Minimum Wages and the Joint Distribution Employment and Wages*

Thomas Lemieux
University of British Columbia and NBER

October 2011

Abstract

This paper proposes a new procedure to jointly estimate the effect of the minimum wage on the distribution of wages and employment. The proposed approach offers a common framework for modelling the effect of the minimum wage on both employment and the distribution of wages using distribution regressions. Using Canadian data from 1997-2010, I find that for teenagers, increases in the minimum wages "pushes up" a large fraction of workers to the new minimum wage, but also yields some modest employment losses. There are no discernable impacts of the minimum wage for young adults.

* I would like to thank the Social Science and Humanities Research Council of Canada for financial support.

1. Introduction

Estimating the effect of changes in the minimum wage on employment is one of the most extensively studied issues in labor economics. Most recent studies use a difference-in-difference research design to link state- or province-specific changes in the minimum wage to changes in employment or unemployment. This approach has long been used in Canada where minimum wages are set at the provincial level. A similar research design has also been increasingly used in the United States since state minimum wages have frequently exceeded the value of the federal minimum wage over the last two decades.

As is well known, difference-in-differences estimates rely on the strong assumption that absent changes in the minimum wage, employment would have changed by the same amount in each jurisdiction. Existing Canadian studies have all relied on this assumption, but recent US studies show that it appears to be violated in actual data. For instance, Allegretto, Dube, and Reich (2011) show that difference-in-differences estimates of employment effects of the minimum wage for teenagers are not robust to the inclusion of state-specific trends. Likewise, Dube, Reich, and Lester (2010) also find that disemployment effects of the minimum wage disappear when an arguably better control group (contiguous counties in other states) is used as counterfactual in the estimation.

Another important way of assessing the validity of the difference-in-differences design is to look at the “first-stage” impact of minimum wages on the average wage in the jurisdiction. It is very likely that statistically significant employment effects are spurious unless there is also a “strong” effect of the minimum wage on average wages. A first contribution of the paper is to show such “first-stage” estimates for Canada, something existing studies have failed to do because of the lack of good and consistent micro-data on wages (and employment) until recent years.

But while looking at the effect of the minimum wage on average wages is an important check to be performed when studying the connection between minimum wages and employment, focusing on the average only represents a very coarse representation of how the minimum wage affects the wage distribution. Indeed, DiNardo, Fortin, and Lemieux (1996), Lee (1999), and Autor, Manning, and Smith (2009) all show that the effect of the minimum wage is concentrated at the bottom end of the distribution, with some limited spillover effects above the minimum wage, but no noticeable impact for higher wage values. Accordingly, one would expect most employment effects to be concentrated among low-wage workers earning about the minimum wage, and essentially no employment impact among high-wage workers.

The main contribution of this paper is to propose a distribution regression approach to estimate the joint effect of the minimum wage on the distribution of wages and employment at different points of the wage distribution. Unlike most of the literature on the distributional effects of the minimum wage that has focused on its impact on different quantiles of the wage distribution, here I model the impact of the minimum wage on the proportion of the population earning at least a certain wage. When the wage is very low, this proportion is simply the fraction of individuals employed in the population. As such, the proposed approach nests the standard difference-in-differences design that only focuses on this simple proportion, at opposed to a family of proportions computed for each wage level.

The proposed approach has several advantages relative to the existing literature. First, it provides an additional way of testing the validity of the difference-in-differences design. In particular, since the minimum wage should have little impact at the top end of the wage distribution, it should not affect the proportion of the population earning above a relatively high wage level. Finding an effect of the minimum wage on that proportion would likely suggest a spurious correlation between the minimum wage and other unmodelled labor market factors (macro shocks, other regulations, etc.).

Second, the proposed approach can be used to test the predictions of different models that have been proposed to understand the impact of the minimum wage on wages and employment. For instance, it is possible to distinguish the case where all individuals with a latent wage below the minimum wage lose their jobs, from one with labor market imperfections where most of these individuals end up earning exactly the minimum wage, which generates a spike in the wage distribution.

