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IMPACT OF INDIVIDUAL AND INSTITUTIONAL FACTORS ON WAGE RATE FOR NURSES IN CANADA: IS THERE A MONOPSONY MARKET?

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Impact of Individual and Institutional Factors on Wage Rate for Nurses in Canada: Is There a Monopsony Market?

Ruolz Ariste*, Ali Béjaoui†

Abstract

Several studies and media sources often report a labour shortage in the nursing profession. Given this shortage, one might assume that registered nurses (RNs) would have a perspective of maximizing wage income: increase the hourly wage or the number of hours worked. Institutional incentives in place can influence these two components, particularly the hourly wage. However, previous studies of Canadian nurse wages were limited to individual factors and did not take into account contextual factors such as hospital market share, labour market size or unionization. Based on market share, some refer to the nursing labour market as a monopsony; which depresses wages and might explain the shortage. However, this has not yet been tested empirically in the Canadian RN labour market. This article aims to fill this gap by using the confidential microdata files of the Labour Force Survey (LFS) for the years 2010 to 2012 and the multi-level analysis to shed light on this issue. The contribution of this work is that it takes into account both individual and contextual variables to try to explain nurses' hourly wage. In accordance with the monopsony model, we hypothesize a negative correlation between hourly wage and level of market share; i.e. monopsony employers would pay a lower wage rate. The results do not support the monopsony model to explain nursing labour shortage: there is no statistically significant relation between RNs wages and market share; no relation was found for market size either. This suggests explanation for RN labour shortage must be investigated elsewhere.

JEL Classification: I11; I18; J31; J38

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I. Introduction

It is generally established that there is a shortage of nurses in Canadian labour market. Given this shortage, nurses who wish to maximize their income may choose to work more hours, negotiate a higher hourly rate or even operate both levers simultaneously. However, existing studies show that they didn't have a higher work intensity (i.e. they didn't work higher number of weekly hours)[1] than similar workers in other sectors of the economy (Laberge and Montmarquette, 2009). This implies that the revenue maximization objective may be pursued by seeking higher pay rates. With a high unionization rate, such a strategy is plausible. Indeed, the nursing sector exhibits a high union density. RNs who were either unionized or covered by a collective agreement between 2010 and 2012 represented 81.0 % in Canada (Uppal, 2011). It is generally accepted that, all things being equal, unionized workers generally earn more than non-unionized ones. However, the literature also suggests that nurses face a labour market characterized by monopsony (or oligopsony): i.e. they offer their labour at a single hospital (or a few hospitals) in a given region. In such a context, these hospitals may offer a lower wage than what we would have seen in a competitive market (i.e. if there were a large number of hospitals in a given region). The stakes are between the unions which target higher hourly wages for their members and the employers who seek to pay lower wage rates. These low wages on the one hand, do not encourage nurses to work more, and on the other hand, induce employers to demand for more work hours, which ultimately would fuel the nursing shortage.

[1] The labour intensity is reduced to the number of worked hours. But it could be defined as a more complex concept that also includes workload; for example the ratio number of patients per nurse.

There is a relatively large literature on the effect of monopsony power on wages in the nursing labour market. Previous studies that have examined such relationship include: Hurd (1973); Link and Landon (1975); Sloan and Elnicki (1978); Feldman and Scheffler (1982); Adamache and Sloan (1982); Bruggink et al. (1985); Hirsch and Schumacher (1995, 2005). Among these studies, most of the earlier ones find a positive relationship between wages and the degree of hospital competition, as predicted by the monopsony theory. Exceptions are found in Adamache and Sloan (1982) and Hirsch and Schumacher (1995). A relatively recent study has confirmed these exceptions and found no evidence of monopsony power in RN labour market (Hirsch and Schumacher, 2005). These authors found in their 2005 study that there is some evidence among women that wages are lower in markets with lower worker mobility, but not for RNs.

Despite the importance of the nursing imbalance issue in Canada, few studies have been undertaken on Canadian nurses' wage. Those available, consider only individual factors such as education level, seniority, leaving aside institutional factors such as the degree of hospital competition and nurse unionization (Vujicic 2003; Buhr, 2006). This study intends to fill part of this gap; especially with respect to the institutional factors that can help to understand nurses' wage. The contribution of this work is the inclusion of both individual and institutional variables in a multi-level analysis to understand the effect of monopsony on nurses' wage in Canada. Previous Canadian studies did not explicitly consider hospital competition and nurse unionization. Hirsch and Schumacher (1995, 2005) accounted for variables at both levels in their studies on wages' nurses for the United States. As contextual or institutional level variable, they included the degree of hospital competition in their model, but they use two stages estimation procedure; which can compromise the analysis and interpretation of variables. Multilevel method

prevents the analysis and interpretation of variables at non-appropriate levels (Hox and Roberts, 2011).

This paper tries to answer the general research question: *What is the impact of individual and institutional factors on the hourly wage of nurses working in Canadian hospitals?* We start from the main assumption that monopsony or oligopsony exists on the nursing labour market in Canada, but the presence of unionism could eventually offsets this force.

Two specific hypotheses derive from the monopsony assumption. Ceteris paribus:

1. There is a negative relationship between hourly wages and hospital market share
2. There is a positive relationship between hourly wages and market size

The specific hypothesis from the offsetting union effect is that:

3. Unionized nurses earned more than their non-unionized counterparts.

The rest of the article is organized as follows. The second section presents an overview of the theoretical monopsony model. In the third section, data sources, operationalization of the concepts and some descriptive statistics are discussed. The empirical model is outlined in the fourth section while section 5 presents the results. In section 6, a general discussion is offered along with study limitations. Finally, a conclusion is provided in Section 7.

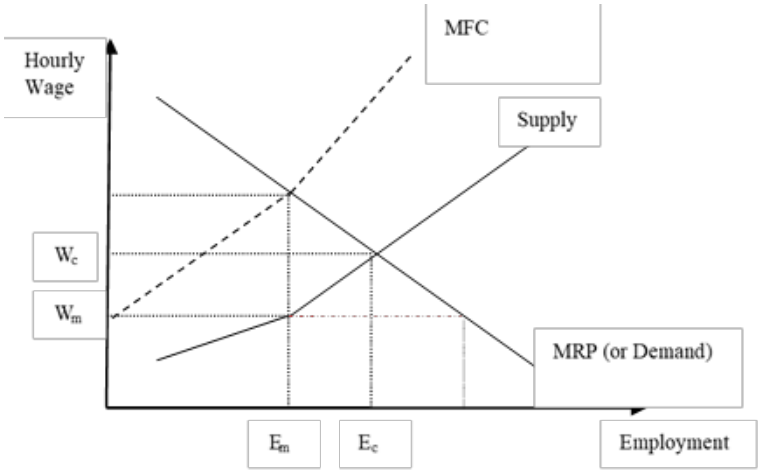
II. The theoretical monopsony model

2.1. Monopsony nurse labor market with union coverage

Pioneer theoretical studies that discuss monopsony/monopoly market in general include Robinson (1933), Archibald (1954). For nurse labour market specifically, Yett (1970); Link and

Landon (1975); Sullivan (1989) were among the first authors who addressed monopsony with or without union coverage. Without union coverage, a strong monopsonist will hire nurses to the point where the marginal factor costs (MFC) equal the marginal revenue product (MRP), but will pay only wage W_m. At this wage, he will get level of employment E_m, but would be willing to hire $\bar{E}_m$ nurses (an additional number given by the dash-dot line). This results in underemployment and the monopsonist will report vacancies $E_m\bar{E}_m$ at wage W_m (see Figure 1).

