Economy Wide Spillovers From Booms: Long Distance Commuting and the Spread of Wage Effects – Online Appendix Material –

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A LFS and CPS Data

A.1 Labour Force Surveys

Our Labour Force Survey (LFS) extracts come from the Public Use files for the years 1997-2015. Respondents are in the survey for 6 months and then leave. They are asked the wage on their main job when they first enter the survey or at the start of a new job but are not re-asked their wage in subsequent months if they remain on the same job. In that sense, the wage observations for job stayers become 'stale'. In response, we use data from two months in each year (May and November) which are over 6 months apart and, so, include completely separate samples of wage and employment observations. From this extract, we further limit the sample by restricting attention to those between the ages of 20 and 54 who do not report being full- or part-time students. All wage calculations use a sub-sample of currently employed, wage and salary workers. Workers paid by the hour report their hourly wage directly. Those not paid by the hour have their wages converted to an hourly measure by Statistics Canada. Wages are converted to 2000 dollars using the CPI deflator obtained form http://www5.statcan.gc.ca/cansim/a26?id=3260020.

A.2 MORG Current Population Survey

Our Current Population Survey Merged Outgoing Rotation Group data for 1997-2015 are downloaded from the National Bureau of Economic Research.[1] From these data, we extract a sample of individuals between the ages of 20 and 54 who do not report being full- or part-time students. The construction of our wage data closely follows Lemieux (2006). Wage data is based on those who report employment in the reference week as wage and salary workers. In all wage calculations, we set allocated wages to missing. Our hourly wage measure is based on reported hourly wage for those who report hourly payment and not adjusted for topcoding. For workers who are not paid hourly, we use edited weekly earnings and divide the result by usual hours worked per week. We topcode the result by multiplying the weekly earnings topcode by 1.4 and dividing by 35. We convert wages to 2000 dollars using a CPI deflator and winsorize wages below 2 dollars.[2] All calculations using the earnings weight provided.

[1] The link is http://www.nber.org/data/morg.html

[2] CPI data from http://data.bls.gov/cgi-bin/surveymost?cu and includes all items.

A.3 Resource Employment and Region Groups

US Resource Employment

State	Northeast	Midwest	South	West	ER States
CT	0.06				
ME	0.08				
MA	0.07				
NH	0.10				
NJ	0.05				
NY	0.08				
PA	0.42				
RI	0.05				
VT	0.27				
IL		0.15			
IN		0.31			
IA		0.19			
KS		0.71			
MI		0.13			
MN		0.31			
MO		0.23			
NE		0.13			
ND		2.28			2.28
OH		0.31			
SD		0.54			
WI		0.10			
AL			0.66		
DE			0.08		
DC			0.00		
FL			0.09		
GA			0.12		
KY			1.47		
MD			0.04		
MS			1.54		
NC			0.09		
SC			0.09		
TN			0.24		
VA			0.25		
WV			4.63		4.63
AK				3.30	3.30
AZ				0.45	
AR				0.50	
CA				0.20	
CO				1.04	
HI				0.03	
ID				0.58	
LA				3.97	3.97
MT				1.31	
NV				1.43	
NM				3.01	3.01
OK				3.04	3.04
OR				0.10	
TX				2.24	2.24
UT				2.22	2.22
WA				0.17	
WY				12.07	12.07
Region	0.15	0.25	0.38	1.21	2.78

Notes: Each cell shows the fraction of employed wage and salary workers in the resource sector. This sector is defind as Oil and gas extraction (211), Metal ore mining (2122), Nonmetallic mineral mining and quarrying (2123) Not specified type of mining, Support activities for mining (213). Data from the MORG 1997-2015.

Canadian Resource Employment

Province	Maritimes	Eastern	West	Pacific	ER Prov
Newfoundland	4.07				4.07
Prince Edward Island	0.37				
Nova Scotia	0.94				
New Brunswick	1.42				
Quebec		0.55			
Ontario		0.55			
Manitoba			1.15		
Saskatchewan			4.94		4.94
Alberta			8.01		8.01
British Columbia				1.07	
Region	1.71	0.55	6.14	1.07	7.09

Notes: Each cell shows the fraction of employed wage and salary workers in the resource sector. This sector is defind as NAICS industry Mining and Oil and Gas Extraction. Data from the LFS 1997-2015. The first four columns refer to Canadian regions for the indicated provinces. The last column shows the same data for resource extraction provinces.

A.4 Canada in year 2000

Canadian Resource Employment in Year 2000

Province	Maritimes	Eastern	West	Pacific	ER Prov
Newfoundland	2.54				2.54
Prince Edward Island	0.13				
Nova Scotia	0.96				
New Brunswick	1.36				
Quebec		0.58			
Ontario		0.53			
Manitoba			1.23		
Saskatchewan			3.32		3.32
Alberta			5.87		5.87
British Columbia				0.64	
Region	1.37	0.55	4.45	0.64	5.05

Notes: Each cell shows the fraction of employed wage and salary workers in the resource sector. This sector is defind as NAICS industry Mining and Oil and Gas Extraction. Data from the LFS 1997-2015. The first four columns refer to Canadian regions for the indicated provinces. The last column shows the same data for resource extraction provinces.

A.5 Canada in year 2013

Canadian Resource Employment in Year 2013

Province	Maritimes	Eastern	West	Pacific	ER Prov
Newfoundland	6.34				6.34
Prince Edward Island	0.29				
Nova Scotia	0.81				
New Brunswick	1.56				
Quebec		0.56			
Ontario		0.58			
Manitoba			1.01		
Saskatchewan			5.39		5.39
Alberta			9.22		9.22
British Columbia				1.55	
Region	2.20	0.57	7.11	1.55	8.33

Notes: Each cell shows the fraction of employed wage and salary workers in the resource sector. This sector is defind as NAICS industry Mining and Oil and Gas Extraction. Data from the LFS 1997-2015. The first four columns refer to Canadian regions for the indicated provinces. The last column shows the same data for resource extraction provinces.

A.6 Employment Shares by Region

US Employment Shares

State	Northeast	Midwest	South	West	ER States
CT	1.20				
ME	0.43				
MA	2.30				
NH	0.47				
NJ	2.99				
NY	6.35				
PA	4.17				
RI	0.36				
VT	0.22				
IL		4.43			
IN		2.18			
IA		1.07			
KS		0.94			
MI		3.30			
MN		1.91			
MO		2.01			
NE		0.63			
ND		0.23			0.23
OH		3.91			
SD		0.26			
WI		2.01			
AL			1.49		
DE			0.29		
DC			0.23		
FL			5.62		
GA			3.17		
KY			1.37		
MD			2.01		
MS			0.88		
NC			2.95		
SC			1.41		
TN			1.98		
VA			2.71		
WV			0.55		0.55
AK				0.23	0.23
AZ				1.89	
AR				0.88	
CA				11.74	
CO				1.72	
HI				0.41	
ID				0.46	
LA				1.40	1.40
MT				0.29	
NV				0.84	
NM				0.59	0.59
OK				1.14	1.14
OR				1.21	
TX				7.94	7.94
UT				0.84	0.84
WA				2.21	
WY				0.18	0.18
Region	18.49	22.87	24.66	33.88	13.10

Notes: Each cell shows the fraction of employed wage and salary workers in the US. Data from the MORG 1997-2015.