Third, the approach provides a richer description of what happens to both wages and employment at different points of the wage distribution. This helps better assess the welfare consequences of the minimum wage by showing which groups benefit from higher wages, and which groups may suffer in terms of employment losses.

The proposed approach is applied to the case of Canada for the years 1997 to 2010. Canada provides a useful setting for looking at the impact of the minimum wage on wages and employment since the minimum wage has always been set (with a few exceptions) at the provincial level. This feature of the Canadian labor market suggests using a difference-in-differences approach. Not surprisingly, most existing studies have used this research design to estimate the employment impact of the minimum wages (see, e.g., Grenier and Séguin, 1991, Baker, Benjamin, and Stanger, 1999, Campolieti, Fang, and Gunderson, 2005, and Campolieti, Gunderson, and Riddell, 2006).

One innovation of this paper is to use detailed wage data from the Labour Force Survey (LFS) that has been collected for the incoming rotation group since January 1997. The LFS wage data are very similar to the data collected in the outgoing rotation group of the Current Population Survey (CPS) that has been used extensively in U.S. minimum wage studies. With wage data from the LFS available for almost fifteen years, it is now possible to estimate a "first-stage" equation for Canada showing the direct impact the minimum wage on average wages to assess the validity of the difference-in-differences design. More importantly, the rich wage data combined with the large variation in minimum wages over provinces and time provides an ideal setting for implementing the distribution regression approach suggested in this paper.

Interestingly, the average minimum wages (across provinces) in Canada is now at its highest level (relative to manufacturing wages) since the late 1970s (see Appendix Figure A1). As a result, existing studies based on older data may only provide limited guidance on the potential impact of the minimum wage in 2011. One timely contribution of the paper is thus to analyze the impact of the minimum wage on wages and employment in the current era of relatively high minimum wages.

The rest of the paper proceeds as follows. Section 2 presents the distribution regression approach I use to model the joint distribution of wages and employment. It also shows how this approach can be used to test the predictions from various models. Section 3 describes the data and the institutional setting. Section 4 presents standard difference-in-differences estimates of the impact to the minimum wage on employment and wages for teenagers and young adults. Section 5 presents the main results estimated using distribution regressions, and Section 6 concludes the paper.

2. Distribution Regression Approach

2a. Distributional effects of changes in the minimum wage

The econometric approach used in this paper can be motivated using a few examples. Consider a situation where, in absence of a minimum wage, *i)* a fraction p of the population is employed, and *ii)* the distribution of wages among workers follows a (normal) bell shape distribution illustrated in Figure 1a. Figure 1b summarizes the information about the probability of working and the probability of earning a wage rate of at least w, conditional on working. Strictly speaking, Figure 1b is the survivor function (one minus the CDF, i.e. 1-F(w)) rescaled for the proportion of individuals working (p), which is set to 0.7 in this particular example.

Consider what happens when a minimum wage W_m is introduced. In Figure 1, I consider the extreme example where all workers whose wage in absence of a minimum wage is lower than W_m lose their job when the minimum wage is introduced. In this particular setting, the bell shaped distribution in Figure 1a represents the distribution of latent wages, W^*. Workers with a latent wage above W_m are paid the latent wage, while workers with a latent wage under W_m lose their job.

To simplify things assume that, in absence of a minimum wage, the work decision is random and all individuals face the same probability p of being employed. The wage and employment determination is thus characterized as follows:

Employed at $W = W^*$ with probability p if $W^* \geq W_m$

Not employed with probability 1-p if $W^* \geq W_m$

Not employed if $W^* < W_m$

It follows that the rescaled survivor function RS(w) is given by:

$RS(w) = p(1-F(W_m))$ if $w \leq W_m$, and

$RS(w) = p(1-F(w))$ if $w > W_m$.

where F(.) is the CDF of latent wages. This "truncation" model is represented graphically in Figures 1a and 1b for two values of the minimum wage, $W_m = 4$ and $W_m = 5$. In Figure 1a, employment losses due to the introduction of a minimum wage of 4 is captured by the shaded area under the density of latent wages to the left of $W_m = 4$. The additional employment loss linked to a further increase of the minimum wage to 5 is the other shaded area underneath the density (between $W_m = 4$ and $W_m = 5$).

