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Abstract

Energy booms are most often associated with large increases in employment and earnings, as well as positive local labor market spillovers from energy to non-energy industries. In this study, the large, localized, and positive labor demand shock from an energy price boom in Western Canada was also found to increase the routine and manual task content of employment across the occupational distribution. Both occupation groups involving routine manual tasks (operators, fabricators and laborers; and production, craft, and repair), as well as one occupational group involving non-routine cognitive tasks (technicians), significantly increased their employment shares during this boom. However, these results show that only the routinization of employment had a significant impact on wages; not manualization. This conventional boom evidence illustrates how an energy boom can impact labor, beyond the traditional changes in employment and earnings, and serves as a counterexample to the documented occupational polarization often attributed to technological change.

JEL Codes: J23; J31; Q33; R23.

Keywords: employment; energy boom and bust; labor demand; occupational structure; routine tasks.

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1 Introduction & Background

Governments and policy makers often struggle with the labor market implications of a cyclical industry, such as the energy sector, and the plight of the middle class workers that comprise it. For example, booms may require more workers than a locality with energy resources has at the time. In contrast, energy busts may cause local workers to go idle or dormant, or perhaps leave the area for other opportunities. First, knowing the types of tasks that need to be accomplished in a boom, and second, what types of workers can best accomplish those tasks, would help tailor policies to possibly enhance the mobility of and attract the right workers when needed. The focus could then shift to smoothing their consumption or perhaps the retraining of workers when they could be adversely affected by a bust.

When a resource-rich area experiences an energy boom, its energy extraction sector receives a direct positive shock to local labor demand, which may extend to other local industries through spillovers. This positive demand shock for labor increases its price, in the form of wages and earnings, and it increases its quantity, in the form of increased work hours and new employment in the labor force, in order to accommodate the excess demand. From the energy-related labor literature, booms have been found to increase employment and earnings, directly in energy-related industries and indirectly in other local industries, across a host of locations and time frames, and in line with economic theory for a positive labor demand shock (see Marchand and Weber, 2018, for a recent review).

While this literature has shown that labor demand shocks from energy booms have had drastic impacts upon local labor markets with these resources, it was implicitly assumed that the impacts were uniform across the spectrum of occupations and tasks.[1] The current study hypothesizes that this is unlikely to be the case. For example, the positive labor demand shock of an energy boom may generate a higher demand for certain tasks in the directly-impacted energy extraction industry, such as those performed by equipment operators, welders, or cutters. If middle-skilled workers are best fit for performing these tasks, then the employment and wages of that particular occupational group should increase accordingly.

Since Autor et al. (2003) first theorized that workers performing routine tasks were being replaced by automation, due to their substitutability with capital, the task approach to labor markets has become crucial to understanding secular changes to labor demand (for a review, see Autor, 2013). This occupational "job polarization" (coined by Goos and Manning, 2007) or "polarization of occupational employment" (referred to by Autor, 2013) has been

[1]While the uniformity along the task and occupational distribution has not been previously analyzed, the distributional effects on wages, earnings, and income have been previously explored by Marchand (2015), for an energy boom in Western Canada using a local labor market approach, and by Fortin and Lemieux (2015), for an energy boom in Canada using a provincial comparison of Alberta to Ontario.

repeatedly shown over recent decades for both the US (Autor et al., 2008; Acemoglu and Autor, 2011) and for Europe (Goos and Manning, 2007; Goos et al., 2014), with labor demand moving toward higher- and lower-skilled workers, and away from the middle-skilled. For example, Autor and Dorn (2009, 2013) found the contraction of routine middle-skilled jobs raised the share of those employed in low-skilled, non-routine jobs. Most recently, this phenomenon of disappearing routine jobs has been shown over four to five decades in the US, using various underlying data sources (Atalay et al., 2018, 2020; Cortes et al., 2020).

Within this task-oriented literature, there is very little known about the possible occupational impacts of more cyclical shocks to labor demand, such as energy booms. Although this aspect of energy booms has not been previously investigated, it had been previously eluded to by Autor (2015), who speculated that "many of the middle-skill jobs that persist in the future will combine routine technical tasks with the set of non-routine tasks in which workers hold comparative advantage." In addition, Green and Sand (2015), who showed that the occupational polarization found in the US was of larger magnitude than that of Canada, stated that "one must overlay a discussion of the effects of the resource boom after 2000 over any technological determinants story" when looking at Canada. More generally, cyclical aspects have of course not been completely ignored within this context (for examples, see Balleer and van Rens, 2013; Hershbein and Kahn, 2018; Jaimovich and Siu, 2020).

The current paper fills these gaps by joining the local labor market effects of energy booms literature and with that of the routine task and employment polarization literature. The setting for the investigation is a particular conventional energy boom on the local labor markets of Western Canada, following a similar identification strategy already used to establish "first order" boom effects on employment, earnings, and their spillovers (Marchand, 2012), as well as "second order" distributional effects on inequality and poverty (Marchand, 2015). Similarly, the Census of Population from Statistics Canada is used to represent employed individuals within these local labor markets. Given the location of energy resources in Canada, and the large and localized nature of this boom over the mid-1990s to mid-2000s, Western Canada provides a particularly established setting to further explore the employment share and hourly wage changes of an energy boom across the distribution of occupations and tasks. Occupations and tasks are similar to those defined by Acemoglu and Autor (2011), with these same task groups also being more recently used by Cortes (2016), Cortes et al. (2020), and Jaimovich and Siu (2020).

The evidence shows that the lone task group to relatively increase its employment share during the energy boom was routine manual, and it was quite large in magnitude. Therefore, routine tasks were demanded from workers during the energy boom, as employment moved away from non-routine tasks in the tails and toward routine tasks in the middle of the distribution. Manual tasks comprising the lower half of the distribution were also demanded by the boom, but to a lesser extent. Only the routinization of employment during the boom was rewarded in hourly wages, however, as the relationship between manualization due to the boom and wages was insignificant. The main reason that the impact of this boom in the current paper, toward routine work in the middle of the distribution and away from non-routine work at both ends of the task distribution, is important is that it is the exact opposite of the employment polarization brought about by technological change.

