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Manufacturing in a Natural Resource Based Economy: Evidence from Canadian Plants

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Manufacturing in a Natural Resource Based Economy: Evidence from Canadian Plants*

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Abstract

This study investigates the effects of an oil boom on firms' performance using data from the Canadian Annual Survey of Manufactures. We exploit the time variation of the booming natural resource sector activity in an oil-producing area with the location of manufacturing plants. We hypothesize that the effect of the booming sector on plants depends on their spatial proximity, which allows us to create an exogenous treatment variable. The outcome variables include plant-level wages, employment, sales, and exports. We find that the effect of the booming sector on the incidence of exporting varies greatly by plant-level productivity. More productive plants become more likely to export relative to less productive plants. They can do so by paying a higher wage, while employment grows less than plants that serve only the domestic market. We find that initial productivity and plants' ability to export provides an important differentiation in average plants effects. In particular, while there is a great variety in the effect by sector, a clear linkage with the resource industry is not observed.

Keywords: natural resources, heterogeneous firms, regional economics

JEL: L6, O4, R11, R15.

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1 Introduction

Since 1980s, myriad studies show that oil price shocks affect economic performance in both oil-importing and oil-exporting countries. However, only recently have researchers begun to examine the firm level impacts of the oil price shocks, thanks to availability of the large-scale micro data. The research interests have particularly risen in understanding firms' responses to the recent boom in non-conventional oil and gas production in diversified developed economies such as the U.S. and Canada.[1] Some studies have recently investigated the spill-overs from the shale production to local wages, income and employment using U.S. county level data (see Karaki, 2018; Fleming et al., 2015, for a review). In particular, U.S. regional spill-overs are considered by Feyrer et al. (2017). They find that wage income and employment increased substantially in production counties, with additional spill-overs to neighbouring counties.[2] Allcott and Keniston (2018) combine data on oil and gas endowments with Census of Manufactures micro-data, to estimate how oil and gas booms affect local economies in the U.S. They find a positive effect on local wages and an increase in manufacturing industries overall, driven by upstream and locally-traded sub-sectors, but a crowding out of some sub-sectors. Arezki et al. (2017) show that the U.S. fracking revolution increased exports of firms in energy intensive sectors.

In Canada, the natural resources sector has played an influential role in the economy for many years. Due to the geographical concentration of natural resources and the provincial autonomy of managing them, the economic effects have been especially instrumental to the economic performance of oil and gas producing provinces: Alberta, Saskatchewan and more recently Newfoundland and Labrador (Carter, 2016; Mansell and Schlenker, 2016). Aggregate provincial and sectoral economic performances in Canada, in light of this boom of natural resource sector, have been analyzed by Dissou (2010), Raveh (2013), Beine et al. (2015) and Moshiri and Bakhshi-Moghaddam (2018) among others.

A common concern in well-diversified high income economies is how a resource extraction industry affects the productive non-resource economy in the country overall, or at the regional level. Among Canadian policy makers and academics, the discussion on the effect and spill-overs from Canada's natural resource sector on the rest of the economy has been ongoing for decades (Olewiler, 2017), especially since the extraction of oil from the Alberta oil sands expanded on a wave of higher oil prices in world markets and improved extraction technology (e.g. Carney, 2012; Cross, 2015).[3] Where commentators have warned for 'Dutch disease'

[1]The case of US and Canada also relates to other cases of economies affected by a significant natural resource sector growth. Currently, the UK is experimenting with shale gas production, which if successful could similarly transform regional economic circumstances (The Economist, 2018).

[2]Although the effects are arguably smaller than reported in their study (James and Smith, 2018).

[3]The term oil sands is commonly used to refer to the specific concentration of what is technically known

effects,[4] evidence for detrimental effects on manufacturing in Canada has been mixed at best (Beine et al., 2012; Marchand, 2012; Raveh, 2013). We will use a plant-level dataset of manufacturing plants to contribute to the literature that often looked at macro-economic aggregates.

We study the spill-overs from a natural resource sector on local firms and workers. Additionally, in contrast to other studies using plant-level data in this research area, we look at the export performance of plants affected by natural resource sector development. Cross-country evidence suggests that resource-exporting countries tend to have lower exports of manufacturing products (Harding and Venables, 2016). However, the effects might differ at the level of the firm or plant. The decisions to export of heterogeneous firms' has been a central issue in the recent trade literature (e.g. Melitz, 2003; Bernard et al., 2007) including for Canadian firms (Baldwin and Gu, 2003). We look explicitly at the export performance of individual plants following the development of the natural resource sector.

The Canadian case of the natural resource sector influence on the wider economy has some features that make it distinct from the U.S. case. Firstly, the resource sector of the Alberta oil sands is geographically concentrated in one area, Ft McMurray. Secondly, this area is located relatively far from urban centres or industrial areas. For instance, the distance from Ft. McMurray to the nearest large urban centre (and provincial capital) Edmonton is a 450km (6h45) drive.[5] Therefore, while we focus on the performance of manufacturing firms in proximity of the natural resource sector, we take proximity quite liberally. Thirdly, the north of Canada is characterised by a strong relience on the extraction of various natural resources. While some areas may find strong income growth and dependence on the revenues from such sectors, there is also recognition that revenues from resource extraction should ideally be used for sustainable economic development. Further understanding on the extent and mechanism of economic spill-overs to local manufacturing inform such debates and decisions.

In this paper, we study the impact of natural resource extraction on manufacturing plants' performance through their proximity to Ft. McMurray. While the economic size of the extraction combined with the labour movement towards the area should have been a boon for local firm development, the distance to traditional population centres could have been a major constraint. Although the aggregate effect of oil price shocks on the provincial economic performance is well known, our knowledge about the firm-level effects is limited. Therefore,

as bituminous sands found in a large area in Alberta and Saskatchewan. Authors and activists more critical towards the extraction activities of these, due to the effects on the natural environment or the contribution of the industry to global climate change, often use the term 'tar sands' (Davidsen, 2016).

[4]We discuss Dutch disease in Section 2.

[5]Using OpenStreetMaps, https://www.openstreetmap.org/directions?engine=osrm_car&route=56.7292%2C-111.3885%3B53.5354%2C-113.5080#map=7/55.180/-112.404 [accessed 30 April 2018], see also Figure 2 below.

we aim to answer how individual manufacturing plants were affected by a boom in natural resources extraction. We focus our research on changes in employment, labour productivity, wages and exports during an oil boom at the plant level.

From the Annual Survey of Manufacturers (ASM) of Statistics Canada, we obtained yearly plant level data of all manufacturing plants in Canada from 2000 to 2010. For each plant we have information on their economic performance and we correlate this with time-varying revenues in the natural resource sector and the distance of each plant relative to various locations in Canada, such as Ft. McMurray.

We start with developing a general equilibrium model with heterogeneous firms and a natural resource sector. We derive a number of predictions that reflect the interaction between the resource sector and the export decisions, wages, and employment of manufacturing plants, which we take to the plant-level data. We find that on average plants tend to be negatively affected by the natural resource sector in terms of employment, total revenue, productivity and exports. However, there exists a great heterogeneity between sectors, indicating that plants in certain industries actually do rather well. We cannot attribute this effect exclusively to the tradability of the produced output or industry linkages. Instead, we find that firms have above average levels of productivity do relatively better and increase their exports.

2 Theory

Before providing our theoretical model, we briefly discuss some key results from literature. At the sectoral level, the theory of booming sectors was laid out by Corden and Neary (1982) and van Wijnbergen (1984), and coined as Dutch Disease (The Economist, 1977). Demand for goods and services originating from the income generated in a booming natural resource sector will induce a re-allocation of production factors between sectors. Whereas traded goods can be imported at an exogenous world price, non-traded goods and services will meet increased domestic demand. Therefore, when assuming a fixed capital stock and only intersectoral labour mobility, a traded sector competing for these factors of production with a booming natural resource sector will find itself squeezed, whereas a non-traded sector will gain. This spending effect goes along with a resource movement effect, which occurs as the booming sector draws production capital and labour from the other two sectors, resulting in a further contraction of the traded sector, a phenomenon believed to be detrimental to the long-term performance of an economy (Krugman, 1987).

While the standard framework provides insights into the allocation of resources between sectors in the wake of a natural resource windfall, it is silent on important features concerning how some firms are affected differently than others. With the advent of firm level data, these questions can now be empirically tested, but theoretical models that can provide a framework for this empirical work have lagged. New trade theories offer a convenient framework to model monopolistic competition and firm heterogeneity within industries, and new insights into the development of sectors and the overall economy. Although there is large literature using such models for international trade, they have received very few applications to the issue of resource booms.

In the following section, we present a model similar to Østenstad and Vermeulen (2016), which analyzes the effect of a windfall on firm selection, trade, and welfare. Our model, however, is different in two ways. First, we simplify the framework to include only one mobile factor of production, labor.[6] Second, we extend the model to include an oil sector. The extension allows for a resource movement effect in addition to the spending effect of a resource boom. We model a resource boom as an increase in the oil price or an increase in total factor productivity in the oil sector, which prompts a reallocation of labor from manufacturing firms to the oil sector. The inclusion of a resource movement effect is key to capture the development of local firms in the vicinity of the oil fields that are likely to experience competition for labor from the oil sector.