Figure 1b shows what happens to the rescaled survivor function when a minimum wage is introduced. Since there are no longer any wage observations below the minimum wage, the rescaled survivor function is flat (at RS(w) = p(1-F(W_m))) for all wage values below W_m. For values of w above the minimum wage, RS(w) is the same as in the absence of a minimum wage.

Increasing the minimum wage from 4 to 5 first reduces the rescaled survivor from p(1-F(4)) to p(1-F(5))). For wage values between 4 and 5, the effect on employment gets progressively smaller and reaches zero for $w \geq 5$. More generally, the effect of raising the minimum wage from W_m to W_m' on the rescaled survivor function is equal to:

$$p(1-F(W_m')) - p(1-F(W_m))) = p(F(W_m) - F(W_m')) < 0 \quad \text{if } w \leq W_m, \tag{1a}$$
$$p(1-F(W_m')) - p(1-F(w))) = p(F(w) - F(W_m')) < 0 \quad \text{if } W_m < w \leq W_m', \tag{1b}$$
$$0 \quad \text{if } w > W_m'. \tag{1c}$$

This simple model has some strong implications for how changes in the minimum wage affect the employment at different point of the distribution. For low values of wages W_0 that fall below all observed values of the minimum wage, the rescaled survivor function p(1-F(W_0)) is the overall employment rate in the labor market. So equation (1a) provides the traditional employment effect of the minimum wage.

At the other end of the spectrum, equation (1c) indicates that the fraction of the population that is employed and earns a wage above the higher value of the minimum wage (W_m') should not be affected by an increase in the minimum wage. Finally, for wages between the lower and higher values of the minimum wage, equation (1b) shows that the effect of the minimum wage should be negative but smaller (in absolute terms) than the overall employment effect shown in equation (1a).

The pure truncation model presented in Figure 1 is clearly too extreme. Many studies such as DiNardo, Fortin, and Lemieux (1996) have shown clear visual evidence of a spike in the wage distribution right at the value of the minimum wage. This suggests that some of the workers with a latent wage W^* lower than the minimum wage W_m end up earning exactly W_m instead of losing their job. In the extreme version of this "spike" model presented in Figure 2, all workers with a latent wage smaller than W_m end up earning exactly W_m.

Figure 2a shows that in this pure "spike" model, all workers who would have lost their job in the truncation model end up at a mass point corresponding to the value of the minimum wage. The mass point generates a discontinuous drop in the rescaled survivor function at the values of the minimum wage featured in Figure 2b ($W_m = 4$ and 5). As in the case of the truncation model, the rescaled survivor is flat until we reach the value of the minimum wage, since no workers earn less than the minimum. The difference is that there is no disemployment effect, which means that the rescaled survivor function unless drops down once the wage exceeds the value of the minimum wage.

Using the same procedure as before, we now get a very different effect of raising the minimum wage from W_m to W_m' on the rescaled survivor function:

0	if $w \leq W_m$,	(2a)
$p(1-F(0)) - p(1-F(w))) = pF(w) > 0$	if $W_m < w \leq W_m'$,	(2b)
0	if $w > W_m'$.	(2c)

The fact that an increase in the minimum wage has no impact for low values of the wage is another way of restating that there are not disemployment effects in the "spike" model. For values between the lower and higher minimum wages (equation 2b), the effect is positive, reflecting the fact that increasing the minimum wage pushes up workers with lower latent wages all the way to the value of the minimum wage. As before, the minimum wage has no effect at the top end of the distribution (equation 2c) since wages, and thus employment probabilities are unaffected in that part of the distribution.