Canadian Employment Shares

Province	Maritimes	Eastern	West	Pacific	ER Prov
Newfoundland	1.43				1.43
Prince Edward Island	0.41				
Nova Scotia	2.79				
New Brunswick	2.28				
Quebec		23.10			
Ontario		39.60			
Manitoba			3.60		
Saskatchewan			2.91		2.91
Alberta			11.51		11.51
British Columbia				12.36	
Region	6.92	62.70	18.03	12.36	15.86

Notes: Each cell shows the fraction of employed wage and salary workers in Canada. Data from the LFS 1997-2015.

A.7 Manufacturing Employment

Manufacturing Employment: Canada vs US

	Canada		US	
Year	All	Ontario	All	Eastern
1997	15.7	18.9	17.1	19.6
1998	16.0	19.2	16.8	19.4
1999	16.4	19.8	16.1	18.7
2000	16.5	20.2	16.0	18.5
2001	16.0	19.4	15.0	17.3
2002	16.2	19.7	14.1	16.6
2003	15.9	19.5	13.8	16.2
2004	15.8	19.4	13.3	15.6
2005	14.8	17.9	12.8	15.0
2006	14.0	16.8	12.7	14.8
2007	13.0	15.7	12.4	14.6
2008	12.5	14.5	12.2	14.1
2009	11.6	13.1	11.3	12.6
2010	11.2	12.8	11.1	12.7
2011	10.8	12.1	11.2	12.9
2012	11.0	12.8	11.2	13.0
2013	10.4	11.8	11.2	13.2
2014	10.3	11.7	10.8	12.7
2015	10.1	11.4	10.7	12.7

Notes: Each cell shows the fraction of employed wage and salary workers in the manufacturing sector. US data from the MORG, Canadian data from the LFS.

A.8 Timing of the Oil Boom

The oil price series plotted in Figure 4 in the text could be read as suggesting that the oil boom started in about 1997 rather than 2003. That is actually a reflection of our need to start our wage data plots in 1997 (since that is when the LFS first includes wages). We include, below, a longer term plot of the real oil price. In this plot it is more evident that 1997 is, in fact, just a short term movement down in what is actually a quite flat period for the real oil price from the end of the previous boom in 1983 to the start of this boom in 2003.

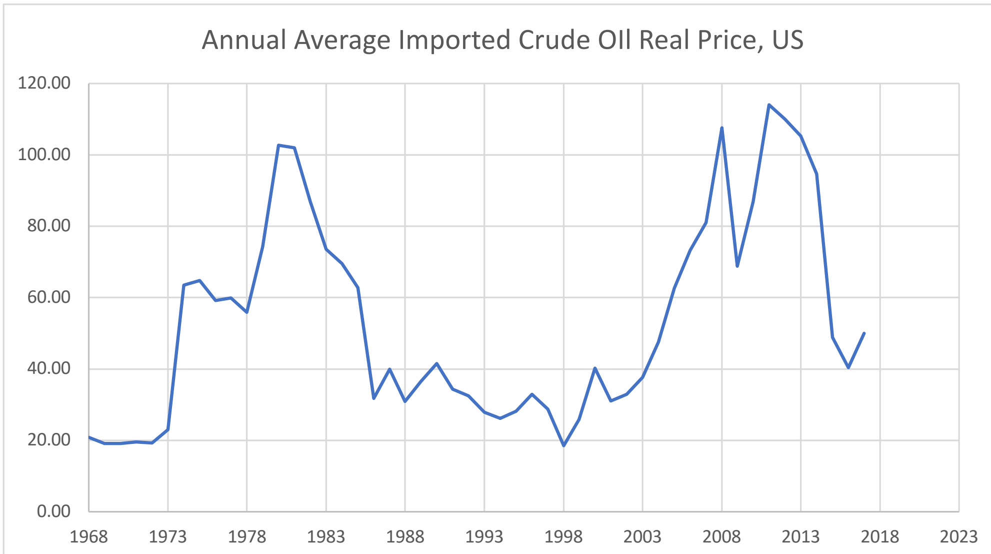
Of course, one might still want to focus on the lowest point as a benchmark point for starting the more recent boom but, in fact, the period between the mid-1990s and 2003 was not seen as a boom. This is reflected in the relative importance of employment in extractive resources over this period. As shown in the second figure below, the proportion of employment in extractive resources is actually declining until about 2000 and starts to turn sharply upward around 2003. This corresponds to common definitions of when the most recent boom started and so we use 2003 as the start of the boom in our discussions in the paper.

B Model

In order to frame our investigation of potential labour market spill-over effects from a resource boom, we use a variant of a search and bargaining model with multiple sectors from Beaudry et al. (2012) and Tschopp (2015). In particular, we consider an environment in which the economy has two geographically separate areas. One region has oil and gas reserves, and we call this the resource province. The other region is a non-resource province. Our main focus is on wage determination of the non-resource province before and after the oil price boom. For this reason, to keep the exposition simple, we set the model out in partial equilibrium form (treating the employment rate and migration rates as exogenous rather than solving for them in the context of the model). We consider a comparison with two steady states differentiated by there being higher and lower productivity in the oil sector in the ER region. We envision the non-ER region as having several local labour markets, indexed by $c \in C$. A worker in any c may have the option of living and working locally, or commuting or moving permanently to the resource province which, for simplicity, we consider as one labour market.