Both occupation groups performing routine manual tasks experienced large relative employment increases, with the increase for production, craft, and repair being somewhat larger in magnitude than the increase for operators, fabricators, and laborers. Technicians, performing non-routine cognitive tasks, were also in demand. In contrast, the boom caused relative employment losses in the occupations of professionals and sales at the upper end of the distribution, and for protective services and food preparation, buildings and grounds, and cleaning at the lower end of the distribution. The conclusion and discussion that end the paper show how these employment and wage changes may map to certain skill groups and consider what the evidence produced here for conventional energy may mean for shale-oriented energy with regards to a boom, as well as regarding the effects of a subsequent energy bust, more generally.

2 Data Description & Identification

The Census of Population, administered by Statistics Canada, is a quinquennial survey containing detailed demographic and economic information on individuals living in Canada. Each long-form survey wave is conducted on a twenty percent sample of the population, allowing for a full representation of the Canadian population through the use of sampling weights. The relative advantage of the Census data is its large number of individual observations, which are needed to fill the local geographic cells, especially when additionally examined by occupation groups. The Research Data Centre (RDC) version of this data, in particular, allows for a richer selection of the geographical and occupational descriptors required to construct the local cells.

Given that the last conventional energy boom in Canada occurred from the mid-1990s to the mid-2000s, this study uses the 1996 and 2006 Census waves to represent this period, which correspond to the collection years of 1995 and 2005, respectively. As shown in Figure 1, the real energy price trends of crude oil and natural gas sharply increased from 1995 to 2005. This is particularly true in comparison to the relative energy price stagnation in the five years before the 1996 Census. And, although the price run-up in oil continued to its peak in 2008, the 2006 Census collection year of 2005 marked the peak price for natural gas. Despite the emergence of technologies allowing for the shale oil and gas boom that followed in the 2010s, these previous price peaks remain the highest values, even when extending the data to mid-2020.

Four provinces comprise the western region of Canada: Alberta, British Columbia, Manitoba, and Saskatchewan.[2] The local labor market definition is set at the Census division, with 88 Census divisions available in Western Canada, as shown in Figure 2.[3] This definition generates a higher number of geographical areas per population relative to the number of local areas per population used in the previous literature on the U.S.[4] Concordance is kept between Census divisions across the two waves of Census data by integrating all of the changes at the smaller Census subdivision level over time using the 2006 boundaries. Geography is based on the location of current residence for a respondent in each wave.

The sample used to construct the labor market outcomes for this study is limited to males, aged 15 to 64 years old, employed and paid civilians, who worked full-time, full-year, meaning those that worked 30 hours or more per week and 40 weeks or more per year, respectively.[5] These restrictions follow Acemoglu and Autor (2011) in order to bring the study in-line with the previous literature, as well as limit the effects of part-time or seasonal work, or any gender-related issues or other phenomena outside of the subject at hand.[6]

The energy areas, or treatment set, are defined based on the percentage earned from the energy extraction sector being greater than or equal to ten percent of all earnings generated within a local labor market. The non-energy areas, or comparison set, are the local labor markets with earnings from energy extraction falling under a threshold of five percent. Energy extraction as a sector is defined as oil and gas extraction, coal mining, and support to oil, gas, and mining. These thresholds and sector definition have been established in the literature.[7]

There are seventeen Census divisions which are considered energy areas receiving the

[2]This definition excludes the Northwest Territories, Yukon, and Nunavut, due to their relatively small populations and lack of geographical disaggregation as compared with provinces.

[3]These local labor market definitions have been previously used in Marchand (2012, 2015).

[4]For example, Autor and Dorn (2009, 2013) use over 700 commuting zones to represent over 300 million individuals living in the U.S., while the current study uses 88 Census divisions to represent the roughly 10 million individuals living in Western Canada. All Canadian Census divisions are contained within provincial boundaries, while U.S. commuting zones are allowed to span across state boundaries.

[5]Canada uses 15 years of age for eligibility to work, while the US uses 16 years of age as its lower bound. The 30 hours per week cut-off follows the Canadian Census definition of a full-time worker and is also a slight departure from the US-based literature, which uses 35 hours per week for this purpose.

[6]These sample restrictions are only somewhat tighter than that of Marchand (2012, 2015).

[7]The base year used to define the fraction of total earnings from energy extraction is the 1996 Census wave, which is the same used for the second boom in Marchand (2012) and for the lone boom in Marchand (2015).

labor demand shock of the energy boom as a treatment, as shown in Figure 2. The percentages of energy extraction earnings grew in all Census divisions of the treatment group over the boom, with the exception of the top two, which declined slightly. The non-energy areas are comprised of fifty-seven Census divisions, representing the comparison set that did not receive the shock. There are also fourteen excluded Census divisions, which are either within the buffer zone of the two thresholds (with 5 to 10 percent of earnings coming from energy extraction) or are major cites (Calgary, Edmonton, Vancouver, or Winnipeg).[8]

Employment shares for any particular group are calculated as either the aggregate body count of that group or the aggregate amount of hours worked accruing to that group of workers, as a share of all workers or all hours worked in a given year, respectively.[9] Annual work hours are found by multiplying the individual responses for the number of weeks worked in the calendar year by the number of hours worked in the reference week prior to the Census day. The hourly wage for any particular group is calculated as the average over that group of workers.[10] This wage outcome uses the responses for annual earnings over the calendar year divided by the constructed annual work hours.[11] Wages are set in real terms to maintain consistency across time by deflating the nominal wage values by the Canadian consumer price index, so that all values are represented in 2005 dollars.

3 The Routinization & Manualization of Employment

Does an energy boom alter the demand for tasks that need to be accomplished by workers? If it does, how does it do so, across the occupational distribution more generally, and in which direction and magnitude across the various tasks and occupations? Previous studies of energy booms assumed these impacts were uniform along the occupational and task distributions. Given that an energy boom provides a positive shock to local labor demand, with a direct impact on one particular industry, energy extraction, as well as indirect spillovers into others,

[8]The main treatment and comparison set definitions exactly follow Marchand (2012, 2015), whereas an alternative treatment reapplying the definitions to the current sample restrictions is used as a robustness check. This increases the treatment set by five Census divisions and reduces the comparison set by one and the excluded set by four, thereby increasing the overall observation count from 74 to 78 Census divisions.

[9]While total employment count and total hours worked could be used interchangeably to represent this employment share, the distinction does not matter much for the evidence of the current study, as the results do not greatly vary between these definitions. As noted in footnote 8 on page 1049 of Acemoglu and Autor (2011), only second-order differences will appear between the two.