Figure 1: Monopsony nurse labor market with union coverage



Source: Link and Landon (1975)

Note that the supply curve for nurses is kinked. Wage increases will be met, but wage decreases will result in a substantial loss of nurses to the wage cutter. With union coverage, resulting employment and wage levels, however, depend on the union's goals. A strong union vis-a-vis the monopsonist / oligopsonist can treat the MRP curve as the demand for the services of its members. In fact, the union may be strong enough to dictate the wages of its members on a take-it-or-leave-it basis. That wage can vary between W_m and W_s without decreasing employment levels. If the union chooses to maximize the wages of the current membership, it will set wages at W_s. Maximization of employment as a goal will result in the hiring of E_c nurses at the wage

W_c; which is the equivalent outcome of a competitive market. The weaker the union versus the oligopsonist, the closer the wage will approach W_m (i.e., the oligopsony-nonunion case). If a strong union attempts to whipsaw the individual oligopsonists, the hospitals may collude to form an organization to bargain with the union. This would be the case of a classical bilateral monopoly. The Canadian nurse labour market is perceived as a bilateral monopoly. Whether or not vacancies will be reported depends on the ability of the union to maintain the wage at or above W_c. It is expected that the coefficient for the monopsony variable to be negative: a high level of monopsony will produce a low hourly wage for RNs. On the contrary, a positive correlation is expected for the union variable: a high level of unionisation will lead to higher nurse hourly wage.

2.2. Other factors that explain hourly wages

The above mentioned variables are at the institutional level. It is also necessary to introduce variables at the individual level in order to be able to explain RN wage differences *within* a region. These individual level variables include: level of education, number of years of experience, tenure, employment status (full time versus part-time), family status. As per the human capital theory (Becker, 1964), it is expected that the coefficients associated with education level and years of experience to be positive: hourly wages should increase with the level of education and the number of years of experience. , tenure and union coverage (among the γ_{10}) should be positive:, with tenure and with the fact of being covered by a union. Moreover, wages are expected to be higher in Alberta and lower in Quebec relative to Ontario.

III. Data

3.1. Data Sources

Different data sources are used to answer the research question and formally test the three sub-hypotheses. Our main data source is the Labour Force Survey (LFS) of Statistics Canada (2005, 2012a), microdata file (CMF), which contains detailed information from 1987. Among others, it contains data on the nursing workforce, the number of paid work hours, paid and un-paid overtime hours, hourly wage rates, employment status, the reason of employment status, union status, previous employment, geographic region. We used annual data from 2010 to 2012. The LFS is a well-known survey used to publish unemployment rates in Canada. It covers all persons aged 15 and over residing in the provinces, except persons living on Indian reserves, full-time members of the Armed Forces and institutional inmates. For more information on the methodology of the LFS, see Statistics Canada (2008).

Another data source is the Canadian MIS[2] Database (CMDB) managed by the Canadian Institute for Health Information (CIHI). The CMDB is the national administrative data source on hospitals and health regions (CIHI, 2011). It covers the period from 1995-1996 to 2013-2014[3] and focus on variables such as name and address of hospitals (including postal code), number of employees, number of beds, labour costs, etc. This database is used to measure hospital market share in a given region (from the number of beds) and therefore the potential impact of monopsony. More specifically, the area code is used to locate the facility in the employment insurance region (EIR) of the LFS.

The dataset includes all registered nurses identified in the National Occupational Classification -

[2] Management Information Systems.
[3] Prior periods (1932-1993) are covered by the annual Health Care Facilities - Hospitals, Statistics Canada.

Statistics (NOC-S) 2006 and working in the public sector, specifically in hospitals.[4] Thus, all RNs with employment in a hospital (full time, part time or on call; permanent or temporary) have been retained. The final sample excludes nurse supervisors, nurses working in the private sector and male nurses because of low cell size; they risk being identified in a given region.[5, 6] Other exclusions are listed below: individuals who are full-time students or under the age of 18; who are not employed at the time of the survey; who are self-employed or without pay; who do not have at least a high school diploma or have a master's or doctorate. The final sample for the years 2010-2012 includes 18,368 RNs; which represent 6.6% of all RNs in Canada in 2012.

3.2. Defining the concepts and variables

Some variables and concepts need to be defined to avoid confusion. This is the case for *RN hourly wage*. In the LFS, salaries or wages may be declared on an hourly, weekly, monthly or annual basis. They relate to the main job and include tips and commissions, before taxes and other deductions, but they usually do not include benefits.[7] Hourly and / or weekly wages[8] are calculated together with the weekly working hours usually paid. This means they do not include overtime. All RN hourly wages less than $5 or greater than $150 were excluded from the sample.[9]

[4] Statistics Canada uses the concept of "financing" to classify jobs. Thus, all hospital employees are classified in the public sector.

[5] Another reason is that for the purpose of the multilevel modelling, it would be difficult to have enough of them in each cluster. For these same reasons, we have not included Licenced Practical Nurses or Orderlies either.
[6] In 2012, about 3.5% of RNs in Canada were nurse supervisors and 7.2% of RNs were males.
[7] Personal communication with Labour Statistics Division staff, December 2013.
[8] These two wage dimensions are found in the LFS database.
[9] We chose this lower and upper bound to account for outliers. The ceiling of $150 was chosen because we take into account the fact that an employee with a bachelor degree and who is not part of the management team generally earns less than this amount.

Education level is a binary variable with 1 for RNs with a community college, CEGEP or university certificate below Bachelor's degree and 2 for RNs with a Bachelor's degree.

The variable *years of experience* does not exist as such in the LFS. This is a theoretical variable measured by subtracting the age from the number of years of schooling and adding 6 years (the age of starting school). This is a variable that is correlated with age. It is different from *tenure* which refers only to the current job.

Employment status includes full-time and part-time employment. The latter consists of persons who usually work less than 30 hours per week at their main job or their only job.

Family status is a categorical variable derived from the combination of marital status and presence of one young kid or not.[10] It ranges from 1 to 4 with:

- 1 = being married or in a common-law relationship with young kid;
- 2 = being married or in a common-law relationship without young kid;
- 3 = not being married nor in a common-law relationship with young kid;
- 4 = not being married nor in a common-law relationship without young kid.