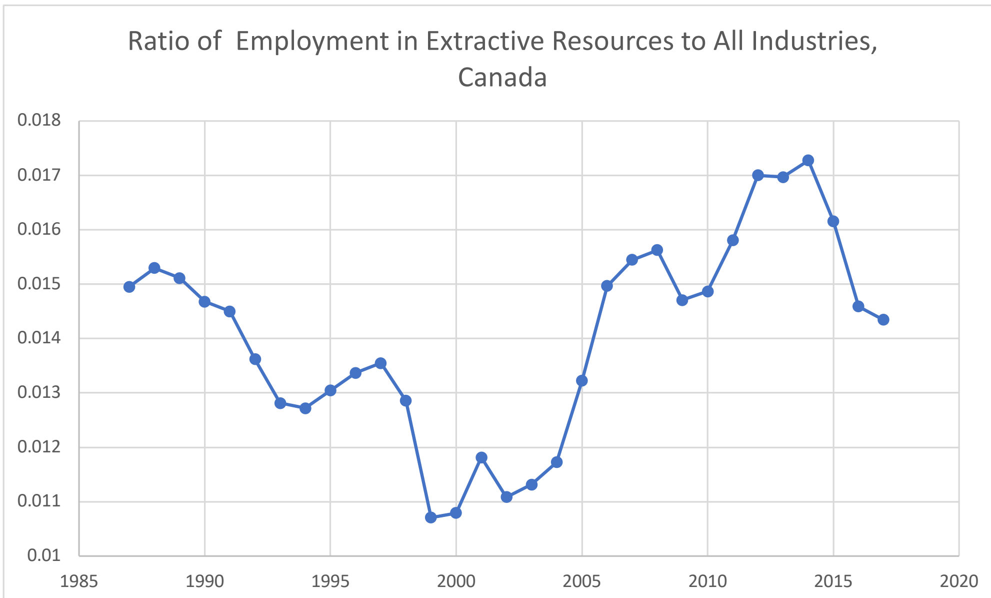
The oil boom (i.e., the state with high productivity in the resource sector) makes it more attractive for workers from the non-resource province to migrate to work in the resource province. This has two effects on wages in local labour markets in the non-ER region. First,

Figure 1:



Annual Average Imported Crude OIl Real Price, US
120.00
100.00
80.00
60.00
40.00
20.00
0.00
1968
1973
1978
1983
1988
1993
1998
2003
2008
2013
2018
2023

Figure 2:


Ratio of Employment in Extractive Resources to All Industries, Canada
0.018
0.017
0.016
0.015
0.014
0.013
0.012
0.011
0.01
1985
1990
1995
2000
2005
2010
2015
2020

the actual migration of workers reduces labour supply, resulting in an increase in wages. Second, for the workers who do not migrate, the option to migrate makes their bargaining position stronger relative to their employers, also raising wages. Since many workers can present this option in bargaining without actually pursuing it, the latter, spillover type effect could be very wide ranging and large. These wage effects, to the extent they exist, could have effects on firm decisions on whether to open job vacancies and, hence, on the employment rate.

For simplicity, we only present part of the full model here. In particular, in the complete version of the model, workers in the ER region are also making decisions about permanent migration to the local economies in the non-ER region. In steady state, the flows in the two directions must balance one another (with any flows reflecting individual idiosyncratic cost shocks). Further, we will treat the employment rate and the actual commuting and migration rates as exogenous, implying that we are only working with a partial equilibrium version of the model here.

Environment. The non-resource economy consists of firms and workers, and unfolds in continuous time. All agents are infinitely lived and discount the future at a rate, ρ. Each firm belongs to one of I industries, $i \in \{1, ..., I\}$, and seeks to hire a single worker in order to commence production. Production takes place in one of c local labour markets and traded at nationally determined prices. Once firms and workers meet, they bargain over the surplus. We assume, for simplicity, that there are always gains from trade between workers and firms for all jobs created in equilibrium in the local economy. The resource province is similar, except that it contains an additional industry (oil and gas). One could extend the model to allow intermediate inputs in production, including oil, for the firms in the non-ER region. In that case, the oil price increase would appear as an increase in costs for the firms in that region. This would amplify the differences in productivity between the ER and non-ER regions that are the bases of migration in our model. Not allowing for oil to impact on non-ER region firms can be seen as a normalization with a zero effect in the non-ER regions and a positive effect in the ER regions that actually reflects both the positives there and the negatives in the non-ER region firms.

The probability of a match in in the local labour market is determined by the matching function $m(L_c - E_c, N_c - E_c)$, where L_c is the size of the labour force in c, E_c is the number of employed workers (and, thus, the number of matches), and N_c is the total number of vacancies (both filled and unfilled). Thus, the number of matches is a function of the number of unemployed workers, $(L_c - E_c)$, and the number of unfilled vacancies, $(N_c - E_c)$. We assume that the matching function is constant returns to scale. Given this, Beaudry et al. (2012) show that in steady state the probability a vacancy meets a worker (ϕ_c) and the probability an unemployed worker meets a vacancy (ψ_c) can both be written as a function of the employment rate, ER_c.

Firms. Denote by J_{ic} the discounted value of a filled job in industry i and city c. In steady state, this must satisfy the Bellman equation:

$$\rho J_{ic} = (p_i - w_{ic} + \epsilon_{ic}) + \delta \cdot (V_{ic} - J_{ic}), \tag{1}$$

where p_i is the price paid for output in industry i, w_{ic} is the wage paid to a worker in i and c, and ϵ_{ic} is a city-industry specific cost advantage such that $\sum_c \epsilon_{ic} = 0$. The profit flow to the firm is $p_i - w_{ic} + \epsilon_{ic}$. V_{ic} is the discounted value of an unfilled vacancy. With some exogenous probability δ, the employment relationship breaks up and the firm gains V_{ic} and loses J_{ic}. V_{ic} must satisfy the Bellmen relation:

$$\rho V_{ic} = -r_i + \phi_c \cdot (J_{ic} - V_{ic}), \tag{2}$$

where r_i is the flow cost of maintaining a vacancy. Workers meet firms at rate ϕ_c. When a match occurs, the firm gains $J_{ic} - V_{ic}$. For simplicity, and without loss of generality, we set $r_i = 0$. As in Beaudry et al. (2014), we assume that firms must pay a fixed cost, k_{ic}, to open a vacancy in industry i in city c. We assume that the cost is rising in the relative size of industry i in that city:

$$k_{ic} = \left(\frac{N_{ic}}{L_c}\right)^{\lambda} e_{ic}, \tag{3}$$

where N_{ic} is the number of vacancies (both filled and unfilled) in the i-c cell, L_c is the size of the labour force in c, $\lambda > 0$ is a parameter, and e_{ic} is a local idiosyncratic cost component to opening a vacancy. The idea behind this specification is that entrepreneurs are needed for opening a firm and exist in proportion to the population of a city. As a sector expands relative to the size of the city, it must engage less productive (higher cost) entrepreneurs. Entrepreneurs enter the sector freely until $k_{ic} = V_{ic}$. As opposed to more typical specifications where entrepreneurs are homogeneous and enter until the value of a vacancy is driven to zero, this approach permits the co-existence of different industries within each city.

Workers. The discounted value of employment for a worker is denoted by E_{ic}. It must satisfy the following Bellman relationship:

$$\rho E_{ic} = w_{ic} + A_c + \delta \cdot (U_c - E_{ic}), \tag{4}$$

where w_{ic} is the wage paid to a worker in industry i and city c, and $A_c = \Psi_c - \gamma \cdot p_c^H$ is the net value of the local amenity over housing costs where p_c^h is the price of housing and Ψ_c is a local amenity. Thus, workers' (indirect) flow utility while working is $w_{ic} - \gamma p_c^h + \Psi_c$.