[10]Weekly wages, constructed by dividing the annual reported wages by the reported weeks worked, could be used interchangeably with hourly wages in this study.

[11]Hourly wage could also be truncated at the tails of its distribution, in order to dispel any outliers in the data. For example, in Acemoglu and Autor (2011), hourly wages below $3.41 and weekly earnings below $136 (in 2008 dollars) were dropped, as were wages above 1/35th of the top-coded value of weekly earnings. No truncation, from either tail of the wage distribution, was done for the current study.

it seems most likely that this alters the demand-side of the labor market in other ways too, as certain tasks need to be done and specific occupations need to be filled. This would especially be true within the local labor markets that contain energy resources.

Occupations and tasks first need to be properly defined. Over five hundred occupation titles are available in the Canadian Census data using the common 1991 Standard Occupational Classification (SOC91), numbering 515 in 1996 and 509 in 2006.[12] These occupations are then aggregated to ten harmonized occupation groups, following those used in Acemoglu and Autor (2011). Ranked from top to bottom of the distribution (based on average wages), these ten occupation groups are: managers; professionals; technicians; sales; office and administration; production, craft, and repair; operators, fabricators, and laborers; protective services; food preparation, buildings and grounds, and cleaning; and personal care and personal services.

These occupations, now defined and harmonized, can then be used to form the task definitions. According to Autor (2013), who describes three different approaches to defining tasks, the use of occupations as a proxy for job tasks (i.e. workplace activities) is the most common. The other two are the use of Dictionary of Occupational Titles (O*Net) and the independent collection of task information, with all three approaches having their own strengths and weaknesses. For example, Autor et al. (2003) were the first to differentiate between routine and non-routine tasks, as well as between manual and other tasks, breaking them into five unique task groups (ranked from top to bottom): non-routine analytic, non-routine interactive, routine cognitive, routine manual, non-routine manual.

The task definition of the current study again follows Acemoglu and Autor (2011), with non-routine cognitive, routine cognitive, routine manual, and non-routine manual, listed from the top to the bottom of the occupational distribution. These same task groups were additionally used more recently by Cortes (2016), Cortes et al. (2020), and Jaimovich and Siu (2020). Each task grouping contains two or three of the aggregate ten occupations. Non-routine cognitive tasks include managers, professionals, and technicians. Routine cognitive tasks include sales, and office and administration occupations. Routine manual tasks cover the aggregate occupations of production, craft, and repair, and operators, fabricators, and laborers.[13] Non-routine tasks comprise protective services; food preparation, buildings and

[12] In contrast, the equivalent count for the United States using the Dictionary of Occupational Titles (O*Net) during the same time span is over one thousand occupations, or roughly double the number of occupations available in the Canadian Census.

[13] "Routine" aspects of these occupations may not be as routine as defined. Although the task itself may be repeatable, and perhaps even codifiable and replaceable by capital, the tasks being completed may not take place in the same location for very long. This would mean, for example, that the location itself is consistently non-routine. This would apply to the extraction of energy resources in relatively remote locations which may change location intermittently, making it presumably difficult to codify tasks when needed to be done

grounds, and cleaning; and personal care and personal services.

To empirically test whether employment is differentially affected by an energy boom across the task and occupational distributions, a local labor market regression is used determine the magnitudes of each relative employment share change attributable to the boom for comparison:[14]

$$\Delta ESH_{cp} = \alpha \cdot Treat_{cp} + \gamma \cdot Prov_p + \varepsilon_{cp} \quad (1)$$

where ΔESH_{cp} is the change in the employment share of a particular set of workers, grouped by either the four task groups or the ten occupation groups, $Treat_{cp}$ is a binary indicator variable for energy or non-energy areas, and $Prov_p$ represents the provincial fixed effects (with Alberta as the omitted province). The constant term is excluded due to the dependent change outcome being regressed on a set of independent binary variables.

The coefficient of interest, alpha (α), measures the difference in the relative change in the employment share across groups between treatment and comparison areas over the boom period in percentage points. The alpha coefficients on the treatment binary from equation (1) are presented as figures, specifically Figures 3 and 4 to follow, instead of in the form of tables. In addition, the task or occupational ordering in these figures is ascending rather than descending, meaning that the lower-ranked are shown on the left and the higher-ranked are found on the right.[15]

Viewing the evidence presented in Figure 3, an energy boom is shown to lead to increases in the relative demand for certain types of tasks. In the case of the boom in Western Canada over the mid-1990s to early-2000s boom, the employment share only increased for the lone group of routine manual tasks, in the middle-lower portion of the task distribution. It also did so by a relatively large magnitude of 3.88 percentage points, with 95% confidence intervals from 2.46 to 5.30.[16] This shift toward routine manual tasks can also be parsed into separate effects for the routinization and manualization of employment, with roughly equal relative

by capital, under an ever changing set of variables.

[14] This specification closely follows from Autor and Dorn (2009, 2013), who tested different hypotheses related to the "aging" of jobs and the growth of low-wage service jobs, respectively.

[15] Given that these types of figures have historically been depicted with tasks or occupations in descending order, comparisons with the previous evidence must take this change into account. Visually, routine tasks represent the middle of the distribution and non-routine tasks are found in its tails, with manual tasks comprising the bottom half or left half of the distribution and cognitive tasks in the top or right half.

[16] The magnitudes of these relative employment shifts are similar to that of Katz and Margo (2014), who also use decadal changes in employment along the occupational distribution, but in order to examine broader changes from 1920 to 2010. For example, agricultural employment declined by almost 4 percentage points per decade from 1940 to 1980, while professional, technical, and managerial employment grew by over three percentage points per decade from 1940 to 2010.

increases of 2.86 and 2.66 percentage points, respectively.[17]

The positive effects on demand for workers to perform routine manual tasks during the boom were offset by declines in all other task employment shares, with magnitudes that were relatively equal. These employment decreases were by 1.21 percentage points for non-routine manual tasks, by 1.01 for routine cognitive tasks, and 1.65 percentage points for non-routine cognitive. All estimated employment changes were statistically significant at the one percent level, except the decline in routine cognitive employment which was the most imprecise, with a p-value of 0.013.[18]

While the employment changes presented in Figure 3 were remarkably clear, the use of only four broad task categories to examine the boom masks important heterogeneity. This can be seen by examining the employment changes across the less aggregated occupational groups, again with each task group containing two or three occupations. Moving from left to right in the occupational distribution shown in Figure 4 (from bottom to top), these occupations are personal care and personal services (OC10), food preparation, buildings and grounds, and cleaning (OC9), and protective services (OC8) as the non-routine manual tasks; operators, fabricators, and laborers (OC7) and production, craft, and repair (OC6) as the routine manual tasks; office and administration (OC5) and sales (OC4) as the routine cognitive tasks; and technicians (OC3), professionals (OC2), and managers (OC1) as the non-routine cognitive tasks.