The *Herfindahl index (HI)* is commonly used in the literature as an indicator of hospital *market share* or level of competition (Hirsch and Schumacher, 2005; Link and Landon, 1975). It is calculated from the number of beds by summing the squares of each hospital's market share of the total market. Therefore, it is defined as: $HI_j=\sum_i p_i^2$ where j indexes the geographic region, i the hospital and p the hospital market share (Hirsch and Schumacher, 2005). It ranges from 0 to 1, with values closer to 0 indicating a high degree of competition (several hospitals share more or less equally the available beds in the market) and values close to 1 indicating a high degree of

[10] Young kid is defined as a child between ages 0 to 14 years old.

oligopsony (the beds are disproportionally controlled by a small number of hospitals). This *HI* reflects both the number and size of hospitals. Specifically, we followed the typology of markets established by the US government, based on the value of the HI:

Table 1: Market Share Classification Based on the Value of the Herfindahl Index

HI less than 0.15	Low market share, high level of competition (HI1)
HI between 0.15 and 0.25	Moderate market share, moderate level of competition (HI2)
HI more than 0.25	High market share, low level of competition (HI3)

Source: US Department of Justice, 2010, p. 19

The size of the RN sample by degree of hospital market share matters because it is a key variable in our analysis. 38.3% of RN in our sample works in regions where the level of hospital market share is low (high competition) while 45.1% works in regions where the level of hospital market share is high (low competition).

Union status is defined as: a) unionized; b) non-unionized but covered by a collective agreement or an employment contract negotiated by a union; or c) non-unionized and not covered by a collective agreement. In this study, the unionization rate is the percentage of employees who are union members or covered by a collective agreement. This excludes the self-employed.

The *region* in this work refers to the employment insurance region (EIR). There are three types of regions in the LFS: 1) Economic Regions, 2) Census Metropolitan Areas (CMA) / Urban Areas / Census Agglomerations (UA / CA) and 3) EIR.[11] We chose to use EIR because they are generally better distributed and better disaggregated within a province[12] and our study examines

[11]The breakdown of the different geographic regions is only in the CMF. The Public Use Microdata File (PUMF) contains only the three largest CMAs (Montreal, Toronto and Vancouver). Neither the CMF nor the PUMF contains the postal code.

[12] For example, according to the structure of the CMA/UA/CA, no specific region exists for North-West Quebec. Municipalities such as Témiscamingue, Val-d'Or, Rouyn-Noranda would be paired to either Gatineau or Saguenay; which is not too straightforward. However, the EI structure includes a region for North-West Quebec.

the labour market. EIR are distributed as follows: 12 in Quebec; 16 in Ontario; 4 in Alberta; 6 in BC and 16 in the rest of Canada, for a total of 54 regions. The hospitals were located in a given EIR based on their postal code using the interactive application of Employment and Social Development Canada (ESDC) that matches postal codes to EIR.[13]

Market size refers to the number of working age people in a given region. It permits to regroup peer-regions that are likely to have the same characteristics. Based on Hirsch and Schumacher (1995),[14] we identified six market sizes; which permits us to regroup the 54 EIR into six peer-groups:

Table 2: Classification of Regions Based on Labour Market Size

Peer Region	Population 15 years and over (Labour Market Size)	Number of EIR
Peer Region1	Less than 150,000	12
Peer Region2	Between 150,000 and 299,999	15
Peer Region3	Between 300,000 and 499,999	13
Peer Region4	Between 500,000 and 999,999	8
Peer Region5	Between 1 million and less than 2 million	3
Peer Region6	Between 2 and 5 million	3
Total		54

Half (27 of 54) of EIR are found in peer-regions 1 and 2 where the size of the population is less than 300,000. Obviously EIR Montreal, Toronto and Vancouver belong to the last peer-region. EIR Central Ontario, Calgary and Edmonton are part of the peer-region 5. The directory of the municipalities for a given EIR may be found using the interactive application of ESDC.[13,15] Note

[13] Look up EI Economic Region by Postal Code. Accessed in October 2013: http://srv129.services.gc.ca/regions_ae/fra/codepostal_recherche.aspx
[14] These authors identified eight market sizes. We have modified their size structure based on the Canadian context.
[15] A given EIR may include a dozen or even several hundred census subdivisions (municipalities). For example, the EIR of Gatineau includes 10 municipalities while Central Quebec includes over 500 municipalities.

that these demographic sizes are different from those defined by Statistics Canada as population centers.[16]

3.3. Descriptive Statistics

We provide a descriptive overview of the RN hourly wage prior to our formal analysis. Table 3 presents the mean wage rates and standard deviation (in brackets) for RNs by selected job and market characteristics and provinces. Some provinces are combined based on their geographic location and the size of their workforce.[17] Specifically, Newfoundland and Labrador, Prince Edward Island, Nova Scotia and New Brunswick are combined to make up Atlantic Canada (AC) while Manitoba and Saskatchewan (MB & SK) are combined as part of the Canadian Prairies. Quebec, Ontario, Alberta and British Columbia (BC) are kept as stand-alone. These four provinces account for 86% of the total population of Canada. This provincial structure results in six "derived" provinces. It should be reminded that these wage rates do not include benefits and overtime. Mean wage rates and standard deviation are presented for two job characteristics (union status and employment status) in the first part of Table 3.

[16] Statistics Canada now uses the term 'population centre' to replace the term 'urban area'. Population centres are classified into three groups, depending on the size of their population: 1) small population centres, with a population between 1,000 and 29,999; 2) medium population centres, with a population between 30,000 and 99,999 and 3) large urban population centres, with a population of 100,000 or more (Statistics Canada, 2011) .

[17] Some provinces were combined to represent a workforce not less than 1.5 million.

Table 3: **Mean Wage Rates and Standard Deviation (in brackets) for RNs by Selected Job and Market Characteristics and Provinces, 2010 to 2012**