Allcott and Keniston (2014) also develop a model similar to ours.[7] However, there are some important distinctions. They model multiple differentiated sectors of two types: "local" sectors with infinite trade costs and perfectly "tradable" sectors with zero trade costs. Restricting focus to one differentiated sector we greatly simplify the analysis and at the same time highlight the contrast to the standard two sector framework as the distinction between traded and non-traded goods is endogenously determined.

2.1 Model

In this section, we present a general equilibrium model with heterogeneous firms where selection into export markets is endogenously determined. There are two sectors: the oil sector and the manufacturing sector. The oil sector produces an undifferentiated good, oil, which is exported in its entirety at an exogenously given price determined in the international market. The manufacturing sector is characterized by monopolistic competition and consists of

[6]While Østenstad and Vermeulen (2016) distinguish between high- and low-skill labor, this distinction is unsuitable for our context since we do not have data on workers' skills. The model also broadly follows Haaland and Venables (2016).

[7]There are multiple versions of this working paper, using the same NBER number and publication date, even while presenting different theoretical models. We refer here specifically to the version that presents a Melitz (2003)-type theoretical model. Their final published work does not contain a heterogenous firms framework as theoretical underpinning. Hence, a model of an economy with natural resources and heterogenous firms in combination with plant-level empirical results is, to the best of our knowledge, not published yet.

heterogeneous firms producing differentiated goods. While labor is the only input in the manufacturing sector, there is an additional fixed factor used in the oil sector that we interpret as capital. We begin by outlining the preference structure in the economy before presenting the production structure in the manufacturing sector and the oil sector.

2.1.1 Preferences

Preferences over the differentiated manufacturing goods take the CES form:

$$U = \left[\int_{\nu \in \Omega} q(\nu)^{(\sigma-1)/\sigma} d\nu \right]^{\sigma/(\sigma-1)} \qquad \sigma > 1,$$

where Ω is the set of available varieties, $q(\nu)$ is consumption of variety ν, and σ is the elasticity of substitution. Consumers can consume both domestically produced and imported varieties and do not differentiate between products origins. Optimization yields the individual good demand $q(\nu) = p(\nu)^{-\sigma} E P^{\sigma-1}$, where E is the expenditure on manufactured goods and $P \equiv \left[\int_{\nu \in \Omega} p(\nu)^{1-\sigma} d\nu \right]^{1/1-\sigma)}$.

2.1.2 The manufacturing sector

The manufacturing sector consists of heterogeneous firms that produce distinct varieties subject to monopolistic competition. While all firms sell in the domestic market D, only a selection of firms sell in the export market X. Production of each variety incurs fixed and variable costs. While the fixed cost, f_i, is common to all firms selling in the same market $i \in (D, X)$, variable costs vary with firm productivity $\psi \in (1, \infty)$. The cost function is given by

$$c_i = (f_i + q/\psi)\, w,$$

where w is the wage. Maximizing profits, each firm sets a price with a constant markup over the marginal costs of selling in market i, $p_i(\psi) = (\sigma/(\sigma-1))\tau_i w/\psi$, where τ_i is an iceberg trade cost. We have $\tau_D \equiv 1$ for the domestic market and $\tau_X \equiv \tau > 1$ for the export market. The firms' revenue is then given by:

$$r_D(\psi) = \sigma\zeta \left(w/\psi \right)^{1-\sigma} E P^{\sigma-1}, \qquad r_X(\psi) = \sigma\zeta \left(\tau w/\psi \right)^{1-\sigma} \bar{E} \bar{P}^{\sigma-1},$$

where $\zeta \equiv (\sigma-1)^{\sigma-1}\sigma^{-\sigma}$ and $\bar{E}$ and $\bar{P}$ are the fixed expenditure level and price index that exporting firms face in the world market.

Foreign firms producing for the domestic market face a similar cost function as the domestic firms. They face a fixed cost f_M and an iceberg cost τ_M to enter the import market. The foreign wage is taken as given and normalized to 1. Serving the import market yields revenue given by:

$$r_M(\psi) = \sigma\zeta\,(\tau_M/\psi)^{1-\sigma}\,EP^{\sigma-1},$$

As in Melitz (2003), firm productivity is determined by a lottery. After paying a sunk cost f_E to develop a variety, each firm draws its productivity level ψ from the cumulative Pareto distribution $G(\psi) = 1-(1/\psi)^k$. We make the standard assumption that $k > \sigma - 1$. Because of the fixed market entry costs, only firms that draw a sufficiently high productivity ψ will decide to produce. The productivity cut-offs ψ_i are the lowest levels of productivity at which the firm's profits from serving market i are non-negative. Noting that the firm's operating profit is a fraction $1/\sigma$ of its revenue, we see that the productivity cut-offs are determined

by: $$r_D(\psi_D)/\sigma = wf_D, \quad (1) \qquad r_X(\psi_X)/\sigma = wf_X, \quad (2) \qquad r_M(\psi_M)/\sigma = f_M. \quad (3)$$

We restrict the parameter values such that they generate selection into export markets, i.e. $\psi_D < \psi_X$. This implies that exporters employ more workers and have higher revenues from domestic sales. Potential entrants weigh the expected operating profits against the fixed costs. Free entry implies that, in equilibrium, expected profits must equal zero:

$$wf_E = \int_{\psi_D} (r_D(\psi)/\sigma - wf_D)\,dG + \int_{\psi_X} (r_X(\psi)/\sigma - wf_X)\,dG. \quad (4)$$

The total value of output sold by domestic firms in the domestic market D, in the export market X, and by foreign firms in the domestic market M are given by:

$$D = N\int_{\psi_D} r_D(\psi)dG, \quad (5) \qquad X = N\int_{\psi_X} r_X(\psi)dG, \quad (6) \qquad M = \bar{N}\int_{\psi_M} r_M(\psi)dG, \quad (7)$$

where N and $\bar{N}$ denote the mass of firms in the domestic and foreign economy. Note that total expenditure must equal domestic and import sales and the wage bill must equal the total value of sales by domestic firms:

$$E = D + M, \quad (8) \qquad wl = D + X. \quad (9)$$

2.1.3 The oil sector

The oil sector is characterized by a Cobb-Douglass production technology:

$$O = F(L - l, R) = B(L - l)^{\alpha} K^{1-\alpha},$$

where L is the total number of workers in the economy, K is a fixed factor and B is total factor productivity. Oil is freely traded at the price p_o. Factor prices are given by marginal productivity:

$$w = A\alpha \left(K/(L - l) \right)^{1-\alpha}, \qquad (10) \qquad\qquad r = A(1 - \alpha) \left(K/(L - l) \right)^{-\alpha}, \qquad (11)$$

where $A \equiv p_o B$ and r is the return to the fixed factor.

2.1.4 General equilibrium

In general equilibrium, total spending equals total income:

$$E = wL + rK. \qquad (12)$$

The system (1)-(12) determines the general equilibrium values of ψ_D, ψ_X, ψ_M, P, E, w, r, N, l, D, X and M. In Appendix A, we solve the full system in differences to obtain the general equilibrium effects of an oil boom $\hat{A} > 0$, which we can interpret as an increase in the oil price or an increase in total factor productivity in the oil sector.

2.2 The impact of an oil boom

The model set out above lead to the following predictions: An oil boom implies that

- P1) only the most productive firms continue to export,
- P2) the wage rate increases,
- P3) domestic sales increases for a given firm,
- P4) the number of workers increases in a given nonexporting firm,
- P5) the number of workers in a given exporting firm may increase or decrease,
- P6) the total number of workers in the manufacturing sector falls,
- P7) aggregate domestic sales can increase or decrease,

P8) the share of aggregate export sales in total revenues decreases.

Proof. See Appendix B ■

An oil boom increases the marginal productivity of labor in the oil sector. Workers move from the manufacturing sector into the oil sector (P6) and the wage is bid up (P2). In addition to the between-industry reallocation of labor from the manufacturing sector to the oil sector, the oil boom prompts intra-industry reallocations that give rise to a Dutch disease effect. However, the mechanism through which it operates is different from the standard approach as it operates through an endogenous selection of firms into domestic and export markets. The domestic survival cut-off decreases, since the positive effect of higher domestic demand on firms' profits dominates the negative effect from higher marginal costs. Meanwhile, the export cut-off increases, as exporting firms face higher marginal cost but an unchanged world demand. The changes in the cut-off values imply that more firms at the lower end of the productivity continuum can enter the market, whereas the least productive exporting firms exit the export market (P1). It follows that the share of aggregate export sales in total revenues declines (P8).[8]

As domestic demand increases, domestic sales increases for a given firm (P3). Consequently, firms that only serve the domestic market employ more workers (P4). Exporting firms also expand production for the domestic market, but they contract production for the export market. Depending on what effect dominates, they may increase or decrease employment (P5).