The pattern over the task distribution shown in Figure 3 is also preserved over the occupational distribution in Figure 4, as both routine manual occupation groups of production, craft, and repair (OC6) and operators, fabricators, and laborers (OC7) exhibit large and similar magnitude increases in their employment shares of roughly 2 percentage points, 1.77 and 2.10, respectively. Both routine manual changes also remain statistically significant at the five percent level, but with much wider confidence intervals, i.e. much less precision, than for the change in the more aggregate routine manual task group in Figure 3.[19]

The similar relative declines across all other task categories in Figure 3 had masked a very large decline in professionals (OC2) of 2.50 percentage points, which was of an even larger magnitude than the increases of production, craft, and repair (OC6) and operators,

[17]The alternative treatment definition somewhat increases these magnitudes (from 3.88) to 4.22 percentage points for routine manual tasks, and (from 2.86) to 3.41 for routine and (from 2.66) to 2.94 for manual independently.

[18]Under the alternative treatment definition, the magnitude of the routine cognitive effect declines (from -1.01) to -0.80, as does its statistical significance, from a p-value of 0.013 to 0.049, which is still significant at the five percent level. The decline in non-routine cognitive employment also increases (from -1.65) to -2.13, with its statistical significance preserved.

[19]These magnitudes increase to 1.86 and 2.35 percentage points under the alternative treatment definition, while also increasing their statistical significance.

fabricators, and laborers (OC7), but of the opposite sign. This significant decrease was partly masked by its task category counterpart due to a statistically significant increase in technicians (OC3) of 0.97 percentage points occurring at the same time. This was also the only occupation group to have significantly increased, outside of routine manual occupations. This finding confirms that technicians are also a demanded occupation of the boom, along with operators, fabricators, and laborers, as well as production, craft, and repair.

Significant, but smaller, employment declines are also shown for other occupations, namely for food preparation, buildings and grounds, and cleaning (OC9) of 0.69 percentage points, protective services (OC8) of 0.55 percentage points, and sales (OC4) at 0.75 percentage points. Insignificant changes were found for personal care and personal services (OC10), office and administration (OC5), and managers (OC1), meaning that they were statistically indistinguishable from zero. Other than those three exceptions, all other occupational employment changes were statistically significant at least at the five percent level.

The restricted-access Census data provides compelling evidence that an energy boom alters the demand for tasks and the occupational distribution. In general, the employment gains associated with the boom, between energy and non-energy areas, differed across the occupational distribution. Unsurprisingly, the largest relative employment increases were found in the routine task occupations of production, craft, and repair, and operators, fabricators, and laborers. While the relative employment increases were largest for those routine manual tasks, these gains were also spread out even further along the middle portion of the occupational distribution, even reaching the non-routine cognitive task occupation of technicians. As the lower middle portion of the occupational distribution rises, it does so by diverting relative demand away from all other parts of the distribution.

4 Routine & Manual Employment on Hourly Wages

The conventional energy boom in Western Canada has now been attributed to both the routinization and manualization of employment across the occupational and task distributions of male workers. But, what do these employment changes mean in terms of hourly wages? More specifically, how does the increased routinization and manualization of employment translate into wage gains (or losses), both in general and as a result of the boom, through the employment share changes associated with these different types of tasks?

As explained by Autor (2013, p. 20-22), the Mincerian approach of estimating the returns to tasks by regressing wages on tasks may produce misleading evidence. Unlike the Mincer model, where wages are regressed on the pre-determined factors of schooling and experience, tasks are instead endogenously determined by a worker's human capital and its associated productivity as applied to each task. Therefore, the assignment of tasks is itself a function of wages. That said, Firpo et al. (2011) predicted that an increase in the market value of a task will increase the occupational wage associated with it. In the present case, the increased demand for routine and manual tasks from workers should increase their associated wages.

Similar to the wage equations of Acemoglu and Autor (2011) and Autor and Dorn (2013), the initial empirical approach follows a reduced-form estimation between the changes in employment shares, associated with either routine or manual tasks, and the changes in the log hourly wage at the local (Census division) level:

$$\Delta log(HW_{cp}) = \alpha + \beta \cdot \Delta ESH_{cp} + \eta \cdot Prov_p + \varepsilon_{cp} \tag{2a}$$

where $\Delta log(HW)_{cp}$ is the change in the natural log of the local hourly wage level, ΔESH_{cp} are changes in either the routine or manual shares of local employment across workers, and $Prov_p$ represents the province fixed effects (with Alberta omitted). This specification also includes a constant term, α, as the model is estimated as changes in a dependent variable on changes in an independent variable.

The demand for tasks is presented in terms of percentage point changes in employment shares and the wages paid to these tasks are presented in terms of the natural log of their hourly wage levels. The coefficient, beta (β), can be interpreted as the percentage change in wages resulting from a percentage point change in employment or as the elasticity between the local changes in tasks and wages. The estimates of these beta coefficients from equation (2a) are presented in the first row of Table 1, with pairs of columns associated with the routinization and manualization of tasks, respectively.