	Atlantic Provinces	Quebec	Ontario	Manitoba and Saskatchewan	Alberta	BC	Canada
Education level							
Bachelor's degree	32.5 (6.0)	31.2 (8.0)	34.6 (7.9)	35.0 (7.6)	37.7 (6.9)	34.4 (7.1)	34.4 (7.7)
College or CEGEP	32.0 (7.0)	27.2 (7.2)	36.0 (8.7)	35.9 (7.1)	37.1 (8.2)	34.7 (7.6)	33.8 (8.7)
Employment status							
Full time	32.0 (6.6)	28.3 (7.8)	35.2 (8.2)	35.3 (7.6)	37.3 (7.6)	34.2 (7.3)	33.7 (8.3)
Part time	33.1 (6.3)	29.7 (7.4)	36.7 (9.5)	35.8 (6.5)	37.7 (7.4)	35.2 (7.3)	35.0 (8.4)
Union Status							
Unionized	32.4 (6.1)	28.8 (7.2)	36.1 (7.9)	35.7 (6.9)	37.8 (7.2)	34.8 (6.9)	34.4 (7.9)
Non-unionized	28.4 (11.7)	26.4 (12.8)	32.6 (10.2)	30.4 (12.6)	31.0 (10.3)	28.0 (12.2)	31.1 (11.2)
Family status							
Spouse with kid(s)	32.8 (5.8)	29.7 (7.7)	37.1 (7.3)	35.1 (6.6)	37.7 (6.4)	35.3 (6.7)	35.0 (7.5)
Spouse without kid	32.4 (7.0)	29.1 (7.7)	35.7 (9.0)	36.9 (6.9)	37.1 (8.6)	34.5 (7.1)	34.3 (8.5)
No spouse with kid(s)	31.2 (6.5)	27.7 (4.9)	35.4 (6.9)	33.5 (9.2)	38.8 (6.4)	36.8 (6.4)	34.6 (7.4)
No spouse no kid	30.8 (6.8)	26.7 (7.7)	32.5 (8.8)	33.2 (8.3)	37.3 (7.3)	33.3 (8.4)	31.9 (8.7)
Market share							
HI1 (Low)	32.7 (6.3)	28.4 (8.3)	35.8 (8.9)	35.6 (7.1)	36.2 (7.5)	34.6 (7.3)	33.8 (8.6)
HI2 (Moderate)	32.5 (6.8)	28.7 (6.0)	35.1 (7.4)	34.2 (6.6)	38.8 (6.8)	n/a	34.1 (7.6)
HI3 (High)	31.9 (6.6)	29.4 (7.5)	35.2 (8.2)	37.3 (8.4)	37.2 (8.1)	34.2 (7.4)	34.6 (8.2)
Market size							
1 : < 150,000	31.4 (6.4)	29.4 (6.8)	35.6 (8.0)	33.6 (8.5)	38.8 (8.5)	32.9 (6.9)	35.0 (8.0)
2 : 150,000 to 299,999	33.6 (7.4)	30.3 (8.3)	36.0 (7.4)	36.3 (7.6)	37.1 (8.1)	36.2 (6.1)	35.2 (7.4)
3 : 300,000 to 499,999	31.5 (6.9)	28.3 (6.0)	35.1 (8.4)	n/a	n/a	34.6 (7.6)	33.2 (8.0)
4 : 500,000 to 999,999	n/a	28.7 (5.9)	34.9 (7.8)	34.2 (6.6)	36.1 (7.4)	34.1 (6.9)	33.6 (7.5)
5: 1M to < 2M	n/a	n/a	35.7 (7.6)	37.0 (7.2)	37.2 (8.1)	n/a	36.6 (7.9)
6: 2M to 5M	n/a	28.3 (8.9)	36.0 (9.2)	n/a	n/a	34.6 (7.7)	33.3 (9.4)
All Market Sizes	32.2 (6.6)	28.6 (7.7)	35.5 (8.5)	35.5 (7.4)	37.4 (7.6)	34.5 (7.3)	34.0 (8.3)

n/a: not applicable.

At the Canada level, RNs with a bachelor degree were paid 1.8% more than those who have a college degree or CEGEP. The province where the difference matters more is Quebec (14.7%). However, provinces like Ontario, MB & SK, and BC experimented the reverse. This could be

due to the fact that those RNs with a college degree in these provinces have more years of experience or tenure than those with a bachelor degree; which highlights the importance to control for other factors. Moreover, at the Canada level, hourly wage for full-time RNs was lower than that for part-time RNs (-3.7%). This was also the case in the comparing provinces: wage gap of full-time RNs compared to part-time RNs was -3.3% in AC, -4.7% in Quebec, -4.1% in Ontario, -1.4% in MB & SK, -1.1% in Alberta, -2.8% in BC.

Besides, at the national level, unionized RN were paid 10.6% more than those who are not unionized. This was also the case for RNs in the comparing provinces. Wage differences between unionized and non-unionized RN were the lowest in Quebec (9.1%) and the highest in BC (24.3%).

It is important to distinguish between *market share* which refers to the level of competition within a region (as measured by the relative number of beds in a hospital) and *market size* which refers to the size of the workforce in a specific region. Market size is not directly correlated with the HI. However, it is expected that, in less populated areas, fewer hospitals exist, and consequently have higher market share.[18] The second part of table 3 presents the mean wage rates and standard deviation (in brackets) for RNs by market characteristics: market share and market size.

At the Canada level there seems to be a positive gradient between market share and hourly wage. Although this univariate result of higher wages in concentrated markets (high market share) provides evidence that superficially rejects the monopsony model, it is not compelling evidence because we need to control for other factors. Moreover, there is not a clear gradient for a number of provinces.

[18] Where market share data is not available, some use market size as a proxy.

There is not a clear gradient between market size and hourly wage. At the Canada level, there was rather a zigzag pattern with hourly wage tending to be higher in regions of size 5 and lower in regions of size 3, 4 and 6. However, the trend was slightly downwards, suggesting that hourly wage tends to decrease as market size increases; which would be superficial evidence against the monopsony model. The wage difference between the regions with the highest and lowest hourly wage was 10.2%.

At the provincial level, RNs in Quebec generally earned less than those in the other provinces. Those in Alberta earned more. There was a wage difference of about 7.0% between regions with the highest and lowest hourly wage in Quebec as well as in Ontario. This wage difference between regions was the lowest in Atlantic Canada (3.2%).

IV. Empirical Model

The dependent variable is RN hourly wage while the independent variables are the individual characteristics (education, years of experience, tenure, employment status, family status) and the regional/institutional characteristics (market share, market size). Province and union coverage were also included as independent variables. The choice of the individual variables is largely justified by the human capital theory (Becker, 1964). For the contextual variables, note that in the Canadian context, hospitals do not negotiate directly with nurses nor with the unions. Negotiations are directly between the government and unions. One would assume that the Herfindahl index is not relevant in this context. However, it is still matters since there can be targeted negotiation. Depending on the degree of hospital competition, the degree of unionization, geographical contexts and fiscal capacity, entities can negotiate higher wages in one region rather than another. An example is the special status premium for nurses in Gatineau (Quebec) during the 2007-2011 period (Le Droit, 2011) because this city shares its border with

Ottawa (Ontario), which facilitates labour mobility and increases competition. Nonetheless, one might technically argue the fact that collective bargaining is realized at the provincial level limits the variability of the observations in the six derived provinces. To circumvent this potential issue, we applied the bootstrapping technique to produce robust standard errors.

4.1. Distribution function of average hourly wage (dependent variable)

The curve for RNs average hourly wages (from the Stata Kernel distribution) reveals that the distribution is far from normal. In fact, the data show a strong positive asymmetry. Consequently, the dependent variable must be transformed to have a robust model specification and reliable parameter estimates. A logarithmic transformation formula was used (see Appendix A for details).

4.2. Formal presentation of the empirical model

In the LFS sample design, the regions are first selected and then respondents within these regions are selected. In such cases, these respondents (nurses in our case) interact with the social contexts to which they belong; this means they are influenced by these contexts / regions, which in turn are influenced by these employees. Thus, the individual observations are not completely independent, as required by the OLS estimation method.[19] The average intra-region correlation between the variables will tend to be higher than the average inter-region correlation and the standard deviations will be too low; which will lead to significant, but spurious results. *Multi-level (or hierarchical) modeling* is well suited for variables defined at different levels (individual and group). It is more robust than the two-step estimation procedure used by some authors (such as Hirsch and Schumacher 1995, 2005) because by combining the levels, the multi-level model

[19] For example, employees of a given region can be similar and very qualified because of the selection process and the availability of resources.