Aggregate domestic sales may increase or decrease (P7). While a given firm increases its domestic sales, the mass of active firms may go up or down. On one hand, fewer firms enter the productivity lottery as expected profits fall. On the other hand, the domestic survival cut-off decreases.

3 Data and econometric specification

The dataset we use is the Annual Surveys of Manufactures (ASM), which covers all manufacturing plants in Canada and was accessed through Statistics Canada CDER (Canadian Centre for Data Development and Economic Research). Plants can be followed consistently by year from 2000-2010. In our main specifications, we use plants that exist during the entire period, because this will ensure that we are minimizing the effect of strategic entry or

[8] The within-industry reallocations are identical to Østenstad and Vermeulen (2016), whereas the between-industry reallocations are the opposite. The reason is that we include the oil sector, which gives rise to a resource movement effect.

Table 1: Descriptive Statistics

Variable	Abbreviation	Mean	St. dev.	N
Number of workers	N. workers	36.808	141.774	376436
Log Total Revenue	Log total rev.	14.596	1.806	280432
Log Domestic Revenue	Log domestic rev	14.279	1.742	276614
International export sales / total revenue	Int. exp / total rev.	0.133	0.251	392679
Provincial sales / total revenue		0.169	0.320	392679
Log Value Added / all workers	Log value added/worker	11.213	0.664	376436
Log Wage per worker	Log wage/worker	10.466	0.491	376436
Log total revenue at of CSD	Log(CSD product)	23.621	2.540	280419
Indicator for firms that always export		0.073	0.261	412812
Indicator for firms that never export		0.176	0.349	412812

Note: Domestic revenue includes revenue from the whole of Canada. The bottom two indicator variables give the ratio of plants that either always or never export, which is 7.3% and 17.6% respectively.

exit in response to the activity in the natural resource sector.[9] The information on plants includes revenue by location (domestic, by province, by world regions), employment, value added, costs of inputs among others. On our request we obtain further indirect information on plants' locations through information on the distances to certain points in Canada and their association with a Census Subdivision (CSD).[10] All plants are also associated with a 2-digit sector indicator. Descriptive statistics of the plant level outcome variables are given in Table 1. These variables can also be aggregated over the CSD. The way we do this will be defined below.

Canada has three main oil (and gas) producing provinces. Alberta and Saskatchewan in Central Canada produce oil and gas including for a large part through 'non-convential' methods as fracking and open-pit oil sands mining and in-situ methods. The province of Newfoundland and Labrador at the Atlantic coast has more recently seen an expansion of deep-sea offshore oil extraction activities. Figure 1 indicates the variation of resource sector revenue for three oil-producing provinces over time.

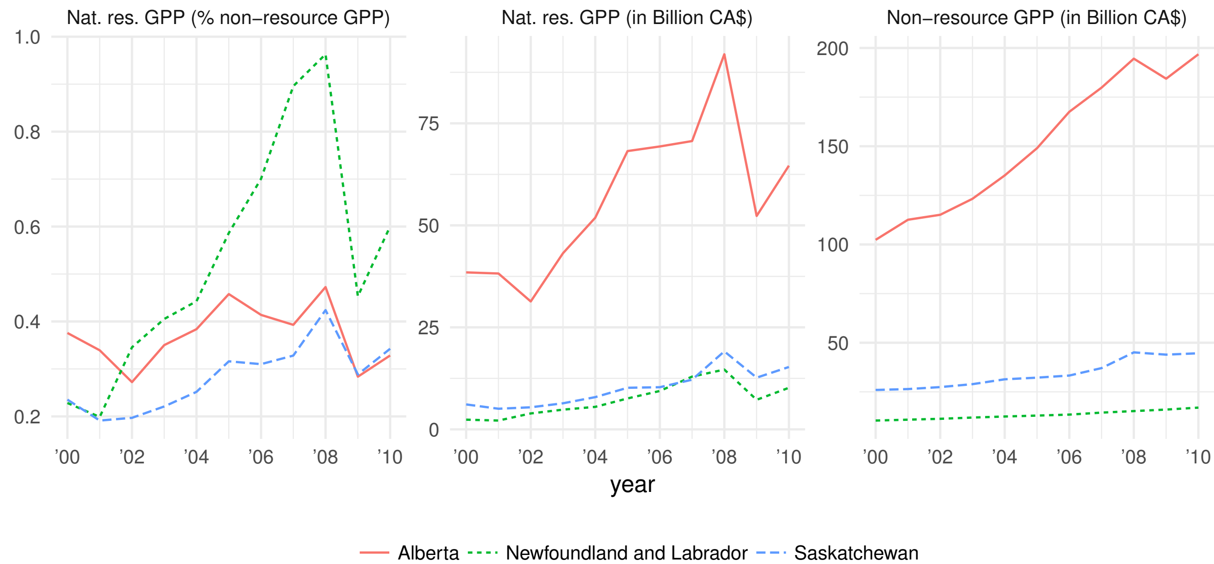
As our main distance measure we use plants' geodesic (straight line) distance to Ft. McMurray, as the city that is concentrated around the oil sands. Figure 2 indicates equi-distance circles from Ft. McMurray.[11] We note that these distances are much larger than what has

[9]Usually entry and exit of plants is determined through the appearances and disappearance of plant identification (id) numbers (Baldwin and Yan, 2010). However, such id's could also change if plants change ownership or merge with other firms without actually changing any activity of the physical plant.

[10]There are 5253 CSDs in Canada, of which 1859 within 1000 km of Ft. McMurray (the major oil-producing city), and 435 in Alberta.

[11]We do not observe the location of each plant directly for confidentiality reasons. Instead, the distances were calculated by staff of Statistics Canada. Similarly, plants are located to a CSD, but we do not know

Figure 1: Resource Sector and Manufacturing production



Source: Cansim Tables 0379-0025 and 0384-0039.

been considered in previous (US based) studies (Feyrer et al., 2017; Allcott and Keniston, 2018).

The main empirical setup is as follows,

$$y_{i,t} = \theta f\left(\text{oil production}_t, \text{distance}_i\right) + \beta x_{i,t} + \alpha_i I(\text{CSD}_i) + \mu_{i,t} I(\text{sector}_i \times \text{year}_t) + u_{i,t}, \quad (13)$$

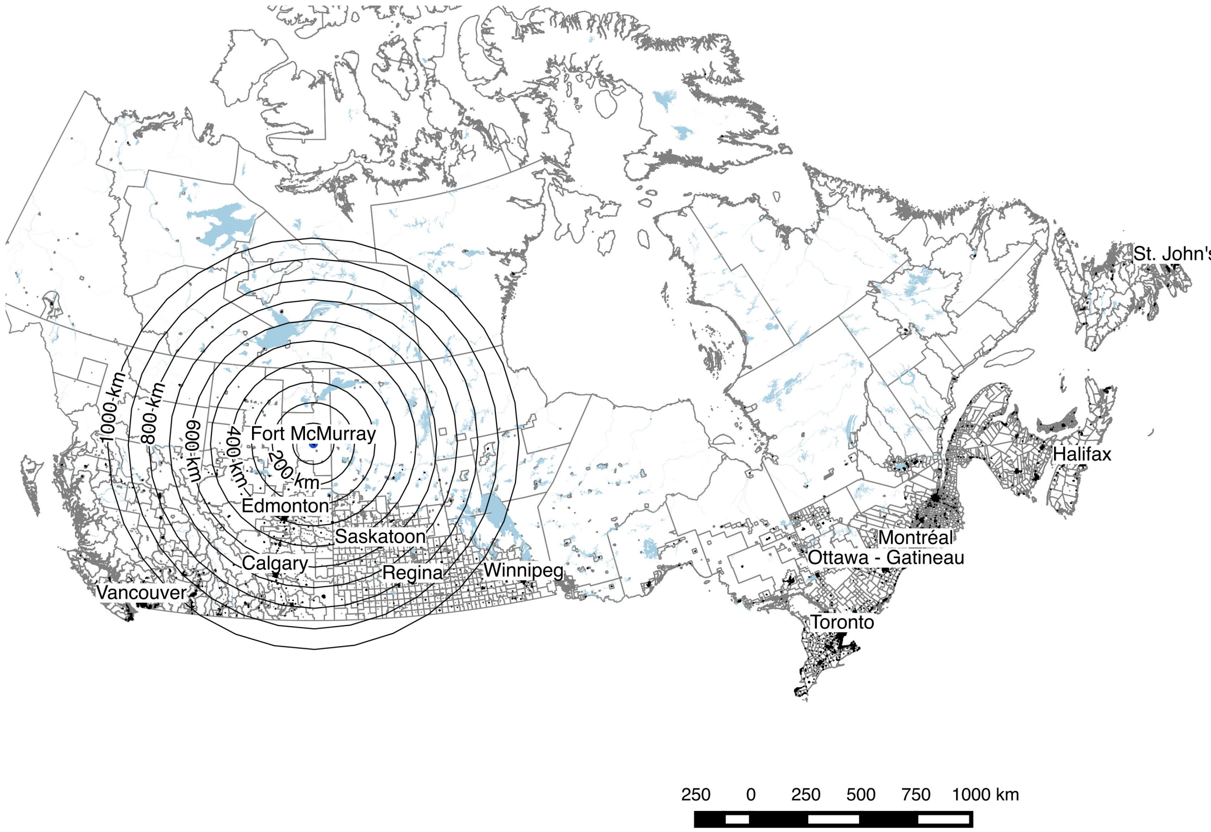
where $y_{i,t}$ represent the various dependent variables at the firm or CSD level, i, and year, t. We will focus on the number of employed workers, the log of revenue from the domestic (Canadian) market, log of international exports (or the ratio of international exports to total revenue), the log of value added per worker (or the log of average workers' wages).[12] The first term on the right-hand-side of equation (13) indicates our exogenous treatment variable, further discussed below.