One important difference between the estimates for the routine share in the first column and the manual share in the third column is that the correlation with wages is only statistically significant for the routine share of employment, at the one percent level, but not for the manual share of employment, even at the ten percent level. Further, as the routine share of employment increases by one percentage point, the hourly wage increases by roughly 0.632 percent. The correlation for the manual employment share, while statistically insignificant, also yields a lower magnitude of 0.418 percent. Therefore, these estimates show that wages only somewhat respond to employment.[20]

In order to specifically measure the effect of the energy boom on wages, through its increased routinization and manualization of employment, the specification expands equation (2a) by including employment share changes interacted with the treatment indicator:

[20] Because both independent elasticity estimations use the full sample of the available 88 Census divisions across Western Canada, the estimates of the first and the third column remain unchanged under the alternative treatment definition.

$$\Delta log(HW_{cp}) = \alpha + \beta \cdot \Delta ESH_{cp} + \gamma \cdot \Delta ESH_{cp} \cdot Treat_{cp} + \eta \cdot Prov_p + \varepsilon_{cp} \qquad (2b)$$

where $Treat_{cp}$ an indicator binary for whether the local labor market is in the treatment group based on the percentage of local earnings deriving from the energy extraction industry. The new coefficient of interest, gamma (γ), can be interpreted as the percentage change in wages resulting from a percentage point change in employment due to the energy boom, while controlling for the elasticity between the local changes in tasks and wages.

The inclusion of the treatment interaction in equation (2b) requires several important changes from the initial empirical approach in equation (2a). First, the observations drop from the full set of 88 Census divisions across Western Canada to a smaller set of 74 Census divisions that fit within the treatment definition.[21] Second, the magnitude of the elasticity estimate between tasks and wages drops for the routine share of employment, (from 0.632) to 0.547 percent, while maintaining its statistical significance at the one percent level. At the same time, this elasticity estimate for the manual share of employment increases both in magnitude and significance, (from 0.418 and statistically insignificant) to 0.721 and significant at the five percent level.[22]

The second row of Table 1 shows the impact of the energy boom on wages, with the results coming through the employment share changes toward routine and manual tasks. A percentage point increase in the routine share of employment due to the boom was associated with an almost unit (one percent) increase in hourly wages, but this estimate on the interaction is only marginally significant (i.e. at the ten percent level). Given that the employment share of routine tasks increased by 2.86 percentage points due to the boom, this would be associated with an increase in hourly wages of 2.85 percent. In light of the evidence of Ross (2017), however, this wage premium for routine tasks may be fleeting and short-lived.

In contrast, a percentage point increase in the manual share of employment yielded less than half of the magnitude of the effect on wages (0.470), as compared to the routine share estimate. Given that the employment share of manual tasks increased by 2.66 percentage points due to the boom, this would be associated with an increase in hourly wages of 1.25 percent. However, the change in the manualization of employment due to the boom did not not lead to any significant changes in wages, as shown by the lack of statistical significance on the interaction coefficient for the manual shares. Therefore, while this boom can been

[21] Under the alternative treatment definition, the observation count increases to 78 Census divisions for the estimates with the interaction term included.

[22] The elasticity estimate for routine shares remains almost exactly the same in magnitude and significance under the alternative treatment definition, while the elasticity estimate for manual shares decreases in magnitude slightly (from 0.721) to 0.709, while still remaining statistically significant at the five percent level.

attributed to both the routinization and manualization of employment, only the routinization of tasks has additionally altered wages.[23]

5 Conclusion & Summary

This is the first study to combine the literature on employment polarization of occupations and tasks with the literature on the local labor market effects of energy sector boom and bust. Despite the extensive literature on how energy booms affect labor market outcomes, this literature remained silent on whether an energy boom could lead to the routinization or manualization of labor demand. This overlap in literature will continue to be an important avenue for research, because the technological progress that drives polarization, and the energy booms that enhance labor market outcomes, may have offsetting effects on the distributions of occupations and tasks.

An energy boom is a particularly large and localized change to determine whether this cyclical change affects the occupational and task distributions in a different or similar manner to those other secular causes. The approach involves figuring out which tasks and occupations are demanded from workers in an energy boom, in order to be able to fill those labor needs as they arise. Therefore, the focus is to determine which types of workers gain in an energy boom relative to others. Figuring out exactly which workers are needed to accomplish those demanded tasks is the final step, but one can remain agnostic and fluid, as worker assignment of skills to tasks can and will change over time.

In exploring these questions, this study uses two waves of the restricted-access version of the Census of Population from Statistics Canada, harmonized at the Census division level. These data represent the local labor markets within the Western Canadian provinces, both with and without energy resources, during what might be the final conventional oil and gas price boom, from the mid-1990s to the mid-to-late 2000s. A strength of the analysis is that it follows the same identification strategy previously used to document first order, and even second order, local labor market effects during a specific time period and in a specific energy producing region. The previous literature is also closely followed for the construction of the worker sample and the defining and ranking of occupations and tasks.

For this particular boom in Western Canada, the relative demand increased for workers to perform routine manual tasks, while the demand for them to perform non-routine and

[23]For the interaction coefficients, both magnitudes were reduced under the alternative treatment definition, (from 0.999) to 0.718 for the routine share interaction and (from 0.47) to 0.28 for the manual share interaction. However, the statistical significance for the routine share interaction increased from a p-value of 0.080 to 0.045 (i.e. from being significant at the ten percent level to now significant at the five percent level), while the manual share interaction decreased even further in significance.

cognitive tasks subsequently decreased. When viewed over the distribution of tasks, this routinization is a movement toward the middle of the distribution, with manualization found in the lower half, disfavoring the tails and upper half of the distribution, respectively. More specifically, both aggregate occupational groups performing routine manual tasks experienced large relative demand increases, with the increase for production, craft, and repair being of somewhat larger magnitude than the increase for operators, fabricators, and laborers. There was also a significant relative demand increase for technicians, who fall under non-routine cognitive tasks. While the boom was attributed to both the routinization and manualization of employment, only routinization was associated with increased wages.

That these specific occupations and tasks were needed during the boom is perhaps not that surprising. Energy extraction is certain to require workers to operate and fabricate equipment, for example, and the production and repair of that equipment, would also seem to be a necessity. But, this evidence vastly differs from the previous findings of the routine task literature, in that the impact of an energy boom is the opposite of the employment polarization found for several developed countries in recent years due to technological change. Workers performing routine tasks are seen as being replaced by technology, which therefore results in less relative demand for middle-skilled workers, and more demand toward the low and high-skilled workers in the tails. The demanded tasks for an energy boom were instead found in the lower and middle portions of the distribution, rather than toward the tails. The magnitude of the effects of an energy boom could also be large enough to locally offset any simultaneously occurring secular changes.