(MLM) prevents analysis and interpretation of variables at non-appropriate levels (Hox, 2010; Hox and Roberts, 2011).

4.2.1. The intercept-only model

A preliminary step of the MLM is to determine how the wage variance is spread over different levels. For this, we begin with the simplest model: the "intercept only model" (M0). It does not include any explanatory variables and is equivalent to an analysis of variance with random effects. Therefore, it is an unconditional model that cannot explain RN wages.

At level 1: $\ln S_{ij} = \beta_{0j} + e_{ij}$ (1)

Where:

ln S_{ij} is the natural logarithm of hourly wage for nurse *i* in region *j* (j = 1, …, 54).

β_{0j} is the intercept. This means each region has a different intercept; which represents a major difference from usual regression models.

e_{ij} represents a random error term associated with nurse *i* in region *j*. We assume $e_{ij} \sim N(0, \sigma_e^2)$, i.e. e_{ij} is normally distributed with zero mean and σ_e^2 which is the variance associated with the lowest-level errors (to be determined for each region).[20]

At level 2: $\beta_{0j} = \gamma_{00} + u_{0j}$ (2)

By substituting (2) into (1), we get the single equation:

$\ln S_{ij} = \gamma_{00} + u_{0j} + e_{ij}$ (3)

Where:

[20] Most multilevel regression software assumes that the residual variance is the same for all regions.

γ_{00} represents the mean of hourly wage (the fixed part of the model);

u_{0j} is a random error term associated with each region *j*. By hypothesis, u_{0j} is normally distributed with zero mean and σ_{u0}^2 which is the variance associated with the highest-level errors;

We assume $u_{0j} \sim N(0, \sigma_{u0}^2)$. These error terms $e_{ij}$and u_{0j} represent the stochastic part of the model and are independent components. This intercept-only model of equation (3) cannot explain any variance in *S*.

The proportion of region-level variance to the total variance is given by the correlation coefficient ρ (rho). It indicates the degree of similarity of nurses in the same region (intraclass correlation).

$$\rho = \frac{\sigma_{u0}^2}{\sigma_{u0}^2 + \sigma_e^2} \quad (4)$$

In the presence of hierarchical data, the standard errors of the fixed coefficients from the OLS model are biased downward. The higher the ρ value, the greater the bias is. For a ρ value greater than 5%, it is generally recommended to use the multilevel models, especially when one is interested in the variance components (Bressoux, 2010).[21]

To demonstrate whether it is appropriate to use the multilevel model, we use the LFS data and found that 10.1% of the variance of the average wage for RNs is explained at the region level; which is high enough to use the multilevel model (see Table B in Appendix B for details).

4.2.2. The variables at the individual level

In the first stage of the MLM, it is necessary to introduce variables at the individual level only in

[21] Procedures such as generalized least squares (GLS) produce unbiased estimates standard errors as they can correct the loss of degrees of freedom due to the intra-class correlation (Kreft, 1996). However, they do not permit variance breakdown.

order to be able to explain RN wage differences *within* a region. Therefore, employees represent the unit of analysis in this smaller level. The equation for this model (M1) takes the following form:

$$\ln S_{ij} = \beta_{0j} + \sum \beta_{kj} X_{ij} + e_{ij} \quad (5)$$

Where *ln* S_{ij}, β_{0j} and e_{ij} are defined as in 3.2.1 in the intercept-only model.

X_{ij} includes variables related to the individual characteristics of RN_i belonging to region *j*. These variables affect RN wages and have β_{kj} coefficients (slopes associated with each first-level explanatory variable k; i.e. k = 1, ..., n, where (n) is the number of first level explanatory variables). It is assumed that these coefficients are different for each region, unlike the usual regression models. In this model, these variables at the individual level, also known as global variables (X_i) include: number of years of experience and its square,[22] tenure, employment status (full time versus part-time). [23] We also include province and union status at this first level.[24]

Using the names of the first level variables, we obtain:

$$\ln S_{ij} = \beta_{0j} + \beta_{1j} Educ_{ij} + \beta_{2j} Exp_{ij} + \beta_{3j} Exp_{ij}^2 + \beta_{4j} Tenure_{ij} + \beta_{5j} Empl\_status_{ij} + \beta_{6j} Fam\_status + \beta_{7j} Union_{ij} + \beta_{8j} Prov_{ij} + e_{ij} \quad (5')$$

These variables were previously defined. It should be added:

Empl_status is an auxiliary variable equal to 1 for full-time employment and 0 otherwise; i.e. RNs working part-time is the reference group.

[22] Wage can be a nonlinear function of the number of years of experience; hence we have also included the square of years of experience.
[23] Note that mobility of nurses cannot be taken into account because we do not have longitudinal data in the LFS.
[24] In principle, all variables that vary between regions and labour markets are excluded in the first step. However, we cannot add too many variables in the second step. So there is a trade-off.

Union is an auxiliary variable equal to 1 for unionized RNs and 0 otherwise; i.e. non-unionized RNs is the reference group.

Prov is a categorical variable (equal to 1 for Ontario, 2 for the Atlantic Provinces, 3 for Quebec, 4 for MB & SK, 5 for Alberta and 6 for BC).

The coefficients associated with *education level*, *years of experience*, *tenure* and *union coverage (among the γ_{10})* should be positive: hourly wages should increase with the level of education, with the number of years of experience, with tenure and with the fact of being covered by a union. Moreover, wages are expected to be higher in Alberta and lower in Quebec relative to Ontario.

4.2.3. The variables at the regional or contextual level

The second stage in this hierarchical model is to explain variation in the regression coefficients β_{0j} and β_{kj} by introducing regional or contextual variables. In other words, we examine whether the wage differences between RNs estimated in the first stage (the β_{kj}) change systematically according to the characteristics of the markets or regions (i.e. we introduce variables that change *between* regions but not within the region). So labour markets are the unit of analysis in this second stage. More particularly, the equations of this model (M2) are introduced as follows:

$$\beta_{0j} = \gamma_{00} + \gamma_{01} HI_j + \gamma_{02} Size_j + u_{0j} \qquad (6)$$

and

$$\beta_{kj} = \gamma_{10} + \gamma_{1k} HI_j + \gamma_{2k} Size_j + u_{kj} \qquad (7)$$

Where:

γ_{00} and γ_{10} are intercepts;

HI_j is the Herfindahl Index of region *j*; with coefficients γ_{01} and γ_{1k}

$Size_j$ (Market size based on peer-regions) are categorical variables representing the six demographic sizes defined in section 2.2. Size 1 (rural area with less than 150.000 workers) being the reference size to omit.

The first subscript in the gammas represents the order of the variable at level 1 and the second indicates the order of the variable at level 2. The *HI* is the cornerstone of the study. Thus, if only one variable needs to be introduced at level 2, the *HI* is the natural candidate.

However, *market size* is also included as a variable in the second level because wages are expected to increase with market size. This could be explained by the monopsony theory and/or higher cost of living in urban areas. Consequently, we include both the *HI* and *market size* as second level variables for testing the monopsony model.