As additional control for regressions at the plant level, represented by $x_{i,t}$, we use the log of a plant's CSD total revenue. This is the total revenue aggregated at the CSD level in which the plant is located, minus the plant's own revenue. Through the inclusion of CSD-level fixed effects, $I(\text{CSD}_i)$, we control for any time-invariant effects, including distance to the oil sector and CSD specific characteristics such as whether it is located within an urban area. We allow nation-wide time effects to be differentiated by sector, indicated by $I(\text{sector}_i \times \text{year}_t)$. This

which CSD this would be.

[12]The ratios (rather than log's) of exports are more appropriate at the plant level when taking into account that a substantial number of plants will have zero exports, as indicated by the final rows.

Figure 2: Distance from Ft. McMurray.



Note: Every circle is 100km further out from Fort McMurray. These circle bands can then be used to define distance bins (e.g. 0 to 200, 200-400, etc.) The borders indicate census survey districts (CSD). Census districts are unrelated to the collection of the plant level data, but are used for the five-yearly the population census.

allows for sectoral differences in export/import competition or its reliance on oil as an input.

The main treatment variable is the combination of the time (and province) varying oil production, in percentage of non-resource Gross Provincial Product (GPP), and the plant/CSD varying distance. One intuitive functional form to use is

$$f\left(\text{oil production}_t, \text{distance}_i\right) = \frac{\text{oil production}_t}{\text{distance}_i}.$$

This functional form implies that the treatment effect would be larger with an increase in oil sector activity, but diminishes with a plant/CSD distance to the sector's physical location. We note that through our selection of fixed effects we absorb the effect of oil-production and distance separately already. Moreover, using this treatment variable we may interact it with other key firm-level indicators to understand how heterogeneity at the firm level affects the firm's response to the resource sector boom. Using key indicators on employment, wages, and sales we can test all the predictions of the model.

We have around 300-500 thousand plant-year observations depending on the dependent variable and setup. Many plants will be far from Ft. McMurray and, therefore, function like a counter-factual against which plants closer to Ft. McMurray will be compared against. We cluster standard errors two-way, by province-year and by province-sector. The first allows for correlation within province for each year given common shocks, while the second allows for across time by province.

4 Results

4.1 Distance

As we take such a wide range of the data in terms of geography and firm characteristics, we start with some more dis-aggregated effects. Firstly, we aim to investigate whether the interaction of resource production with distance to Ft. McMurray does indicate a diminished effect. In order to do so we create indicators for distance brackets and interact those with the time-varying oil production measure. We would expect that at increasing distance brackets any effect decreases. The results are summarized in Figure 3 (tabular results are available in Appendix Appendix C, Table C-1).

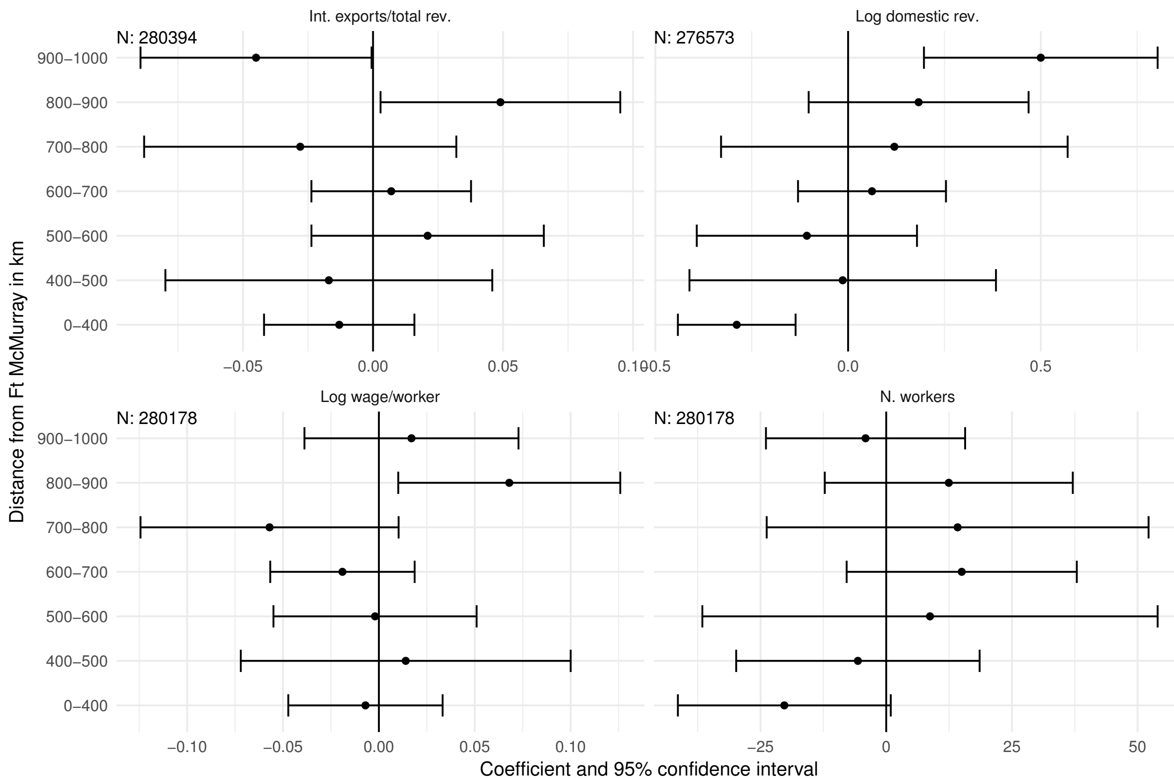
The first bracket is defined from 0 to 400, with further brackets for every 100 km.[13] The first observation is that proximity to Fort McMurray exerts a negative effect from the natural resource sector on each firm level variable, except exports, when compared with firms that are between 900 to 1000 km away. An average firm has substantially smaller revenue and fewer workers. Wages appear little affected even though the point estimates indicate a small (around 5 to 7,5 percentage point) negative effect. Similarly, export are positively affected for around 5%, but effect does not reach the usual statistical significance level. Secondly, a diminishing effect with distance is clearer for the variables of domestic revenue and employment than for the other two.

4.2 Productivity

The main dimension of heterogeneity between plants within the same sector is their level of productivity. In particular their choice and ability to export relies crucially on their level of productivity. We are interested in understanding how the proximity of a natural

[13]The reason for the first larger bracket has to do with data confidentiality reasons. Since outside Ft. McMurray there is little industrial activity until the area around Edmonton few plants could be observed in 100 km brackets until 400 km.

Figure 3: Effect of Resource sector by distance



Note: The indicated point estimates with error bands come from four estimations of the following model,

$$y_{i,t} = \sum_d \{\theta_d \text{oil production}_t \times I(\text{distance}_i \in d)\} + \beta \log(\text{CSD product}) + \alpha_i I(\text{CSD}) + \mu_{i,t} I(\text{sector}\times\text{year}) + u_{i,t},$$

for the distance brackets, $d = \{0\text{-}400, \ldots, 900\text{-}1000\}$, such that we obtain a coefficient for each distance bracket. Plants between 1000 and 4000km function as the base group, plants over 4000 km away are not included. Standard errors clustered at province-by-year and province-by-sector. The estimations for the export ratio includes all plants, including those that do not (or never) export. A tabular representation of these results are given in Appendix C, Table C-1.