While unemployed, a worker has an option to search for jobs in the local economy (option 1). The value of doing so is denoted by U_c. The search is random, with workers finding jobs in industry i in proportion to its size, η_{ic}.[3] The job finding rate is given by ψ_c. Conditional on not finding a job in c, a worker may consider options outside their local economy in the resource province. This option might entail a permanent move, denoted P, or a commuting (temporary) option, denoted T. If a move is permanent, a worker just becomes unemployed in the resource province and continues to search. Thus, they exchange U_c for U_R, the value of search in location in the resource province. There are frictions to preventing workers from moving freely, parameterized by μ^P, and a location specific moving cost, θ_{cR}. A worker may also commute. We assume that to commute outside of c, a worker must have a job offer in the resource province – thus, this option works much like finding a job locally. Conditional on not finding a job locally, the probability of being offered a commuting option is given by μ^T. As we discuss in detail below, the value of commuting jobs are augmented by a location specific commuting flow cost, τ_{cR}, which should be interpreted as generalized travel costs that may depend on distance or non-pecuniary factors, such as language or cultural ties. These costs, in part, will determine the expected value of the commuting option. We label permanent moves to the resource province option 2. Similarly, we denote the commuting option as options 3. The value of local search must then solve:

$$\rho U_c = d + A_c + \psi_c \cdot \underbrace{\left(\sum_j \eta_{jc} E_{jc} - U_c \right)}_{\text{option 1}}$$
$$+ (1-\psi_c) \left[\mu^P \underbrace{\max\left\{(U_R - \theta_{cR} - U_c), 0\right\}}_{\text{option 2}} + \mu^T \underbrace{\sum_j \eta_{jR} \max\left\{(E_{jcR} - U_c), 0\right\}}_{\text{option 3}} \right]. \quad (5)$$

Wages. Wages are determined via Nash bargaining, with the rule:

$$(E_{ic} - U_c) = \kappa \cdot (J_{ic} - V_{ic}), \quad (6)$$

where κ is a parameter capturing the relative bargaining strength of workers versus firms. Using equations (1) and (2), write:

$$J_{ic} - V_{ic} = \frac{p_i - w_{ic} + \epsilon_{ic}}{\rho + \delta + \phi_c}. \quad (7)$$

[3] What matters for searchers is the relative number of vacancies posted in a sector. In steady state, given our assumptions of a common job destruction rate, random search, and a constant returns to scale matching technology, the proportion of vacancies in a sector equals the proportion of employment in that sector. Because we have data on employment but not vacancies, we work with the employment proportions.

Using (4), write:

$$E_{ic} - U_c = \frac{1}{\rho + \delta} \left[w_{ic} + A_c - \rho U_c \right]. \tag{8}$$

Let $\Gamma_c = \frac{\rho+\delta}{\rho+\delta+\phi_c}$, so that bargaining gives the following equation for wages that is a function of ρU_c:

$$w_{ic} = \frac{\kappa \Gamma_c}{1 + \kappa \Gamma_c}(p_i + \epsilon_{ic}) + \frac{1}{(1 + \kappa \Gamma_c)} \cdot \left[\rho U_c - A_c \right].$$

This equation represents wages as an increasing function of productivity and workers' value of search, and a negative function of net local amenities. To derive an expression for ρU_c, one needs to solve for each of the options in equation (5). We take the following steps:

1. Using (4), one can write:

   $$\sum_j \eta_{jc} E_{jc} - U_c = \frac{1}{\rho + \delta} \cdot \left(\sum_j \eta_{jc} w_{jc} + A_c - \rho U_c \right) \tag{9}$$

   and substitute for option 1.

2. If the option to permanently move occurs frequently enough (μ^P is sufficiently high), a steady state spatial equilibrium will imply that the value of permanent moves are driven to zero. As in standard spatial equilibrium models, we assume that housing is not perfectly elastically supplied. Thus, an increase in oil prices will initially make the resource provinces more attractive and they will receive an inflow of workers from non-resource provinces. This will simultaneously increase the cost of housing in resources provinces while lowering it in the non-resource regions, and this process will continue until the value of option 2 is driven to zero. Thus, as long as the permanent move mobility friction is small enough, the permanent move option is directed: unemployed workers decide to search locally or move and search in the resource province. A spatial equilibrium implies that workers must be indifferent between these options. However, if permanent move mobility frictions are large, option 2 will not be driven to zero and workers can use this option to bargain higher wages locally. Below, we solve for the wage equation by assuming a spatial equilibrium holds, and option 2 is zero, as a baseline. A derivation of the wage equation when this is not the case is provided in Beaudry et al. (2012). However, we empirically evaluate the relevance of permanent moves in the main text.

3. Workers who do not find a job locally or get the option to permanently move may get the option to commute. A worker gets the option to commute long distance to R with

the (conditional) probability μ^T. The Bellman equation for employment in a particular industry i in R for a commuter is:

$$\rho E_{icR} = w_{iR} - \tau_{cR} + A_c + \delta \cdot (U_c - E_{icR}),$$

where τ_{cR} is the flow commuting cost that varies by c. Because of the commuting costs, not all commuting matches will be acceptable. In particular, only jobs where $E_{icR} > U_c$ will form a match. Denote by η^T_{icR} the proportion of jobs in i from the set of acceptable jobs in the resource economy for those commuting from c. This conditional distribution reflects the fact that those observed in long distance commuting jobs may have different industrial employment than non-commuters in c and residents of R. In particular, in the data, commuting employment is relatively highly concentrated in the high-paying resource extraction sector, and this captures that fact. Taking an average of the above equation using η^T_{icR} as weights over industries for which $E_{icR} > U_c$ gives the conditional expected utility of commuting:

$$\sum_j \eta^T_{jcR} E_{jRc} = \frac{1}{\rho + \delta} \cdot \left(\sum_j \eta^T_{jcR} w_{jR} - \tau_{cR} + A_c + \delta U_c \right).$$

Then,

$$\begin{aligned} \sum_j \eta^T_{jcR} E_{jRc} - U_c &= \frac{1}{\rho + \delta} \cdot \left(\sum_j \eta^T_{jcR} w_{jR} - \tau_{cR} + A_c + \delta U_c \right) - U_c \\ &= \frac{1}{\rho + \delta} \cdot \left(\sum_j \eta^T_{jcR} w_{jR} - \tau_{cR} + A_c + \rho U_c \right). \end{aligned}$$

Finally, the unconditional expected utility can be written as:

$$\sum_j \eta_{jR} \max\left\{(E_{jcR} - U_c), 0\right\} = \frac{G_{cR}}{\rho + \delta} \cdot \left(\sum_j \eta^T_{jcR} w_{jR} - \tau_{cR} + A_c + \rho U_c \right) \tag{10}$$

where $G_{cR} = \sum_j \eta_{jR} \cdot 1[E_{icR} > U_c]$ is the probability of meeting an acceptable commuting job for workers in c given the option to commute. G_{cR} depends on the value of unemployed search in c, wages paid the resource province, and on location specific commuting costs, τ_{cR}. Other things being equal, the probability of meeting an acceptable job will be increasing in oil prices, as this will improve wages in the resource provinces. Likewise, other things being equal, this probability is decreasing in commuting costs. For high-cost locations, G_{cR} may be equal to zero, and commuting is no longer a viable option and does not factor into local wage determination. Expression (10) can be substituted in for option 3.