By hypothesis, in equations (6) and (7), the regression coefficients (gamma) do not vary between regions. Therefore, they do not carry any *j* index indicating to which region they belong. Being applied to all regions, they are designated as *fixed coefficients*. Any inter-region variation that still exists in these coefficients after they were estimated with the contextual variables is interpreted as the variation of the error terms. Therefore, the gammas are the *fixed part* of the model.

u_{0j} and u_{kj} are the random errors at the contextual level. They are specific to each region, with variance σ^2_{u0} *and* σ^2_{uk} respectively. The covariance between u_{0j} and u_{kj} is σ_{u0k} for $k \neq 0$. It is generally assumed to be non-zero.

It is expected that the coefficient γ_{01} for the *Herfindahl index* to be negative: a high index (monopsony indicator) will produce a low hourly wage for RNs. The coefficient γ_{02} *for Size* should be positive: large (urban) market will pay higher hourly wage for RNs.

4.2.4. The main effect multi-level model

Equations (6) and (7) can be included in equation (5) to produce one single equation, generating the full multi-level model.

$$lnS_{ij} = \gamma_{00} + \gamma_{01}HI_j + \gamma_{02}Size_j + u_{0j} + \gamma_{10}X_{kij} + \gamma_{1k}HI_jX_{kij} + \gamma_{2k}Size_jX_{kij} + u_{kj}X_{kij+} + e_{ij} \quad (8)$$

Notes:

1. We used the contextual variable names, but not the individual variable names. If we had used the latter, the equation would be more complicated to write.
2. Below, we rearrange the equation terms to show the deterministic (fixed) and stochastic parts of the model.

$$lnS_{ij} = \gamma_{00} + \gamma_{01}HI_j + \gamma_{02}Size_j + \gamma_{10}X_{kij} + \gamma_{1k}HI_jX_{kij} + \gamma_{2k}Size_jX_{kij} + (u_{0j} + u_{kj}X_{kij+} + e_{ij}) \quad (8')$$

This equation suggests, from the interaction terms $\gamma_{1k}HI_jX_{kij}$ and $\gamma_{2k}Size_jX_{kij}$ that the relationship between hourly wages and the individual variables depends on the level of market share and market size.

V. Results and interpretation

We reproduce in the last column of table 4 the results for the multi-level model with the best fit: the model with individual and contextual variables, and random coefficient, but without interaction (M3). Additionally, results for the intercept-only model (M0), the model with only the individual variables (M1) and the model with the individual and contextual variables (M2)

are also provided. Results for M3 are discussed below. As previously mentioned, the bootstrapping technique was applied to produce robust standard errors.[25] Some estimates that were significant without the bootstrapping become non-significant or marginally significant with the bootstrapping.

The coefficients are estimated with a high degree of precision. The Wald test generated a chi-squared value of 2,145 as well as the associated p-value. This permits us to test the null hypothesis that the coefficients for the independent variables are simultaneously equal to zero. Based on the p-value (Prob. > chi-squared = 0.000), we are able to reject the null hypothesis, meaning that including these variables create a statistically significant improvement in the fit of the model.

The coefficient for the main independent variable (*HI*) has large standard error (twice the value of the coefficient) and p-value of 0.60; therefore, it is not significant. The monopsony model predicts that this coefficient should be negative and increasing; that is, the lowest wage rate when hospital market share is high and increasing wage as market share decreases. Putting in another way, the model predicts lowest wage rate in markets with low level of competition and increasing wage as level of competition increases.[26] Thus, *based on market share, our finding suggests there is no monopsony in the RN labour market*.

The monopsony model also leads to the prediction that the coefficient on market size should be positive and increasing; that is, the lowest wage rates in the non-urban markets and increasing wages as market size increases. The coefficients for *market size* (*regions)* were not significant

[25] Random sampling with 50 replications based on 54 clusters was performed for M2, M3 and M4.
[26] Putting this way, the model predicts a positive relation between wage rate and level of competition.

either (p-value of 0.52). Therefore, based on market size, we found no support either for the monopsony in the RN labour market.[27]

The deviance decreases significantly when we introduce the level 1 predictors, and very slightly with the level 2 predictors. It declines a bit more with the random coefficient model (M3). However, the deviance increases in the subsequent model with cross-level interaction (M4, see Table C in appendix C), which leads to conclude that M3 offers a better fit than any other model. Given our hypothesis that unionisation counteracts employer concentration, it is natural to add the interaction term *HI x union* in the model. However, because *HI* is not significant, adding this interaction penalizes the model and did not produce the best fit.[28,29]

The intercept of 2.98 could be interpreted as a baseline for RN hourly wage. The fitted hourly wage is obtained by reversing the logarithmic function (See Appendix A); which gives a baseline wage of \$19.70 per hour ($e^{2.98}$).

An analysis of the coefficients of the control variables provide some additional insights. Looking at the first level variables, the coefficient for *education* is positive and significant: RNs with a Bachelor degree earns 6.0% more per hour than those with a community college or CEGEP. Likewise, the coefficient associated with *years of experience* is positive and significant: For each year of experience, hourly wage increased by 1.5%. But, this variable is entered as a quadratic one, meaning that the effect is non-linear and depends on what level of experience the RN has. *Squared years of experience* is negative (the expected sign) and also significant. Its coefficient

[27] The variable *unemployment rate* was tested in an alternative model and was also not significant (not shown in this paper).
[28] The REML (restricted multi-level) models produce about the same results as the FML. However, the deviance is lower in the FML. Results from the REML are available upon request.
[29] It should be noted that in the random part, there is no difference between the asymptotic estimate for the 2nd level variable and the final bias-corrected (bootstrap) estimate (0.0108). It is as an indication that there is no bias in the second-level variance estimate.

suggests that wages for RNs are maximized after 25 years of experience.[30] Likewise, the coefficient for *union status* is positive and significant: unionized RNs earned 18.4% more per hour than those who are non-unionized. This confirms our hypothesis of a positive correlation between hourly wage and level of education, experience, being unionised.

Besides, even though the coefficient for tenure is weak, it is still positive and significant, as expected. Coefficient for *employment status* is negative: hourly wage for RNs who works full-time was 1.3% less than for those who work part-time. However, the coefficient is marginally significant when bootstrapping is applied ($p < 0.08$). Notwithstanding, it has the expected sign, in line with Zeytinoglu et al. (2006) who report that part-time nurses received no benefits, but had an additional adjustment in their hourly wage.[31]

The *family status* seems to matter to some extent. RNs with no spouse/no kid earn 4.6% less per hour than those with spouse/kid(s), with $p < 0.05$. The coefficients also show an upward gradient: no spouse/no kids, spouse/no kids, spouse/kids and no spouse/kids. Nonetheless, there was only a marginal statistical significance in hourly wage between RNs with spouse/kid(s) and those with spouse/no kid(s) or those with no spouse/kid(s). These results suggest that RNs with no spouse/no kid(s) tend to earn less than those from any other family status.