Table 2: Plant level regressions - Switchers

variables / switch	into int. exports	out int. exports	into prov. exports	out prov. exports
Oil production / distance	-1.569^{***}	8.958^{***}	-1.766^{***}	1.545
	(5.751)	(13.587)	(4.052)	(0.789)
× I(group 2)	1.663^{***}	-9.918^{***}	0.359	4.060^{*}
	(3.059)	(14.138)	(0.722)	(1.874)
× I(group 3)	4.807^{***}	-9.330^{***}	2.016^{**}	-0.663
	(3.309)	(11.076)	(2.415)	(0.336)
× I(group 4)	3.559^{***}	-9.322^{***}	2.350^{**}	-2.038
	(5.685)	(15.212)	(2.274)	(1.052)
I(group 2)	0.004	-0.014^{**}	0.000	-0.020^{***}
	(0.918)	(2.262)	(0.062)	(2.936)
I(group 3)	0.007	-0.026^{***}	-0.003	-0.015^{**}
	(1.034)	(2.962)	(0.5)	(2.211)
I(group 4)	0.018	-0.051^{***}	0.003	-0.024^{**}
	(1.639)	(4.005)	(0.319)	(2.069)
log(CSD product)	-0.683^{***}	1.254^{***}	-0.560^{*}	0.586^{**}
	(3.151)	(4.55)	(1.948)	(2.3)
N	79866	76308	60958	61932
R-sq	0.141	0.157	0.328	0.162

T-statistics in brackets, based on standard errors clustered by province-by-year and province-by-sector. CSD and sector-by-year fixed effects included. Only plants existing during all periods are included. Plants that never export or always export are excluded. The groups are productivity quantiles defined in 2000, the first year of observation, where group 4 represents the highest productivity quantile. $p < 0.01^{***}$, $p < 0.05^{**}$, $p < 0.1^{*}$

resource sector affects plants' ability to export following prediction P1. Since we do not expect that there is a clean break between exporters and non-exporters according to their level of productivity as the theory suggests, we measure instead the fraction of firms that export, given their level of productivity and other time-constant firm characteristics. We allocate plants in four groups, based on their level of productivity in the year 2000, using the measure of value added per worker.[14] For each plant we create indicator variables designating whether the plant switches into or out of exports, while we differentiate between international and provincial exports.[15] We regress these indicator variables against out treatment variable interacted with the productivity groups, while we exclude all firms that never switch state (e.g. consistently export or never export). Results are presented in Table 2, where the base group represent the lowest productivity quantile, and the other groups represent quantiles at increasing productivity levels up to the fourth quantile.

[14]Taking the average productivity of 2000 and 2001, to average out some potential yearly disturbance, gives qualitatively similar results.

[15]A switcher is a plant that changes state from $t-1$ to t, and remains in the new state for at least two periods, i.e. until $t+1$. For instance, switching into exports at time t implies not exporting in $t-1$, and exporting in time t and $t+1$.

Table 3: Plant level regressions

variables	N. workers	Log domestic rev.	Log wage/worker
Oil production / distance	582.880**	3.630*	0.016
	(2.095)	(1.704)	(0.048)
exporter_{t-1}	12.426***	0.176***	0.033***
	(7.59)	(3.812)	(6.722)
exporter_{t-1} × Oil production / distance	−341.301	−1.268	1.082***
	(1.04)	(0.549)	(3.856)
log(CSD product)	−1878.767***	−29.295***	−3.070***
	(3.261)	(10.333)	(7.672)
N	191385	188617	191385
R-sq	0.117	0.295	0.325

T-statistics in brackets, based on standard errors clustered by province-by-year and province-by-sector. CSD and sector-by-year fixed effects included. Only plants existing during all periods and who switch at least once in exporter status are included. $p < 0.01$ ***, $p < 0.05$ **, $p < 0.1$ *

The first two columns focus on international exports, the last two at provincial exports. For international exports we find that the most productive plants, group 4, are more likely to become exporters, and less likely to only serve the domestic market. For the base group the effects are reversed, with the groups in the middle showing intermediate effects. These results are in line with prediction P1. For provincial exports we find a similar mechanism, but the effects are much weaker and barely statistically significant. This is in line with the notion that domestic trade faces fewer barriers than international trade, even while the international US border is closer than some Canadian provincial borders (McCallum, 1995).

This differentiation by productivity implies that exporters and non-exporters will develop differently conditional on their exposure to the natural resource sector. In Table 3 we present results on plant level outcomes, where we interact the treatment variable with an export indicator, and only include plants that switch exporter status at least once within the sample period. This selection of firms can be thought of being close to the theoretical margin of the minimal level of productivity required to export. The reason for this selection is to exclude plants that, for whichever reason, are not susceptible to the changes in the economic environment with regards to their exporting status.[16]

We look at the employment per plant, their domestic sales and the average wage as a first test of prediction P2, P3, P4 and P5. The coefficient on the exporter dummy, row 2, indicates that exporters on average employ more people, have higher revenues (from domestic markets) and pay higher wages, which is all in line with the empirical literature of heterogeneous firms.

[16]Our selection here may be questioned as being partly spurious since it is based on observed behaviour, rather than past determinants. However, our selection is also very liberal, as we are essentially just excluding firms that never change their export status. Since we can learn relatively little from firms that either always export, or never export, on their choice of exporting it seems reasonable to exclude them from the sample.

We find that all plants tend to increase employment. However, the likelihood for a given non-exporting firm to do so is larger than for an exporting firm, as given by the interaction term in the third line. This therefore appears to confirm the prediction that non-exporting firm will increase their employment (P4), but for exporting firms the effect is more ambiguous (P5). We find some evidence for an increase in domestic revenue in response to the natural resources sector (P3), in row 1, but only exporters increase the average wage per worker (P2), row 3, which suggest that our model glosses over some differentiation within the labour market.

4.3 Sectors

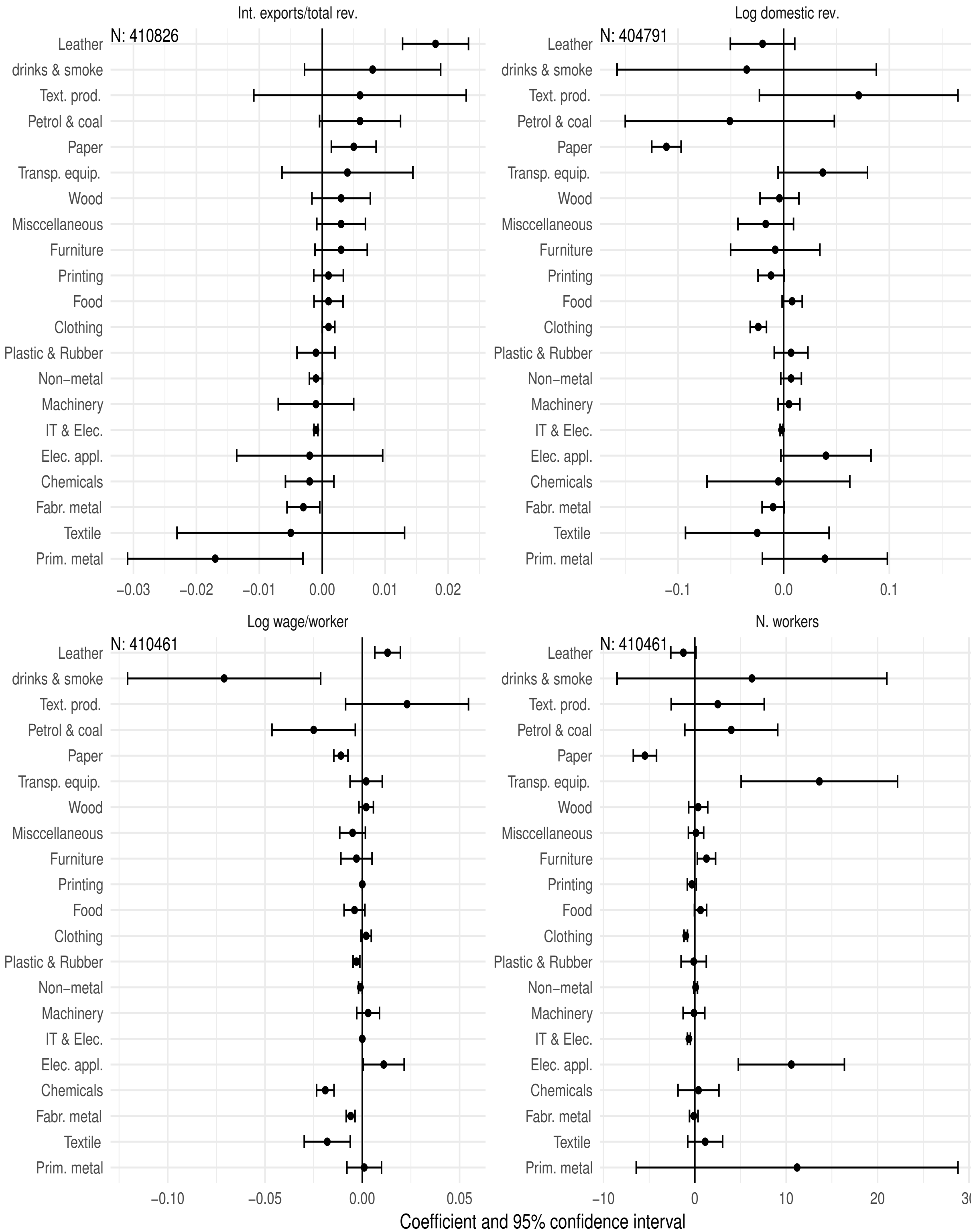
To understand further the variation in the effects, we allow for different estimates for each of the 21 sectors. We present the results graphically in Figure 4 (tabular results are available in Appendix C, Table C-2).[17] We ordered the sectors by their export ratio and kept the same order for the other outcome variables. Interestingly we find sectors that have significant negative effects as well as significant positive effects for each variable. There is some consistency between the plots, where sectors towards the middle tend to have small effects close to zero, while sectors towards the bottom and the top of the first plot also demonstrate effects in the other plots. Allcott and Keniston (2018) suggest sectoral differentiation based on a sectors' output tradability and its linkage (up/downstream) with the natural resource sector. Arezki et al. (2017) indicate that energy intensive industries benefited from the lower American gas price (due to the limits on exports). Our sectoral results do not quite point to such an effect, but also do not rule this out, without precise data on input-output linkages. Nevertheless, results show that the mechanism might be more complicated as sectors respond with different signs, not just different intensities. Moreover, within the sectors there will be differences in productivity between plants, such that the results of Table 2 offer a more consistent explanation of heterogeneous effects than differentiation by sector.