This finding for an energy boom has only been previously eluded to in the literature, but it has never been properly identified for any region until now. For example, for the case of Canada, Green and Sand (2015) had stated that “one must overlay a discussion of the effects of the resource boom after 2000 over any technological determinants story” when considering changes in its occupational distribution. More generally, Autor (2015) speculated that “many of the middle-skill jobs that persist in the future will combine routine technical tasks with the set of non-routine tasks in which workers hold comparative advantage: interpersonal interaction, flexibility, adaptability, and problem solving.” His broad definition for middle-skill jobs includes builders, electricians, installers, plumbers, and technicians, which all “typically require at least two years of post-secondary vocational training.” These are similar occupations to those demanded in an energy boom.

In terms of how the increased wages from the increased demand for routine tasks map back to the returns for certain skill groups, Marchand and Song (2013) identified several education groups of interest for Alberta, the Western Canadian province with the most energy resources, in the baseline year of 1995. Workers specializing in routine manual tasks (operators, fabricators and laborers; and production, craft, and repair) had the highest concentrations of less than high school graduates, high school graduates, and trades and apprenticeships. In contrast, workers in non-routine cognitive tasks (managers, professionals, and technicians) had the highest concentrations of less than 4-year university graduates, 4-year university graduates, and greater than 4-year university graduates. This indicates that relative increase in demand for routine tasks is likely to increase demand for lower-to-middle-skilled individuals.

6 Discussion & Policy Implications

The energy boom, of the mid-1990s to mid-to-late 2000s, is spoken of in the current study as the perhaps the final conventional energy boom. This is because the most recent energy boom that followed in the first half of the 2010s was predominantly a shale boom. The effects of a shale-oriented boom may of course differ from the effects of a conventional energy boom; just because the evidence for this previous conventional energy boom is associated with an increased demand for routine tasks from workers does not necessarily mean that the same prediction would hold for a future more shale-oriented energy boom or whatever may follow. Assuming for the moment that it would apply, however, what would these findings suggest for policy makers?

For any given energy boom, whether the production is mostly from conventional or shale sources, the big worry for governments containing energy resources is where to get the additional workers that they need, when they need them. This would be true for any cyclical shock, but it has proven to be especially true for the energy extraction industry, with their shocks being particularly large and localized. Therefore, increasing the mobility of demanded workers during these times should be a priority. In Alberta, for example, during the boom of the current study, over a hundred thousand workers migrated from within Canada to the Western Canadian province, many of whom lived in temporary work camps and maintained their primary residence elsewhere (Laporte et al., 2013).

So, what types of policies might succeed in attracting those needed workers during booms? Once the types of workers in demand are identified, areas containing those workers could be targeted for advertising campaigns, listing the available opportunities associated with relocating. Further, relocation expenses could be partially or fully covered by governments. If the targeted workers cannot be found within the country, then immigration policy could be loosened accordingly. For Canada, which already has a point-based system for immigration, the Provincial Nominee Program and the Temporary Foreign Worker Program are both policies meant to further expedite the immigration process for workers with skills from outside of the country.

During the 2010s, the wide-spread adoption of new technologies in the energy sector, namely the pairing of hydraulic fracturing with horizontal drilling, subsequently led to the shale boom, particularly within the United States. This adoption of technology also led to workers being replaced with new forms of capital within the energy industry, thereby leading to an even greater demand for higher skill workers. There seems to at least be some anecdotal evidence for this, in terms of the recent changes to how technology and labor are being used in tandem in the Permian oil deposit of West Texas (Krauss, 2017) and the recent purchasing of automated trucks in Alberta's oil sands (Cosh, 2018).

Of course, both the conventional energy boom of the 1990s and 2000s, as well as the shale boom of the early-to-mid 2010s, were immediately followed by bust periods, the latter of which remains to this day. The energy industry recently experienced an unprecedented price collapse, due to the rise of US shale production in the 2010s having kept oil and gas prices down, to the Russia and Saudi Arabia price war, and the spread of Covid-19, more recently. For the first half of 2020, the average price of West Texas Intermediate was around $37 and the average price of Western Canadian Select was around $19, with brief periods of negative pricing.

If workers performing routine manual tasks were the most demanded during the boom, then it is this set of workers who might be targeted for help in a subsequent energy bust, if governments decided to offer assistance in this manner. Further, in the midst of an energy bust, it is this set of routine manual workers who would be made even worse off due to the possibility of technological replacement and the lack of an energy boom on the horizon to be their savior. Therefore, a better understanding of how the demand for occupations responds to an energy boom would allow the industry and governments to better navigate through boom and bust periods. This is also why the parsing of cyclical trends from the secular is so important.

Given that boom and bust cycles can take a decade or more to repeat, having these worker go on unemployment or some other similar assistance would not make sense from either a public finance perspective, other than for short periods of time, nor from a human capital perspective, as skills used during the boom could atrophy during the bust or no longer be needed in the next boom. Therefore, policies to increase their job opportunities should be the priority, such as greater financial assistance for further education or potential worker retraining programs. In addition, the policies previously mentioned to attract workers during boom periods could be inversed during bust periods, as evidenced by requests to alter or suspend the Temporary Foreign Workers Program during times of unprecedented unemployment in Canada, such as at present.

Although the current study has interesting implications and extensions to the shale boom and bust that followed, an analysis using the Canadian Census data may not be feasible. First, due to the suspension of the long-form Census for the 2011 wave, the data collected for 2010 under the National Household Survey is not directly comparable to other Census waves. Second, even though the long-form Census was brought back for the 2016 wave and the 2021 wave yet to come, the 2015 collection year would only represent the shale bust, rather than the boom, and 2020 might follow as a deeper continuation of that bust. That said, the American Community Survey, which replaced the long-form Census for the US, also has a large sample size and is available at a higher frequency, for every year since 2005.