The regression results suggest also that some differences exist between provinces. RNs in AC and Quebec were paid respectively 9.7% and 19.8% less per hour than those in Ontario. However, the coefficient for AC was marginally significant while that for Quebec was strongly

[30] *dlnS/dExp* = 0.01509 -2(0.0003)Exp. First order condition: max = 0 = 0.01509 -2(0.0003)Exp. So, 0.0164 = 2(0.0003)Exp and Exp = 0.01509/0.0006 = 25.2 years.
[31] Data for this study come from a survey of 1,396 nurses employed in three teaching hospitals in Southern Ontario.

significant. Wage per hour for RNs in MB & SK, Alberta and BC was not statistically different from that for RNs in Ontario.[32]

[32] It should be noted that the coefficient for Alberta was statistically significant in M2 (level 1 and 2 predictors, without random coefficient).

Table 4: Successive Models for RN Hourly Wage: Intercept Only, Level 1, Level 2 Predictors and Random Coefficient (N =18,368)

Model	Intercept only (M0)	Level 1 predictors (M1)	Level 1 and 2 predictors, (M2)	Level 1 and 2 pred, with random coefficient (M3)
Fixed part		(p value)	(p value)	(p value)
Intercept	3.49	3.27	3.27	2.98
Education (Ref = Comm. college/CEGEP)		0.0597*	0.0597*	0.0599*
Years of exp.		0.0151*	0.0151*	0.0152*
Squared years of exp.		-0.0003*	-0.0003*	-0.0003*
Tenure		0.0025*	0.0025*	0.0024*
Employm. Status (Ref = Part-time)		-0.0125*	-0.0125 (0.11)	-0.0129 (0.08)
FS – Spouse, no kid (Ref = S&K)		-0.0167*	-0.0167 (0.11)	-0.0174 (0.10)
FS – No spouse, with kid (Ref = S&K)		0.0163 (0.10)	0.0163 (0.26)	0.0134 (0.38)
FS – No spouse, no Kid (Ref = S&K)		-0.0446*	-0.0447*	-0.0462*
Spouse hourly wage		0.0008*	0.0008*	0.0008*
Union Status (Ref = Non-unionized)		0.1838*	0.1838*	0.1839*
Atlantic Provinces (Ref = ON)		-0.0959*	-0.0925*	-0.0975 (0.10)
Province of QC (Ref = ON)		-0.1981*	-0.1979*	-0.1983*
Provinces of MB & SK (Ref = ON)		0.0193 (0.22)	0.0245 (0.21)	-0.0122 (0.87)
Province of AB (Ref = ON)		0.0508*	0.0539*	0.0407 (0.62)
Province of BC (Ref = ON)		-0.0200 (0.23)	-0.0159 (0.14)	-0.0051 (0.92)
Market Share (HI)			0.0229 (0.48)	0.0575 (0.60)
Market Size (Region)			0.0007 (0.89)	0.0110 (0.52)
Random part		(SE)	(Bootstrap SE)	(Bootstrap SE)
Level 1 variance (σ_e^2)	0.0725	0.0625 (0.0006)	0.0625 (0.0026)	0.0614 (0.0026)
Level 2 variance (σ_{uo}^2)	0.0082	0.0010 (0.0002)	0.0010 (0.0004)	0.0108 (0.0028)
Random effect for union (σ_{u8}^2)				0.0146 (0.0040)
Deviance[+]	4,588.2	1,302.1	1,300.9	1,187.9

*: Significant at the 5% level.

+: The deviance is a measure of the model misfit. It is given by the formula *-2*LogLikelihood*. In general, models with a lower deviance fit better than models with a higher deviance.

FS = Family status; S&K = Spouse and kid.

VI. General Discussion and Study Limitations

6.1. General Discussion

As discussed in the introduction, recent studies do not tend to support the monopsony model in nurse labour market (Adamache and Sloan, 1982; Hirsch and Schumacher 1995, 2005). Consequently, the finding of this current study is in line with recent empirical advances in monopsony models of nurses' labour market.

It should be noted that there is another approach to test for monopsony market. It seeks to explicitly estimate the elasticity or the inverse elasticity of labour supply in a given hospital. It uses an index based on prices or wages, as the Lerner index. The latter considers the difference between wages and marginal cost as a measure of the degree of monopsony. In fact, in a competitive market, the wage equals the marginal cost while a monopsony employer equalizes the marginal revenue product to the marginal cost. Hirsch and Schumacher (1995) argue "*an important limitation of this approach is that the presence of an upward sloping labour supply curve is necessary but not sufficient evidence of a monopsonistic outcome. Rather, wage and employment outcomes predicted by the monopsony model must be directly tested*." More recently, this elasticity-based approach was used by Staiger et al. (2010) in a natural experiment: an exogenous change in nurse wages at Department of Veterans Affairs (VA) hospitals. They found evidence for the monopsony model. However, this may be due to the fact that VA hospitals are highly differentiated workplaces. This elasticity-based approach is not used in this current study.

Some differences were found for RN wage rates for some provinces. It should be noted that this does not account for differences in cost of living (COL) between provinces. Quebec generally has a lower COL than the rest of Canada. For example, an approximation by Kozhaya (2006) for

Montreal Economic Institute shows that the cost of living in Ontario is about 12% higher than that in Quebec.

Taking account of this difference, the negative gap between the GDP per inhabitant in Quebec and the Canadian average drops from 13% to 6%, while the gap with Ontario falls from 16% to only 4%, leaving Ontario at only a slight advantage. Kozhaya (2006, p. 2).

Similarly, information from Economic Development Winnipeg (2015) shows that basic household costs were lower in Quebec than in any other province.[33] If the COL were accounted for, the hourly wage gap of Quebec RNs relative to Ontario would drop. However, this dimension is out of scope of this study.

The finding suggest that RNs with *no spouse/with kids* earns relatively the highest hourly wage. These nurses may have an incentive to take on higher paid or more challenging jobs (such as jobs in operating rooms or intensive care units) since being the only provider, they have to make more money to care for their family. This finding aligns somewhat with Zeytinoglu et al. (2006) who report that nurses are less inclined to leave the profession as the importance of their earnings for the family increases.

6.2. Study Limitations

Nurse wages are from survey data and not from administrative data; which could raise question about reliability and sampling error. To reduce potential bias due to small sample size, we have pooled the data, using three-year data. Moreover, triangulation of RN wages from the LFS with data from the Census and Canadian Federation of Nurses Union shows a large degree of

[33] Basic household costs in Manitoba were the second or third lowest, depending on the family structure.

compatibility (Ariste and Béjaoui, 2015). Therefore, the fact that these results are based on self-reported wages is not a concern.

Another possible limitation is that the MLM might not be the best empirical model for these data. The intra-class correlation was not substantially high (10.1%) while the threshold to use the MLM is > 5%).[34] Besides, with the high unionisation rate in nursing labour market in the public sector, wage variation tends to be limited. We have attempted to address this issue by bootstrapping the estimates.