[17] The indicated point estimates with error bands come from four estimations of the following model,

$$y_{i,t} = \sum_s \left(\theta_s \frac{\text{oil production}_t}{\text{standardized distance}_i} \times I(\text{sector} = s) \right) + \\ \beta \log(\text{CSD product}) + \alpha_i I(\text{CSD}) + \mu_{i,t} I(\text{sector} \times \text{year}) + u_{i,t},$$

for each sector, s. Standardized distance is a distance measure at the sectoral level, standardized distance$_i$ = $\frac{\text{distance}_i - \overline{\text{distance}_s}}{sd(\text{distance}_i)}$, where the $\overline{\text{distance}_s}$ is the mean distance of plants within the sector s to which the plant belongs. The standardization solves an issue resulting from the potential that certain sectors might be geographically concentrated. Standard errors are clustered at province-by-year and province-by-sector. A tabular representation of these results is given in Appendix C, Table C-2.

Figure 4: Effect of Resource sector by sector



Note: see footnote 17.

Table 4: Plant level regressions

variables	N. workers	Log domestic rev.	Int. exports/total rev.	Log wage/worker
Oil production / distance	128.676	1.254	0.673	0.638^{*}
	(1.586)	(0.903)	(1.608)	(1.947)
log(CSD product)	-2598.948^{***}	-30.289^{***}	-1.772^{***}	-3.505^{***}
	(3.848)	(10.443)	(9.052)	(9.572)
N	280178	276573	280394	280178
R-sq	0.123	0.313	0.208	0.328

T-statistics in brackets, based on standard errors clustered by province-by-year and province-by-sector. CSD and sector-by-year fixed effects included. Only plants existing during all periods are included. $p < 0.01^{***}$, $p < 0.05^{**}$, $p < 0.1^{*}$

4.4 Average effects

Naturally we may estimate an average plant effects with a simplified model that does not allow for the heterogeneity of sectors. As plants affected positively cancel against those that are affected negatively it remains unclear *a priori* which dominate. Additionally, we aim to test the predictions that look at the average effect of sectors, in particular P6, P7 and P8. In order to do so we aggregate plants up to the level of the CSD-by-sector-year.[18] Results are presented in Tables 4 and 5 respectively. At the plant level we find little effect. While the coefficients on the four outcome variables are positive, the effects are statistically insignificant at conventional significance levels, and only log wage/worker at 10% level. This provides us with additional evidence that our analysis; taking into account explicitly the heterogeneous effects of a resource sector boom is appropriate and informative.

Using the aggregation to the CSD level in Table 5, we find an average effect that suggest that the natural resource sector decreases employment and domestic revenue, but does not affect exports or wages. The effect of employment is in line with prediction P6, the effect of domestic revenue clearly points to a net negative effect (P7), while the effect on the share of exports (P8) suggest the predicted direction but is not statistically distinguishable from zero, and neither is the small positive effect on wages (P2).

Moreover, our results contrast with what was found by other studies that looked at local spill-overs from the natural resource sector, such from Cust et al. (2017) and Feyrer et al. (2017). They found that while some sectors were affected negatively, the average effect on employment was positive, whereas we find the opposite. There are several potential explanations for this. Firstly, the characteristics of the resource sector is different. It is geographically concentrated but also remote from other industrial activity. Secondly, the Alberta oil sands are large relative to the non-resource output of the province. This contrast

[18] To create a dataset at the CSD-by-sector-year level we take the sum of workers and (raw) revenues of all firms, the median for variables such as wage, value added and distance from Ft. McMurray.

Table 5: CSD level regressions

variables	N. workers	Log domestic rev.	Int. exports/total rev.	Log wage/worker
Oil production / distance	-1424.590^{**}	-16.513^{***}	-0.369	0.016
	(2.52)	(3.142)	(1.106)	(0.089)
N	90741	59819	60033	66850
R-sq	0.360	0.415	0.248	0.312

T-statistics in brackets, based on standard errors clustered by province-by-year and province-by-sector. CSD and sector-by-year fixed effects included. Plants are aggregegated to CSDs. Only CSD-year observations with at least 10 firms are included. $p < 0.01^{***}$, $p < 0.05^{**}$, $p < 0.1^{*}$

with U.S. focused research that look at the oil fracking industry which is geographically much more widely distributed over the country. Thirdly, due to the geographical remoteness of Ft. McMurray we include business activity of plants at larger distances than previous studies. Thus, our results do not exclude the possibility that plants at smaller distances are positively affected from natural resources.

4.5 Discussion

Our identification strategy relies on a mechanism through which resource activity is geographically concentrated and from which there exist spillovers that are stronger for firms that are geographically closer relative to others. Ft. McMurray is not the only place in Canada where significant resources are extracted. Off the coast of Newfoundland and Labrador (NL) offshore oil drilling was developed in the same time period. Since offshore resource extraction is quite different from onshore resource extraction, the effect might be different too (Cust et al., 2017; Caselli and Michaels, 2013). Therefore, we can change our setup to take the provincial capital and main coastal port in Newfoundland, St. Johns, as reference point for distance and take its provincial resource production to create a new treatment variable. Note that this also implies a completely different set of firms to measure the effects against. Newfoundland is an island, with little industry outside fishery and forestry. We present these results, for regressions using the CSD level, in panel (b) of Table 6, while panel (a) repeats our benchmark result of Table 5 for ease of comparison. We find the same mechanism and effects for St. Johns as we found for Ft. McMurray.

Additionally, our identification also implies that if we replace our reference from Ft. McMurray to another city far away from Alberta, we should find different, potentially zero, effects. We take Toronto as our new reference point, while using the time-varying resource production measure of Alberta. These results, presented in panel (c) of Table 6, indicate very different effects from what found earlier. The point estimate of the effect on the number of employed workers and provincial exports is positive, rather than negative, and not sta-

Table 6: Treatment origin

variables	N. workers	Log domestic rev.	Log prov. exports	Log value added/worker
		(a) Origin: Ft. McMurray, AL		
Oil production / distance	-1424.590^{**}	-16.513^{***}	-45.011^{***}	-1.561^{***}
	(2.52)	(3.142)	(3.919)	(3.588)
N	90741	59819	41140	66850
R-sq	0.360	0.415	0.439	0.342
		(b) Origin: St. Johns, NL		
Oil production / distance	-142046.800^{***}	-1183.264^{***}	-861.936^{***}	-52.789^{*}
	(3.729)	(5.999)	(6.06)	(1.873)
N	90741	59819	41140	66850
R-sq	0.360	0.418	0.441	0.342
		(c) Origin: Toronto, ON		
Oil production / distance	14936.060	-15.586^{**}	7.119^{*}	-1.579
	(1.036)	(2.089)	(1.747)	(0.724)
N	66853	59819	41140	66838
R-sq	0.443	0.415	0.439	0.342

T-statistics in brackets, based on standard errors clustered province-by-year and province-by-sector. CSD and sector-by-year fixed effects included. Plants are aggregegated to CSDs. Only CSD-year observations with at least 10 firms are included. $p < 0.01^{***}$, $p < 0.05^{**}$, $p < 0.1^{*}$

tistically significant. Interestingly, the effect of the log of domestic revenue and log of value added per worker is of a similar size to those presented in panel (a), but the significance level is lower.

Next to the geographical variation we rely on the time variation of the treatment variable. First, we ask whether the effect is different when oil production is rising from when oil production is falling. In most theoretical models we do not make a distinction based on the sign as the effect is mirrored. However, in reality we might expect that in the short to medium term, when some prices and contracts are fixed, the adjustment to oil revenue need not be symmetric for positive and negative changes. Table 7 present the results of a model where we interact the treatment variable with an indicator variable that takes the value of one if the change in the resource revenue between the current and last period is positive. We find that the effect on each of our outcome variable is not mirrored in the sign. Instead, each variable seems to be dominated by one side. Only for provincial exports do we find an opposite effect for positive and negative shocks, but even in this case the size of the coefficients are very different. Interestingly, while the employment effect goes through negative resource shocks, the productivity indicator is mainly driven through positive shocks.