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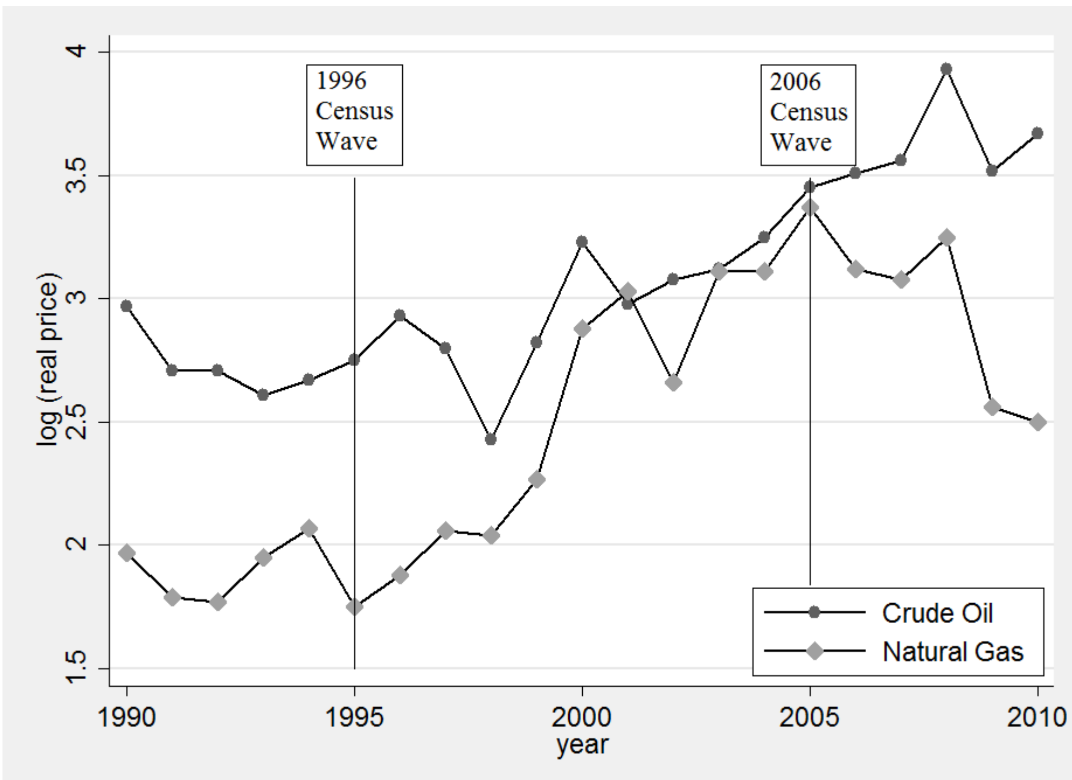
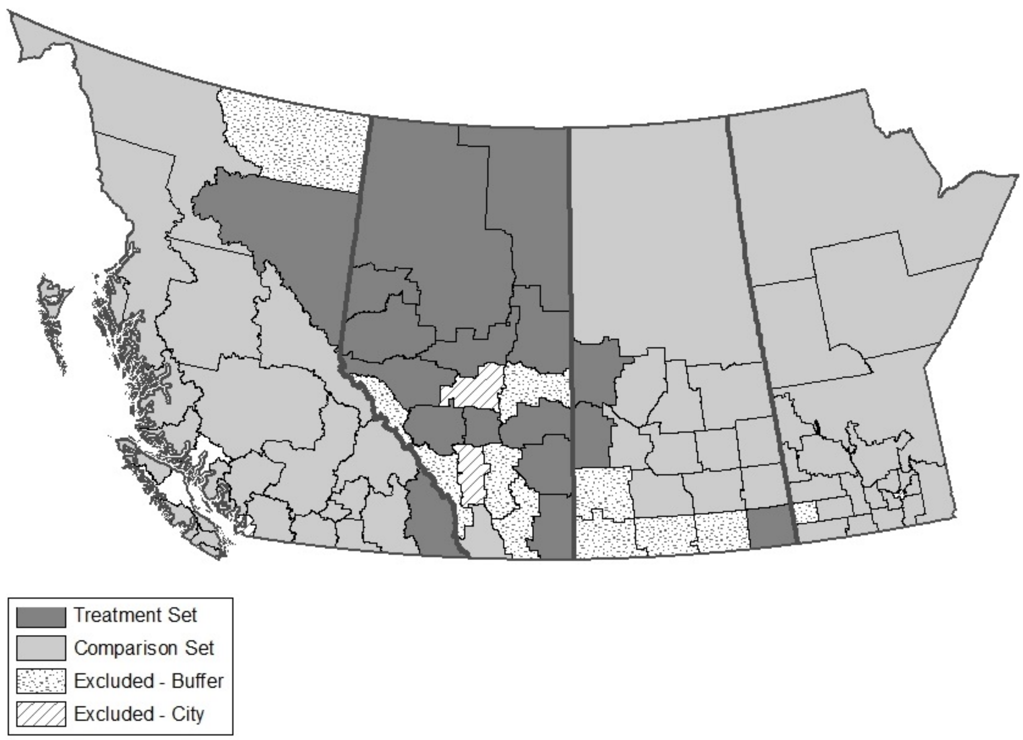
Figure 1: Intensity of Energy Boom through Real Energy Price Trends



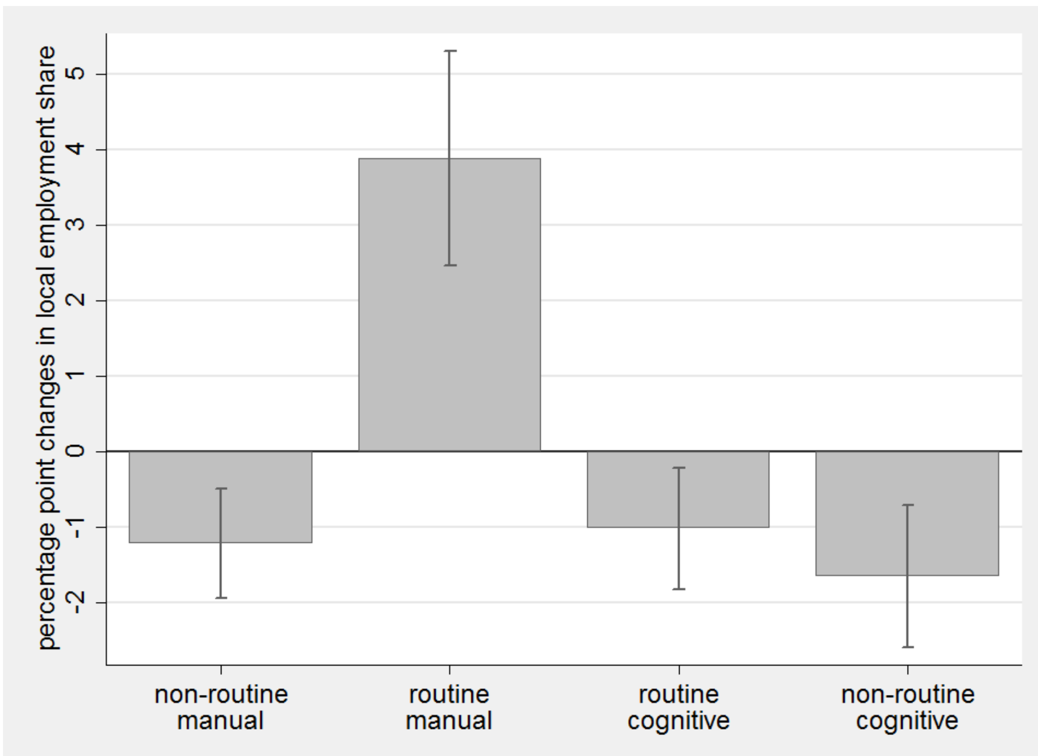
Notes: Author's calculations of 1990-2010 Canadian Association of Petroleum Producers data. The log real price of crude oil is based on the average wellhead price in dollars per cubic meter. Log real price of natural gas is based on the average wellhead/plant gate price in dollars per thousand cubic meters. Each Census wave corresponds to the previous year of collection.

