materials. The code for our econometric analysis is publicly available on GitHub with the associated link provided in the Supplementary Materials.

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No potential conflict of interest was reported by the author(s).

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