Finally, we present results where we add lags of the treatment variable, and present a

Table 7: Differentiation by sign

variables	N. workers	Log domestic rev.	Log prov. exports	Log value added/worker
Oil production / distance (−)	-1207.840^{***}	-13.225^{***}	-63.570^{***}	-0.433
	(3.37)	(6.258)	(3.423)	(0.787)
Oil production / distance (+)	-337.666	-5.153	19.742^{***}	-1.770^{***}
	(1.104)	(1.115)	(3.439)	(4.126)
N	90741	59819	41140	66850
R-sq	0.360	0.415	0.439	0.342

T-statistics in brackets, based on standard errors clustered province-by-year and province-by-sector. CSD and sector-by-year fixed effects included. Plants are aggregegated to CSDs. Only CSD-year observations with at least 10 firms are included. $p < 0.01^{***}$, $p < 0.05^{**}$, $p < 0.1^{*}$

Table 8: Lags and measures

variables	N. workers	N. workers	Log total rev.	Log total rev.
	(a) (Oil production (% GPP) / distance with lags			
(Oil production (% GPP) / distance)$_t$	-1424.590^{**}	-669.001^{***}	-14.844^{***}	-13.553^{***}
	(2.52)	(2.659)	(3.596)	(6.224)
(Oil production (% GPP)/ distance)$_{t-1}$		-410.509^{***}		-3.059^{*}
		(2.607)		(1.703)
(Oil production (% GPP)/ distance)$_{t-2}$		-416.496^{***}		-0.811
		(2.887)		(0.464)
(Oil production (% GPP)/ distance)$_{t-3}$		-491.521^{***}		-0.745
		(3.039)		(0.456)
N	90741	66658	60033	58682
R-sq	0.360	0.443	0.462	0.465
	(b) (Oil production (CA\$B) / distance with lags			
(Oil production (CA\$B)/ distance)$_t$	-11.059^{**}	-4.853^{***}	-0.107^{***}	-0.101^{***}
	(2.373)	(2.577)	(3.653)	(6.086)
(Oil production (CA\$B)/ distance)$_{t-1}$		-3.324^{***}		-0.027^{*}
		(2.989)		(1.862)
(Oil production (CA\$B)/ distance)$_{t-2}$		-3.304^{***}		-0.008
		(3.289)		(0.659)
(Oil production (CA\$B)/ distance)$_{t-3}$		-2.914^{**}		0.007
		(2.518)		(0.777)
N	90741	66658	60033	58682
R-sq	0.360	0.443	0.462	0.465

T-statistics in brackets, based on standard errors clustered province-by-year and province-by-sector. CSD and sector-by-year fixed effects included. $p < 0.01^{***}$, $p < 0.05^{**}$, $p < 0.1^{*}$

treatment variable based on the gross provincial product of resource sector, rather than as a percentage of provincial non-resource GPP as used up to here. We only present results for two outcome variables for space considerations. The results in Table 8 indicate that dynamic shocks in the treatment variable are persistent over time and that the treatment measure makes qualitatively little difference.

5 Conclusion

This article used plant-level panel data from 2000-2010 to investigate how plants, and by extension firms, respond to growth of a natural resource sector in their proximity. In this way we add to the Canadian and international literature that looks at geographical aggregates such as states or provinces. Heterogeneity between firms, due to size, industry and idiosyncratic levels of productivity may affect how firms respond to changes in their external economic environment that are hard to control for outside of such detailed data.

We focused on the interaction of productivity and exporting behaviour of firms. We find that the incidence of exporting is affected by the boom of natural resource sector, with high productivity firms being more likely, and less productive firm less like to export. At the same time, exporting firms on average increase wages, but are less likely to increase employment.

Our results indicate the presence of a sharp heterogeneity in firms performance, originating from their initial level of productivity. We find that plants with higher levels of productivity are not negatively affected by the growth of the natural resource sector, for instance through competition of labour and increasing wages. However, there is no strong evidence that those higher productivity exporting firms increase employment, unlike those that are not exporting. We do not find clear evidence that plant performance is driven by industry linkages with the natural resource sector.

The results of our study reinforce the argument for less stringent policies on provincial and international trade and migration put forward by Beine et al. (2015) and Moshiri and Bakhshi-Moghaddam (2018). The more open trade policy will help productive firms to expand their business during the oil boom. The same argument can also be made for more open immigration policy as labour movement will mitigate the rising wage effects on productivity of exporting firms when oil prices rise. In fact, one of the reasons for not observing Dutch disease in Canada, despite high correlation between the Canadian dollar and the oil prices, is large trade flows and labour movement across the provinces during the oil price shocks. Firms distant from the oil-producing centers, which are affected negatively by high oil prices and rising wages, could sell their products to consumers and firms in the booming sector. Labour movement to the booming areas also reduces the wage pressure on both exporting and non-exporting firms, controlling their otherwise rising costs.

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Appendix A Solution of model.

Log differentiating and solving the system (1)-(12) we obtain the general equilibrium effects of an oil boom:

$$\hat{\psi}_D = -\frac{1}{\sigma - 1}\left[\hat{E} + (\sigma - 1)\hat{P} - \sigma\hat{w}\right], \tag{A-1}$$

$$\hat{\psi}_M - \frac{1}{\sigma - 1}\left[\hat{E} + (\sigma - 1)\hat{P}\right], \tag{A-2}$$

$$\hat{\psi}_X = \frac{1}{\sigma - 1}\sigma\hat{w}, \tag{A-3}$$

$$\sigma\hat{w} = (1 - s_X)\left[\hat{E} + (\sigma - 1)\hat{P}\right] - (k - \sigma + 1)[(1 - s_X)\hat{\psi}_D + s_X\hat{\psi}_X], \tag{A-4}$$

$$\hat{D} = \hat{N} + (1 - \sigma)\hat{w} + \hat{E} + (\sigma - 1)\hat{P} - (k - \sigma + 1)\hat{\psi}_D, \tag{A-5}$$

$$\hat{X} = \hat{N} + (1 - \sigma)\hat{w} - (k - \sigma + 1)\hat{\psi}_X, \tag{A-6}$$

$$\hat{M} = \hat{E} + (\sigma - 1)\hat{P} - (k - \sigma + 1)\hat{\psi}_M, \tag{A-7}$$

$$\hat{E} = s_D\hat{D} + (1 - s_D)\hat{M}, \tag{A-8}$$

$$\hat{w} + \hat{l} = (1 - s_X)\hat{D} + s_X\hat{X}, \tag{A-9}$$

$$\hat{w} = \hat{A} + (1 - \alpha)\theta\hat{l}, \tag{A-10}$$

$$\hat{r} = \hat{A} - \alpha\theta\hat{l}, \tag{A-11}$$

$$\hat{E} = \lambda\hat{w} + (1 - \lambda)\hat{r}. \tag{A-12}$$

where $s_X \equiv \frac{X}{D+X}$ is the share of export sales in industry production, $s_D \equiv \frac{D}{D+M}$ is the share of home firms' sales in the domestic market, $\theta \equiv \frac{l}{L-l}$ and $\lambda \equiv \frac{wL}{Y}$. Note that the parameters are related by the following equations:

$$\lambda = \frac{\alpha(1 + \theta)}{1 + \alpha\theta}, \tag{A-13}$$

$$\lambda = \left(\frac{1 + \theta}{\theta}\right)\left(\frac{s_D}{1 - s_X}\right)\mu. \tag{A-14}$$

Equations (A-1)-(A-12) determine the general equilibrium values of $\hat{\psi}_D$, $\hat{\psi}_X$, $\hat{\psi}_M$, $\hat{P}$, $\hat{E}$, $\hat{w}$, $\hat{r}$, $\hat{N}$, $\hat{l}$, $\hat{D}$, $\hat{X}$ and $\hat{M}$ given $\hat{A}$. Solving the system yields:

$$\hat{w} = \frac{1}{B}\frac{1}{s_D}\left[(1-\lambda)\theta + s_D\right]\hat{A}, \tag{A-15}$$

$$\hat{r} = -\frac{1}{B}\left[1 + \theta + \theta\left(C - \frac{1}{s_D}\lambda\right)\right]\hat{A}, \tag{A-16}$$

$$\hat{E} = \frac{1}{B}\left[(C+1)(1-\lambda)\theta + 1\right]\hat{A}, \tag{A-17}$$

$$\hat{l} = \hat{N} = -\frac{1}{B}\left(C - \frac{1-s_D}{s_D}\right)\hat{A}, \tag{A-18}$$

$$\hat{P} = -\frac{1}{B}\frac{1}{\sigma-1}\left[(C+1)(1-\lambda)\theta + 1 - \frac{\sigma}{s_D(1-s_X)}[(1-\lambda)\theta + s_D]\right]\hat{A}, \tag{A-19}$$

$$\hat{\psi}_X = \frac{1}{B}\frac{\sigma}{\sigma-1}\frac{1}{s_D}[(1-\lambda)\theta + s_D]\hat{A} \tag{A-20}$$