Figure 2: Census Divisions of Western Canada with and without Energy Resources



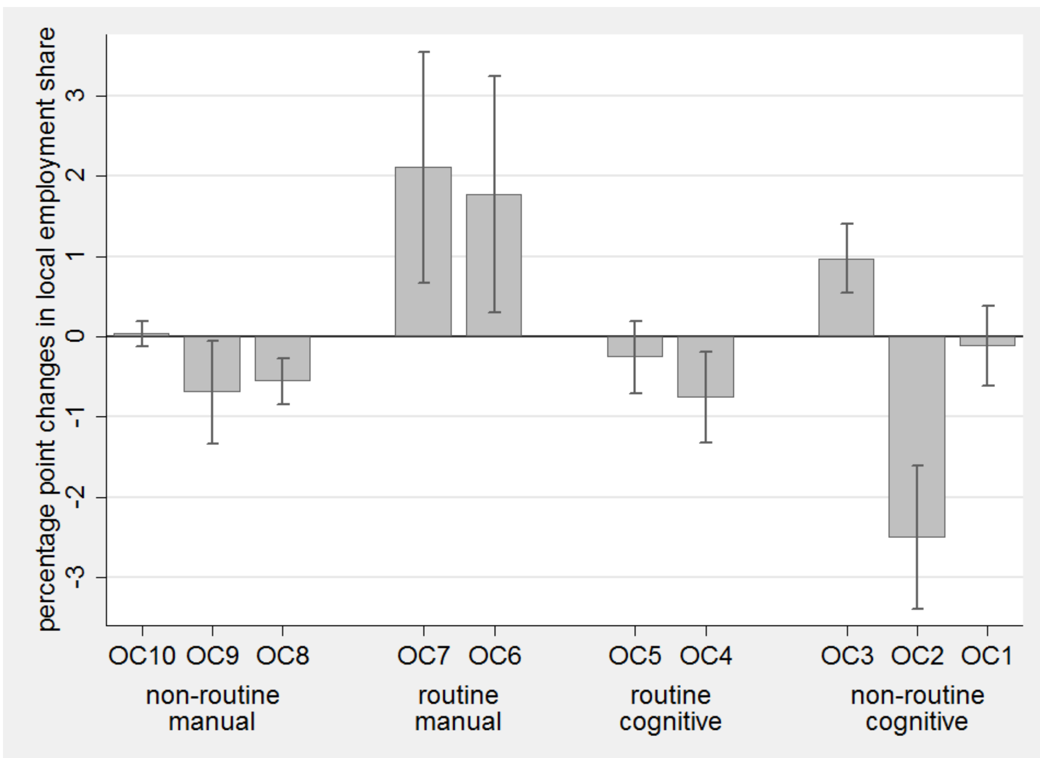
Notes: Author's calculations based on 1996 Census data using the 2006 Census division boundaries. The treatment set is based on a Census division having more than ten percent of its total earnings from the energy extraction sector in the base year of 1995, while the comparison set is based on having less than five percent of its total earnings from that sector.

Figure 3: Employment Share Changes along Task Distribution due to Energy Boom



Notes: Author's calculations of 1996 and 2006 Canadian Census data. Histogram bars represent alpha coefficients on the treatment binary from equation (1) multiplied by 100. Coefficients are interpreted as percentage point changes in local employment shares due to the energy boom. I-bars represent 95% confidence intervals. Province fixed effects are included. Observations are 74 Census divisions.

Figure 4: Employment Share Changes along Occupational Distribution due to Energy Boom



Notes: Author's calculations of 1996 and 2006 Canadian Census data. Histogram bars represent alpha coefficients on the treatment binary from equation (1) multiplied by 100. Coefficients are interpreted as percentage point changes in local employment shares due to the energy boom. I-bars represent 95% confidence intervals. Province fixed effects are included. Observations are 74 Census divisions.

Table 1: Hourly Wage Changes from Employment Share Changes due to Energy Boom

Δ Log (Hourly Wage)	(1)	(2)
Δ (Routine Share)	0.632 ***	0.547 ***
	(0.176)	(0.172)
	[0.001]	[0.002]
Δ (Routine Share) * Treat		0.999 *
		(0.561)
		[0.080]
Province Fixed Effects	Yes	Yes
Observation Count	88	74

Δ Log (Hourly Wage)	(3)	(4)
Δ (Manual Share)	0.418	0.721 **
	(0.347)	(0.343)
	[0.232]	[0.039]
Δ (Manual Share) * Treat		0.470
		(0.544)
		[0.391]
Province Fixed Effects	Yes	Yes
Observation Count	88	74

Notes: Author's calculations of 1996 and 2006 Canadian Census data. First rows represent beta coefficients on employment share changes from equations (2a) and (2b), interpreted as the elasticity between log point changes in hourly wages and percentage point changes in local employment shares. Second rows represent gamma coefficients on employment share changes interacted with the treatment binary from equation (2b), interpreted as the elasticity between log point changes in hourly wages and percentage point changes in local employment shares due to the energy boom. Δ Log denotes changes in natural logarithm points. Stars denote statistical significance (* for 10%, ** for 5%, and *** for 1%). Robust standard errors reported in parentheses. P-values reported in brackets. Province fixed effects are included. Observations are Census divisions.

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