Making these substitutions allows one to write the wage equation as:

$$w_{ic} = \alpha_{1c}(p_i + \epsilon_{ic}) + \alpha_{2c}\Lambda_c + \alpha_{3c}\bar{w}_c + \alpha_{4c}\bar{w}^T_{cR}, \tag{11}$$

where

$$\Lambda_c = (\rho + \delta) \cdot d + (1 - \psi_c) \cdot \mu^T \cdot G_{cR} \cdot \tau_{cR}$$

and

$$\bar{w}_c = \sum_j \eta_{jc} w_{jc}$$
$$\bar{w}^T_{cR} = q^T_{cR} \cdot \sum_j \eta^T_{jR} w_{jR},$$

where the q^T_{cR} is a mobility weight, defined by $q^T_{cR} = (1 - \psi_c) \cdot \mu^T \cdot G_{cR}$. The α parameters can be written as explicit functions of structural parameters such as δ, ρ, ψ_c, and ϕ_c. We do not attempt to back out estimates of the underlying structural parameters because our interest is actually in their net effects as reflected in the α's.

Equation (11) captures the idea that in a bargaining environment, a workers' wages will depend not just on the productivity in that sector (captured by $(p_i + \epsilon_{ic})$ in this case), but also on outside options. In our environment, those options reflect the value of continued search which depends on the composition of local employment and on the value of the mobility options. As discussed above, the two mobility options differ in important ways. In particular, in a spatial steady state equilibrium, the option to permanently move plays no role in wage determination. This is because the permanent move option, provided mobility is high enough, is directed – workers chose to search locally or move and search in the resource province – and this drives its value to zero. Commuting, in contrast, is not directed; this option acts like an extra set of industry options for the local market. In addition, workers who commute face the same housing prices and, thus, the mechanisms which equate utility across locations in a spatial steady state concept are absent. Therefore, provided commuting is viable (τ_{cR} is not too high), the commuting option will always play a role in local wage determination.

Empirical Specification Note that in equation (11), w_{ic} is written as a function of its average. This generates a standard reflection problem. Here, we show how to eliminate this problem by writing wages as a function of national-level prices.

First, note that we can express the wage of industry i in a city relative to another arbitrarily chosen base level industry, which we call industry 1, with the relation:

$$w_{ic} - w_{1c} = \alpha_{1c}(p_i - p_1) + \alpha_{1c}(\epsilon_{ic} - \epsilon_{1c}). \tag{12}$$

Using this expression, we aim to eliminate $\bar{w}_c$ from the right hand side of (11) by replacing it with the national industrial prices. Write:

$$\begin{aligned}\bar{w}_c &= \sum_j \eta_{jc} w_{jc} = \sum_j \eta_{ic}(w_{jc} - w_{1c}) + w_{1c} \\ &= \alpha_{1c} \sum_j \eta_{jc}(p_j - p_1) + \alpha_{1c}\left(\sum_j \eta_{jc}\epsilon_{jc} - \epsilon_{ic}\right) + w_{ic} - \alpha_{1c}(p_i - p_1)\end{aligned}$$

Substituting this into (11) gives:

$$\begin{aligned}w_{ic} = \frac{\alpha_{3c}\alpha_{1c}}{1-\alpha_{3c}} p_1 + \alpha_{1c}(p_i + \epsilon_{ic}) + \frac{\alpha_{2c}}{1-\alpha_{3c}}\Lambda_c + \frac{\alpha_{3c}\alpha_{1c}}{1-\alpha_{3c}} \sum_j \eta_{jc}(p_j - p_1) \\ + \frac{\alpha_{4c}}{1-\alpha_{3c}} \bar{w}^T_{cR} + \frac{\alpha_{3c}\alpha_{1c}}{1-\alpha_{3c}} \sum_j \eta_{jc}\epsilon_{jc},\end{aligned} \tag{13}$$

Which deals with the reflection problem in (11) directly. Similarly, we can write $\bar{w}^T_{cR}$ as a function of the national industry prices:

$$\sum_j \eta^T_{jcR} w_{jR} = \alpha_{1R} \sum_j \eta^T_{jcR}(p_j - p_1) + \alpha_{1R}\left(\sum_j \eta^T_{jcR}\epsilon_{jR} - \epsilon_{1R}\right) + w_{1R}.$$

Performing this step and substituting into (13) yields the following equation:

$$w_{ic} = \frac{\alpha_{3c}\alpha_{1c}}{1-\alpha_{3c}} p_1 + \alpha_{1c}p_i + \frac{\alpha_{2c}}{1-\alpha_{3c}}\Lambda_c + \frac{\alpha_{3c}\alpha_{1c}}{1-\alpha_{3c}}\tilde{R}_c + \frac{\alpha_{4c}\alpha_{1R}}{1-\alpha_{3c}}\tilde{X}^T_{cR} + \tilde{\xi}_c, \tag{14}$$

where $\tilde{R}_c = \sum_j \eta_{jc}(p_j - p_1)$ and $\tilde{X}^P_{cR} = q^T_{cR}\sum_j \eta^T_{jcR}(p_j - p_1)$. $\tilde{\xi}_c$ is a term that depends on local cost shocks equal to:

$$\tilde{\xi}_c = \frac{\alpha_{3c}\alpha_{1c}}{1-\alpha_{3c}} \sum_j \eta_{jc}\epsilon_{jc} + \alpha_{1c}\epsilon_i + \frac{\alpha_{4c}q^T_{cR}}{1-\alpha_{3c}}\left[\alpha_{1R}\left(\sum_j \eta^T_{jcR}\epsilon_{jR} - \epsilon_{1R}\right) + w_{1R}\right].$$

Additionally, note that national-level industrial premia (industrial wage differentials averaged across locations) is $\nu_i = \bar{w}_i - \bar{w}_1 = \alpha_1(p_i - p_1) + \varepsilon_i$. Where ε_i is an industry specific constant. Thus, ν_i is proportional to the industrial price differentials, and we can substitute into equation (14) so that $\tilde{R}_c$, for example, can be written in terms of national wage premia, which can be constructed from wage data. Making this substitution:

$$w_{ic} = \alpha_{1ic} + \frac{\alpha_{2c}}{1-\alpha_{3c}}\Lambda_c + \frac{\alpha_{3c}}{1-\alpha_{3c}}\frac{\alpha_{1c}}{\alpha_1}R_c + \frac{\alpha_{4c}}{1-\alpha_{3c}}\frac{\alpha_{1R}}{\alpha_1}X^T_{cR} + \tilde{\xi}_c, \tag{15}$$

where α_{1ic} is an industry effect that varies by city, and $R_c = \sum_j \eta_{jc} \cdot \nu_j$ and $X_c^T = q_{cR}^T \cdot \sum_j \eta_{jcR}^T \nu_i$ are now written in terms of industry wage differentials.