$$\hat{\psi}_M = -\frac{1}{B}\frac{\sigma}{\sigma-1}\frac{1}{s_D(1-s_X)}[(1-\lambda)\theta + s_D]\hat{A} \tag{A-21}$$

$$\hat{\psi}_D = -\frac{1}{B}\frac{\sigma}{\sigma-1}\frac{s_X}{s_D(1-s_X)}[(1-\lambda)\theta + s_D]\hat{A} \tag{A-22}$$

$$\hat{D} = \frac{1}{B}\frac{1}{s_D}\left[1 + \left(\frac{k\sigma}{\sigma-1}\frac{s_X}{1-s_X} + 1\right)(1-\lambda)\theta - \frac{k\sigma}{\sigma-1}\frac{1-s_D}{1-s_X}\right]\hat{A} \tag{A-23}$$

$$\hat{X} = -\frac{1}{B}\left[C - \frac{1-s_D}{s_D} + \frac{1}{s_D}\left(\frac{k\sigma}{\sigma-1} - 1\right)[(1-\lambda)\theta + s_D]\right]\hat{A} \tag{A-24}$$

$$\hat{M} = \frac{1}{B}\frac{k\sigma}{\sigma-1}\frac{1}{s_D(1-s_X)}[(1-\lambda)\theta + s_D]\hat{A} \tag{A-25}$$

where we define:

$$C \equiv \frac{k\sigma}{\sigma-1}\frac{1-s_D(1-s_X)}{s_D(1-s_X)},$$

$$B \equiv 1 + \theta\alpha\frac{1}{s_D}(1-\lambda) + \theta(1-\alpha)\left[(C+1) - \frac{1}{s_D}\lambda\right] > 1.$$

Appendix B Proof of Proposition 1

$P1$) The proof follows from equation (A-20).

$P2$) The proof follows from equation (A-15).

$P3$) Log differenatiation of $r_D(\psi) = \sigma\zeta\,(w/\psi)^{1-\sigma}\,EP^{\sigma-1}$ yields $\hat{r}_D = (1/B)[(\sigma s_X + 1 - s_X)/s_D(1-s_X)][(1-\lambda)\theta + s_D]\hat{A}$, which is positive for $\hat{A} > 0$.

$P4$) The number of workers in a given nonexporting firm increases if its domestic market production q_D increases. Log differentiation yields $\hat{q}_D = (1/B)[\sigma s_X/s_D(1-s_X)][(1-\lambda)\theta + s_D]\hat{A}$, which is positive for $\hat{A} > 0$.

$P5)$ The number of workers in a given exporting firm increases if its total production $q_T = q_D + q_X$ increases. Log differentiation yields $\hat{q}_T = (1/B)[\sigma/s_D(1-s_X)](s_X - q_X/q_T)[(1-\lambda)\theta + s_D]\hat{A}$. $\hat{A} > 0$ implies $\hat{q}_T > 0$ if and only if $\tau\psi_D^{k-\sigma+1} > \psi_X^{k-\sigma+1}$.

$P6)$ The proof follows from equation (A-18).

$P7)$ The effect of an oil boom on total domestic sales is given by equation (A-23). We see that the effect is positive if and only if $1 + [(k\sigma/(\sigma-1))(s_X/(1-s_X)) + 1]\,(1-\lambda)\theta > (k\sigma/(\sigma-1))(1-s_D)/(1-s_X)$.

$P8)$ Log differentiating $s_X = X/(X+D)$ yields $\hat{s}_X = (1-s_X)(\hat{X} - \hat{D})$. Inserting from equations (A-23) and (A-24) yields $\hat{s}_X = -(1/B)[k\sigma/(\sigma-1)](1/s_D)[(1-\lambda)\theta + s_D]\hat{A}$, which is negative for $\hat{A} > 0$.

Appendix C Tabular results of Figures 3 and 4.

Table C-1: Plant level regressions - distance effect

variables	N. workers	Log domestic rev.	Int. exports/total rev.	Log wage/worker
		(a) (Oil production (% GPP)		
$\times$ I(0 < dist < 400km)	-20.266^{*}	-0.289^{***}	-0.013	-0.007
	(1.876)	(3.709)	(0.881)	(0.341)
$\times$ I(400 < dist < 500km)	-5.632	-0.014	-0.017	0.014
	(0.456)	(0.069)	(0.53)	(0.319)
$\times$ I(500 < dist < 600km)	8.709	-0.107	0.021	-0.002
	(0.377)	(0.734)	(0.921)	(0.074)
$\times$ I(600 < dist < 700km)	15.019	0.062	0.007	-0.019
	(1.286)	(0.633)	(0.447)	(0.989)
$\times$ I(700 < dist < 800km)	14.204	0.120	-0.028	-0.057^{*}
	(0.733)	(0.523)	(0.914)	(1.66)
$\times$ I(800 < dist < 900km)	12.445	0.183	0.049^{**}	0.068^{**}
	(0.989)	(1.257)	(2.083)	(2.302)
$\times$ I(900 < dist < 1000km)	-4.113	0.500^{***}	-0.045^{**}	0.017
	(0.407)	(3.232)	(1.985)	(0.597)
log(CSD product)	-2599.449^{***}	-30.300^{***}	-1.772^{***}	-3.505^{***}
	(3.849)	(10.442)	(9.04)	(9.561)
N	280178	276573	280394	280178
R-sq	0.123	0.313	0.208	0.328

T-statistics in brackets, based on standard errors clustered by province-by-year and province-by-sector. CSD and sector-by-year fixed effects included. Only plants existing during all periods are included. Plants located between 1000 and 4000km from FtMcMurray function as base group$p < 0.01$ ***, $p < 0.05$ **, $p < 0.1$ *

Table C-2: Plant level regressions - Sectoral Differentiations

variables	N. workers	Log domestic rev.	Int. exports/total rev.	Log wage/worker
Oil production (% GPP)				
× Food	0.624*	0.008*	0.001	−0.004
	(1.821)	(1.647)	(0.85)	(1.466)
× drinks & smoke	6.251	−0.035	0.008	−0.071***
	(0.83)	(0.559)	(1.45)	(2.805)
× Textile	1.135	−0.025	−0.005	−0.018***
	(1.164)	(0.721)	(0.542)	(2.981)
× Text. prod.	2.506	0.071	0.006	0.023
	(0.965)	(1.481)	(0.697)	(1.427)
× Clothing	−0.994***	−0.024***	0.001**	0.002
	(10.243)	(6.121)	(1.969)	(1.5)
× Leather	−1.253*	−0.020	0.018***	0.013***
	(1.78)	(1.286)	(6.734)	(3.875)
× Wood	0.369	−0.004	0.003	0.002
	(0.694)	(0.426)	(1.268)	(1.052)
× Paper	−5.463***	−0.111***	0.005***	−0.011***
	(8.432)	(15.669)	(2.757)	(5.931)
× Printing	−0.327	−0.012*	0.001	−0.000
	(1.302)	(1.909)	(0.833)	(0.063)
× Petrol & coal	3.988	−0.051	0.006*	−0.025**
	(1.537)	(1.01)	(1.828)	(2.288)
× Chemicals	0.400	−0.005	−0.002	−0.019***
	(0.35)	(0.145)	(1.019)	(8.318)
× Plastic & Rubber	−0.124	0.007	−0.001	−0.003***
	(0.176)	(0.861)	(0.65)	(3.371)
× Non-metal	0.089	0.007	−0.001*	−0.001**
	(0.87)	(1.405)	(1.872)	(2.091)
× Prim. metal	11.192	0.039	−0.017**	0.001
	(1.246)	(1.292)	(2.392)	(0.22)
× Fabr. metal	−0.116	−0.010*	−0.003**	−0.006***
	(0.484)	(1.87)	(2.26)	(5.204)
× Machinery	−0.095	0.005	−0.001	0.003
	(0.157)	(0.95)	(0.327)	(1.003)
× IT & Elec.	−0.648***	−0.002***	−0.001***	0.000
	(7.728)	(2.756)	(6.274)	(0.592)
× Elec. appl.	10.568***	0.040*	−0.002	0.011**
	(3.569)	(1.837)	(0.338)	(2.049)
× Transp. equip.	13.629***	0.037*	0.004	0.002
	(3.12)	(1.713)	(0.754)	(0.474)
× Furniture	1.275**	−0.008	0.003	−0.003
	(2.506)	(0.371)	(1.416)	(0.735)
× Misccellaneous	0.132	−0.017	0.003	−0.005
	(0.31)	(1.266)	(1.521)	(1.486)
log(CSD product)	−1028.313***	−15.328***	−0.908***	−2.331***
	(3.953)	(7.688)	(6.838)	(8.188)
N	410461	404791	410826	410461
R-sq	0.085	0.247	0.187	0.253

T-statistics in brackets, based on standard errors clustered by province-by-year and province-by-sector. CSD and sector-by-year fixed effects included. Only plants existing during all periods are included. Treatment is standardized by distance for each sector: oil production / standardized distance . $p < 0.01$ ***, $p < 0.05$ **, $p < 0.1$ *