VII. Conclusion

The use of monopsony power in nursing labour markets is appealing to explain reported shortages of RNs, particularly in Canada where collective bargaining is done through provincial health ministries. This study uses the confidential microdata file from Statistics Canada LFS and data from administrative sources (the CMDB managed by CIHI) in order to examine the relation between RNs hourly wages and hospital market share. The LFS data were pooled for the period 2010-2012 to have meaningful sample size in each region. Market shares were constructed based on the number of beds in a given hospital and region. Labour markets were defined according to nurse employment location in one of the 54 regions. These regions were regrouped into six peer-regions (market sizes), based on the number of their workforce. Multilevel analysis was applied to properly distinguish control variables at the individual level and institutional level. We found no support for the monopsony theory, whether with respect to market share or market size. Contrary to predictions of this theory which stipulates that RNs wages should 1) decline as market share increases and 2) increase with labour market size, our findings for Canada suggest

[34] Moreover, comparing RNs with a control group (such as women teaching in elementary school) is challenging with the MLM because other professional categories cannot be assigned to a hospital and have a HI. Therefore, it is difficult to perform simultaneously the multi-level estimation and comparison with a control group.

that RNs wages are not related either to market share or market size. They are in line with previous studies that tested directly RNs wages and employment outcomes (Adamache and Sloan, 1982; Hirsch and Schumacher, 1995, 2005). Some other studies have found evidence of monopsony in nurse labour market, mostly for the US. However, they either did not account for union presence (Hurd, 1973) or use an upward sloping labour supply curve as evidence of monopsony (Staiger et al, 2010); which is a necessary, but not sufficient condition. Our finding suggests that the periodically perceived shortage in nursing labour market cannot be explained by the presence of monopsony. Even though a relatively large literature on the effect of monopsony power on wages in the nursing labour market exists, such studies are scant in Canada. Further studies are needed to test for other implications from the monopsony model, such as elasticity estimate of the labour supply for Canadian nurses.

Appendices

Appendix A: Transformation function for hourly wage

The distribution function for average hourly wages for RN (from the Stata Kernel distribution) reveals that the distribution is far from normal. In fact, the data show a strong positive asymmetry.

A.1. Choice of the transformation function

The dependent variable must be transformed to correct the skewness and have a robust model specification and reliable parameter estimates. The Box-Cox procedure (Neter et al, 1996) automatically identifies a form from the family of the power transformation as follows:

$$Y' = Y^{\lambda}, \text{ and } Y' = \ln(Y)$$

Where: λ is a parameter to be determined from the data. The best transformation is found using the Stata command (*qladder* salaire). The best approximation function is the one that follows closely a unit slope line; in this case the logarithmic function

$$Transformed\ Wage = ln(Wage)$$

Besides, natural logarithm (base e)[35] transformation is often used in empirical studies (OECD, 2008).

A residual analysis (*predict resid* in Stata) was used to assess the model relevance via analysis of variance (ANOVA). From the distribution function of all residues (*kdensity resid* - Kernel density), the normality of the error terms has been verified; which means that the problem of asymmetry (skewness) is much less pronounced.

[35] The ln function (base e) is easier to interpret than the log function (base 10). With the ln function, the coefficients obtained are directly interpreted as growth rates.

A.2. Re-transformation of hourly wage to the original scale

During a transformation from the logarithmic scale (where the distribution is normal) to the original scale of a log-normal distribution, an adjustment is necessary in order to preserve the mean. Thus, the estimated wage is obtained by inverting the logarithmic transformation of wages using the following formula (Neter et al, 1996):

$$\widehat{S} = e^{\widehat{lnS}} + {}^{1}/_{2}\,\delta^{2}$$

Where: $\widehat{S}$ is the estimated wage; e is the power function; $\widehat{\text{lnS}}$ is the estimated logarithm of wage and δ^2 is half the mean of the square error (the adjustment ${}^{1}/_{2}\,\delta^{2}$ is needed to ensure the transformation preserve the mean).

With this transformation, the interpretation of the results becomes more challenging. We are in the presence of a semi-log specification and the standard interpretation of the regression coefficients does not apply. These coefficients rather represent changes in percentage of wage following a one unit increase of the independent variables.

Appendix B: Relevance of using the multi-level model

To determine whether it is appropriate to use the multilevel model, we applied the intercept-only model on the RN data and found the following estimates.

Table B: Estimating the variance of the error terms at level 1 and 2 (intercept-only model)

Performing EM optimization:

Performing gradient-based optimization:

Iteration 0: log likelihood = -2294.1052

Iteration 1: log likelihood = -2294.1052

Computing standard errors:

Mixed-effects ML regression Number of obs = 18,368

Group variable: uirtab Number of groups = 54

Wald chi2(0) = .

Log likelihood = -2294.1052 Prob > chi2 = .

ln_hrlyearn2	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
_cons	3.485714	.0124921	279.03	0.000	3.46123	3.510198

Random-effects Parameters	Estimate	Std. Err.	[95% Conf. Interval]	
uirtab: Identity				
var(_cons)	.0081797	.0016312	.0055334	.0120916
var(Residual)	.0724591	.0007149	.0710714	.073874

LR test vs. linear model: chibar2(01) = 1658.00 Prob >= chibar2 = 0.0000

Note that *var(residual)* represents the variance of the first level error terms and *var(_cons)* is the variance of the second level error terms. Consequently, we find the correlation coefficient by applying the formula in equation 4:

$$\rho = \frac{0.00818}{0.08064} = 10.1\%$$

This means that 10.1% of the variance of RN hourly wage can be explained at the regional or contextual level; which is high enough to justify the use of the multi-level model.

Appendix C: Random Coefficient and Main Effect Multi-Level Models for RN Hourly Wage

Table C: Main Effect Multi-Level (M4) Models for RN Hourly Wage, Canada, 2010 to 2012

Model	Cross-level interaction (M4)	
Fixed part		(p value)
Intercept	3.08	
Education (Ref = Comm. college/CEGEP)	0.0598*	
Years of exp.	0.0152*	
Squared years of exp.	-0.0003*	
Tenure	0.0024*	
Employm. Status (Ref = Part-time)	-0.0130	(0.08)
FS – Spouse, no kid (Ref = S&K)	-0.0174	(0.10)
FS – No spouse, with kid (Ref = S&K)	0.0134	(0.38)
FS – No spouse, no Kid (Ref = S&K)	-0.0463*	
Spouse hourly wage	0.0008*	
Union Status (Ref = Non-unionized)	0.1791*	
Atlantic Provinces (Ref = ON)	-0.0833	(0.17)
Province of QC (Ref = ON)	-0.1898*	
Provinces of MB & SK (Ref = ON)	0.0100	(0.89)
Province of AB (Ref = ON)	0.0214	(0.79)
Province of BC (Ref = ON)	-0.0100	(0.85)
Market Share (HI)	- 0.0060	(0.96)
Market Size (Region)	0.0054	(0.75)
HI x Union	0.0492	(0.59)
Random part		(Bootstrap SE)
Level 1 variance (σ_e^2)	0.0614	(0.0026)
Level 2 variance (σ_{uo}^2)	0.0116	(0.0032)
Random effect for union (σ_{u8}^2)	0.0147	(0.0041)
Deviance	1,190.1	

*: Significant at the 5% level.

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