Finally, note that all the coefficients in (14) are location specific. This is because they depend on rate at which vacancies meet workers, ϕ_c, and on the location specific job finding rate, which is a function of ψ_c and q_{cR}^T. The ϕ_c and ψ_c terms reflect the tightness of the labour market and can be written as a (non-linear) function of the local employment rate, while q_{cR}^T is a function of the value of commuting jobs and the commuting costs, τ_{cR}. To make this explicit, we follow Beaudry et al. (2012) and take a log-linear approximation of (14) around the point where cities have an identical industrial composition and labour market tightness, and where commuting costs are high enough to drive the value of commuting to zero for all locations. Adding time subscripts and differencing over time to eliminate city×industry fixed effects yields our empirical specification:

$$\Delta \ln w_{ic} = \beta_{0it} + \beta_1 \Delta R_{ct} + \beta_2 \Delta X_{cRt}^T + \beta_3 \Delta Emp_{ct} + \xi_{ict}, \tag{16}$$

where the βs are constant parameters obtained from the log-linear approximation, and reflect marginal effects of each variable evaluated at the point where cities have common job finding rates. The main coefficients of interest are $\beta_1 = \frac{\alpha_3}{1-\alpha_3}$ and $\beta_2 = \frac{\alpha_4}{1-\alpha_3}$. R_{ct} is now written in terms of log-differences in national-level industrial premia (eg. $R_{ct} = \sum_j \eta_{jct} \ln \nu_{jt}$), which we refer to as average rent, can be constructed in using the observed wage and industry employment data. We discuss how we do this in the main text of the paper. The expected value of the commuting option is given by $X_{cRt}^T = q_{cRt}^T \sum_j \eta_{jcRt}^T \cdot \ln \nu_{jt}$. This is constructed using the observed commuter industrial structure in the resource provinces to construct η_{jcRt}^T, and estimating q_{cRt}^T by using the observed fraction of workers in c who are observed long-distance commuting to R.

The β_{0it} term has i and t subscripts. This reflects the fact that national industrial prices vary by time, and in our empirical specifications we account for this by including year×industry fixed-effects. Thus, our estimated effects exploit within-industry, over-time variation. Intuitively, this means that we identify the local wage rent effect (β_1) by comparing the wage changes for workers in the same industry in two different cities that are experiencing different changes in their industrial composition. For example, we are identifying the bargaining effect by comparing wage changes for construction workers in Hamilton, with the loss of its high wage rent steel sector, to workers in, say, Moncton, without the loss of such a sector. The core idea is that the construction workers in Hamilton were able to bargain higher wages than those in Moncton because their outside option included the possibility of getting high wage steel jobs but they lost that advantage with the decline in the steel sector.

Interpreting the Coefficients. Movement of workers between regions results in a shift in supply of workers in each region, which will have feedback effects on wages through the job finding rate. Our specification includes ΔEmp_{ct} variable to account for this – we compare over-time, within-industry wage changes between localities with different evolutions in the rent variables, holding labour market tightness constant. Thus, the labour supply channel is not being picked up by the coefficients β_1 and β_2. Instead, these coefficients represent spillovers via a bargaining effect. Consider a one unit increase in $\bar{w}_c$ in equation (11). This has a direct effect on within-industry wages of α_{3c}. However, since this increase impacts all industries, average city wages will increase resulting in another round of adjustments, and so on. Multiplying these adjustments out results in a feedback effect of $\frac{1}{1-\alpha_{3c}}$. This results in the coefficient of $\frac{\alpha_{3c}}{1-\alpha_{3c}}$ on $\bar{w}_c$ in equation (13), which reflects both the direct effect of a change in $\bar{w}_c$, plus the direct effect times the indirect effect: $\alpha_{3c} + \frac{\alpha_{3c}}{1-\alpha_{3c}}$. Similarly, shifts in average wages in the resource provinces have both direct and indirect effects. Consider a one unit increase in $\bar{w}^T_{cR}$ in equation (11). The total effect of this increase in the R region will be $\frac{\alpha_{3R}}{1-\alpha_{3R}}$ due to the same arguments above. This will induce a direct effect in c of α_{4c}, and a feedback effect of $\frac{1}{1-\alpha_{3c}}$. Thus, the total impact of this increase will be:

$$\left[\frac{\alpha_{3R}}{1-\alpha_{3R}}\right]\cdot\left[\alpha_{4c}+\frac{\alpha_{4c}\cdot\alpha_{3c}}{1-\alpha_{3c}}\right]=\left[\frac{\alpha_{3R}}{1-\alpha_{3R}}\right]\frac{\alpha_{4c}}{1-\alpha_{3c}}.$$

The last term outside the brackets is the coefficient on $\bar{w}^T_{cR}$ in (13), which includes both the direct and indirect effect. These marginal impacts have the same interpretation in (16), except that they are evaluated at a point where the vacancy filling and job finding rates are common across cities.

Finally, it is important that the wage premia that we work with correspond to rents i.e., wage differences across industries that do not correspond to productivity differences or compensating differentials. If, instead, the wage premia corresponded to compensating differentials for elements of the work in different sectors then workers in other sectors could not use them to bargain a better wage. The higher wage in, say, the asbestos industry would just compensate for an expected loss in health and so there would be no real threat in telling your employer that you will quit to take a higher wage in the asbestos industry if she doesn't raise your wage. As pointed out in Green (2015), whether the industry premia really are rents can be tested empirically in our context: if they are not rents then the average premium should not affect wage setting within sectors.

B.1 Extension: Wage Dependent Unemployment

In this section, we present an extension of the model that allows unemployment benefits to depend on the region in which an individual resides. This is intended to capture key features of the Canadian Employment Insurance (EI) system. In particular, the number of weeks for which one can collect benefits varies by region; in higher unemployment regions, conditional on the same duration of previous job, benefit eligibility is longer compared to low unemployment regions. Importantly, the basis of the weeks of eligibility calculation is the unemployment rate in the location of residence, regardless of where the person was actually employed. Thus, a long distance commuter whose principle residence is in the Maritimes but who works in Alberta will get benefit amounts based on the high wage he earned in Alberta but will get more weeks of benefits than he would in Alberta because of higher unemployment rates in the Maritimes.

We can model regional variation in the benefits just by allowing the flow benefit of unemployment, d, to have a c subscript. An inspection of the wage equation, (11), under this extension indicates that d_c enters the wage equation linearly. Given that, if the benefits do not change over time then city-specific benefits will be differenced out. They will also be differenced out of the average wage term. Allowing them to vary with the employment rate (as they do in the actual system), the effect of their changes are captured as part of the coefficient on the employment rate in the linearized wage equation. So, while benefits will affect wage levels, they will not affect our difference specification results.

The situation becomes more complicated, however, if the benefit varies with the wage. In the Canadian system, benefits are a fixed proportion of past earnings up to a maximum. We introduce this feature into our model by replacing the fixed unemployment benefit, d, with one that varies with the wage and the place of residence. That is, the benefit will equal $d_c w_{ic}$, where d_c is a proportionality parameter that is declining in the employment rate, ER_c, and w_{ic} is the wage in the last industry in which a person worked, i. Given this, the value of unemployment for a person will depend on the previous industry of employment and, so, will be written U_{ic}. Note that the actual benefit rate does not vary across locations but writing the benefit this way allows us to capture differences in other features of the system (such as how it takes to qualify and benefit duration) at the same time.

For brevity, we work with a simplified model, with no migration or commuting options, to make the main points transparent. Under this extension, the Bellman for employment is modified from (4) to:

$$\rho E_{ic} = w_{ic} + \delta \cdot (U_c - E_{ic}), \tag{17}$$

The Bellman for non-employment is modified from (5) to include location specific unemployment benefits as a proportion of the wage in the previous industry:

$$\rho U_{ic} = d_c \cdot w_{ic} + \psi_c \cdot \left(\sum_j \eta_{jc} E_{jc} - U_{ic} \right) \tag{18}$$

To solve, one needs to derive expressions for $\sum_j \eta_{jc} E_{jc}$ and $\sum_j \eta_{jc} U_{jc}$, to obtain an expression for U_{ic} in terms of parameters and variables. This gives,

$$\rho U_{ic} = \frac{1}{\rho + \psi_c} \cdot [d_c w_{ic} + \Lambda_{c1} \bar{w}_c] \tag{19}$$

where $\bar{w} = \sum_j \eta_{jc} w_{jc}$ and

$$\Lambda_{c1} = \frac{\psi_c}{\rho + \delta} + \frac{\psi_c \delta}{\rho + \delta} \left[\frac{(\rho + \delta) \cdot d_c + \psi_c}{\rho(\rho + \delta + \psi_c)} \right].$$

Let $\Gamma_c = \frac{\rho+\delta}{\rho+\delta+\phi_c}$, so that bargaining gives the following equation for wages that is a function of rU_c:

$$w_{ic} = \frac{\kappa \Gamma_c}{1 + \kappa \Gamma_c}(p_i + \epsilon_{ic}) + \frac{1}{(1 + \kappa \Gamma_c)} \cdot \rho U_{ic}.$$

With substitution:

$$\begin{aligned} w_{ic} &= \frac{\kappa \Gamma_c}{1 + \kappa \Gamma_c}(p_i + \epsilon_{ic}) + \frac{1}{(1 + \kappa \Gamma_c)} \cdot \left[\frac{1}{\rho + \psi_c} \cdot [d_c w_{ic} + \Lambda_1 \bar{w}_c] \right] \\ &= \frac{(\rho + \psi_c) \cdot \kappa \Gamma_c}{(1 + \kappa \Gamma_c)(\rho + \psi_c) - d_c}(p_i + \epsilon_{ic}) + \frac{\Lambda_1 \bar{w}_c}{(1 + \kappa \Gamma_c)(\rho + \psi_c) - d_c} \end{aligned} \tag{20}$$

Thus, in the coefficient multiplying the average wage term, d_c enters positively in the numerator and negatively in the denominator, implying that living in a more generous (higher d_c city) amplifies the spillover effects of shifts in industrial composition. The positive effect through the numerator corresponds to the fact that jobs the person would find after the next unemployment spell will have an added benefit of leading to more EI benefits when they end. Since the benefits are assumed to be proportional to wages, a higher expected wage on the next job also means higher expected benefits in the subsequent unemployment spell. The negative effect in the denominator corresponds to the direct bargaining effect in this round: leaving the current job in a more generous EI city has better benefits in the immediate unemployment spell. For both reasons, the spillover effects we discuss will be amplified in more generous regions. Since commuters work in Alberta (getting the expected wage there) but collect benefits in the Maritimes where d_c would be effectively larger, the value of the commuting option is enhanced by this system relative to the option of living and working in the Maritimes, where expected wages (and the benefits that follow from them) are not as large.

C Data for US Estimation

- The US data come from the 2000 Census and from the American Community Survey for the years 2005/2006, 2009/2010, and 2014/2015. We group the ACS data in 2-year intervals to increase sample sizes. All data comes from IPUMS (Ruggles et al., 2015).[4]
- Our sample includes all civilian wage and salary workers between the ages of 22 and 64, inclusive. We further restrict the sample to include those working in the reference week and who have positive wages and salary, weeks worked, and usual hours worked per week in the previous year (or prior 12 months in the case of the ACS data). We exclude workers who report working outside the US.
- We measure wages as the log of the weekly wage. We impose a uniform (across years and states) topcode of $200,000/52 and adjust top-coded wage earners by multiplying by 1.5.
- We use the IPUMS `ind1950` industry variable which contains 134 industries in our sample.

C.1 Commute to ER States

- Workers are coded as 'commuters' if they report working outside their state of residence by using the variable `pwstate2`. We classify a worker as commuting to an ER state if they report working in Alaska, North Dakota, New Mexico, Oklahoma, Louisiana, Texas, West Virginia, or Wyoming.
- Our unit of analysis are commuting zones, as described in Autor et al. (2013) and downloaded from David Dorn's webpage (https://www.ddorn.net/data.htm).
- We use only wage data for commuting zones outside of the ER states, of which there are 584. We calculate regression adjusted wages for these regions by estimating the following equation:

$$\log \text{Weekly Wage}_{icjt} = \mathbf{X}'_{icjt}\beta_t + \omega_{cjt} + \epsilon_{icjt}$$

  where c indexes commuting zone, j indexes industry, and t indexes year and the regression is weighted by the variable `perwt`. $\mathbf{X}_{icjt}$ is a vector of worker characteristics that includes education (4 categories), interacted with an quartic in potential experience and female, black, and immigrant dummies. The ω_{cjt} is a vector of commuting zone×industry×year, which we refer to as regression adjusted wages.

[4] https://usa.ipums.org/usa/index.shtml

- We calculate national level industrial premia using the following regression

$$\hat{\omega}_{cjt} = \nu_{jt} + \xi_{ct} + \varepsilon_{cjt}$$

estimated using the cjt-cell sizes as weights.

- We estimate outside options for workers who work within-state by using the observed employment distributions across industries (η_{cjt}) within each commuting zone:

$$R_{ct} = \sum_j \eta_{cjt} \cdot \nu_{jt}$$

and for workers who commute to an ER state, we use the observed employment distribution of these workers, where the superscript C denotes a commuter along with the fraction who commute, ψ^C_{ct}:

$$X^C_{ct} = \psi^C_{ct} \cdot R^C_{ct} = \psi^C_{ct} \cdot \sum_j \eta^C_{cjt} \cdot \nu_{jt}$$

- We construct instruments for the outside options of within-state workers as:

$$IV1 = \sum_j (\hat{\eta}_{cjt} - \eta_{cjt-1}) \cdot \nu_{jt-1}$$
$$IV2 = \sum_j (\nu_{jt} - \nu_{jt-1}) \cdot \hat{\eta}_{cjt}$$

where $\hat{\eta}_{cjt}$ is the predicted employment share constructed by predicting local employment in an industry using national (non-ER) industrial growth rates: $\hat{N}_{cjt} = N_{cjt-1} \cdot \frac{N_{jt}-N_{jt-1}}{N_{jt-1}}$. We also instrument for local employment rates with a Bartik-style IV:

$$IV3 = \sum_j \frac{N_{cjt-1}}{N_{ct-1}} \cdot \frac{N_{jt} - N_{jt-1}}{N_{jt-1}}$$

- We construct an instrument for X^C_{ct} by using the initial period commuting rate ψ^C_{2000} multiplied by the price of oil.

D Replication of Results Using Canadian Census Data

One potential concern in comparing our US and Canadian results is that the very different data sources may be driving the comparative results. In order to compare like to like, we replicate our results for Canada using Canadian Census data. That data contains similar commuting questions to those used in our US Census analysis.

Data for the analysis in this appendix comes from the restricted access files of the census of Canada for 2001 and 2006, and from the National Household Survey (NHS) for 2011. As in our previous results using Canadian tax data, Economic Regions are used as our geographic variable. We focus on Economic Regions in non-extractive provinces and restrict our focus to individuals aged 22 to 54 at the time of sampling. Furthermore, we restrict our focus to wage earners who are not self-employed and not in full or part time study. We drop from the sample those who report working outside of Canada. As before we consider Alberta, Saskatchewan and Newfoundland to be extractive resource provinces.

The Census and NHS collect data on individuals self reported place of work and residence at both aggregated and fairly granular levels. Using this we can determine an individuals economic region of residence using a consistent geographic definition over time. To keep our analysis consistent with our previous results we consider commuting to ER-provinces rather than Economic Regions. Individuals who report having no permanent place of work are dropped from our analysis. We define 'residents' as individuals who live and work in the same province and long distance commuters as individuals who live and work in different provinces. We do not identify permanent movers.

Industrial classifications change over time in the Census and the NHS. We attempt to use the most parsimonious definition across time.

Our unit of analysis then is Economic Region by industry for areas in non-ER provinces. Our dependent variable is the change in the log weekly wage for the Economic Region by industry between Censuses. Cells for which there are fewer than 20 individuals are dropped from the analysis. We derive this wage variable, our core explanatory variables (ΔR_{ct}, ΔX_{ct}^{T}, ΔER_{ct}), and our instruments in the same manner as for the Canadian tax data.[5] In table 1 we present our results for our preferred specification that does not include moves or long distance commutes to non-ER provinces. OLS results are presented in column 1 and IV results in column 2. Standard errors are clustered at the Economic Region in both regressions and year by industry fixed effects are included. Our first stage results in the IV specification indicate that our instruments are not weak.

[5] See Appendix C for details

From our IV results we observe a coefficient on the industrial composition rent term (ΔR_{ct}) that is close to that obtained using Canadian tax data. Our estimate on the commuting option is however much larger here, and is estimated less precisely than our prior results. The point estimate on the this term is about 4.5 times larger than our estimate obtained using Canadian tax data. Though the standard errors are much larger this result is still significant and indicates a positive effect of having the option to commute to resource extractive provinces on the wage.

The larger point estimate obtained using Census data arises because of the smaller magnitude of the long distance commuting probability in the Census relative to the tax data. Combining the IV estimated coefficient on ΔX_{ct}^{T} from Table 1 with the mean change in the commuting option variable, we find that the observed increase in the commuting option value in our period implied a 0.54% increase in the average wage overall. This compares favourably to the 0.9% result we get from tax data. We view the comparability of the size of the estimated effects as supporting our argument in the paper that what differentiates Canada and the US is not the effectiveness of spillovers when they occur but the much smaller relevance of commuting and moving to resource booms in the US (relative to the total economy) in our period.

There are several potential reasons for why the proportion undertaking long distance commuting is lower in the Census data. Firstly, the Census questionnaire asks for individuals to report the current place of work rather than the place of work in the main job in the previous year. Individuals who worked for a long spell in ER provinces may be missed as a result. Secondly, some long distance commuters in the Census may identify their place of residence as the place they reside while working far from home. The Census question regarding place of residence asks individuals to report the place where they most frequently resided in the past year, or if unsure, where they are living on Census day. For married individuals or individuals in common-law relationships this is less likely a problem as Census guidelines request they report the place of their shared residence with their partner.

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Table 1: Estimation Results: Canadian Census and NHS

	(1)	(2)
	OLS	2SLS
ΔR_{ct}	1.609**	1.182**
	(0.254)	(0.306)
ΔX^T_{Act}	22.745**	37.155*
	(8.516)	(19.557)
$\Delta EmpR_{ct}$	0.111	0.104
	(0.243)	(0.239)
Observations	6,340	6,340
R^2	0.293	.
Fixed Effects:		
Ind.× Year	Yes	Yes
Instrument set:		IV1-IV2
		IV^X
p-val.:		
ΔR_{ct}		0.000
ΔX^T_{ct}		0.027
ΔEmp_{ct}		.
Over-id. p-val		

Notes: Standard errors, in parentheses, are clustered at the Economic Region level. (**) and (*) denotes significance at the 5% and 10% level, respectively. Results estimated using the 2001 and 2006 Census of Canada, and the 2011 National Household Survey. The dependent variable is the regression adjusted city-industry log wage, and cells with less than 20 observations are excluded. Column 1 is estimated using Least Squares and column 2 is estimated via Two Stage Least Squares. The bottom panel of the table shows the results of the first-stage statistics for the excluded variables of the 2SLS procedure.

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