Since assuming away any employment effect may be unrealistic, Figure 3 illustrates an "in-between" case where there is both a spike and some negative employment effects. In terms of the rescaled survivor function, we get that as in the case of the truncation model, the rescaled survivor decreases in response to an increase in the minimum wage for wages $w \leq W_m$. But as in the case of the pure spike model, the effect turns positive when $W_m < w \leq W_m'$. As before, there is no impact on the rescaled survivor for values of the wage above W_m .

Finally, both Lee (1999) and Autor, Manning, and Smith (2009) show some evidence of spillover effects of the minimum wage. This is captured in Figure 4 where the minimum wage also has a positive impact on the value of the rescaled survivor just above the minimum wage. As long as spillovers are limited in the sense that they don't affect the whole upper tail of the wage distribution, we would expect a positive effect on the rescaled survivor for values of the wage just above the minimum wage, but no effect further up the distribution.

2b. Empirical implementation

The empirical analog of the rescaled survivor function is obtained by computing the fraction of individuals in province *p* at time *t* who are employed and earn a wage of at least *w*:

$$\mathrm{RS}_{\mathrm{pt}}(w) = (1/\mathrm{N}_{\mathrm{pt}})\ \Sigma_{\mathrm{i}}\ 1(E_{ipt} = 1 \text{ and } W_{ipt} \geq w), \qquad (3)$$

where E_{ipt} is a dummy indicator for employment of individual *i* in province *p* at time *t*, N_{pt} is the number of observations, W_{ipt} is the observed wage rate, and 1(.) is the indicator function.

The effect of the minimum wage can then be estimated by running the (second-step) distribution regression:

$$\mathrm{RS}_{\mathrm{pt}}(w) = \mathrm{f}(\mathrm{W}_{\mathrm{m,pt}}, \mathrm{w}) + \delta_{\mathrm{p}}(\mathrm{w}) + \gamma_{\mathrm{t}}(\mathrm{w}) + \beta(\mathrm{w})\mathrm{X}_{\mathrm{pt}} + \varepsilon_{\mathrm{pt}}(\mathrm{w}), \qquad (4)$$

or a version of the equation where $\mathrm{RS}_{\mathrm{pt}}(w)$ is replaced with the log odds $\log[\mathrm{RS}_{\mathrm{pt}}(w)]-\log[1-\mathrm{RS}_{\mathrm{pt}}(w)]$. Note that one could also include individual-specific controls and estimate an individual level distribution regression using the linear probability model

$$1(E_i = 1 \text{ and } W_i \geq w) = f(W_{m,pt}, w) + \delta_p(w) + \gamma_t(w) + \beta(w)X_{ipt} + \varepsilon_{ipt}(w),$$

or a corresponding logit regression.

Regardless of the specification used, the key element on the right hand side of the regression equation is the effect of the minimum wage $f(W_{m,pt}, w)$. I discuss below the precise functional form used to capture this effect in light of the predictions of the different models presented in Figures 1 to 4.

The other regressors on the right hand side of the estimating equation are the standard variables used in "difference-in-differences" studies. Province and year effects are captured by $\delta_p(w)$ and $\gamma_t(w)$, respectively. Note that these effects are allowed to vary for different wage values w, which gives a lot of flexibility in the way the underlying wage distribution (and the rescaled survivor) is modeled. X_{pt} is a vector of covariates. Following the literature, I show specifications where the provincial unemployment rate and province-specific linear trends are included in the regression model. As in the case of province and year effects, the effect of these covariates, $\beta(w)$, is allowed to vary at different points of the wage distribution.

The function $f(W_{m,pt}, w)$ has to be flexible enough to accommodate the predictions of the various models considered in Figures 1 to 4. Without loss of generality, assume that, for each value of w, $f(. , w)$ is equal to zero for the lowest value of the minimum wage observed in the data, W_L, i.e. $f(W_L , w) = 0$. For example, consider the case of the truncation model illustrated in Figure 1 where W_L=4. When the minimum wage increases to 5, equation (1a) to (1c) tell us that $f(5 , w) < 0$ for $w \leq 5$ and $f(5 , w) = 0$ for $w > 5$. Furthermore, we expect $f(5 , w)$ to be smaller in (absolute value) when $w \leq 4$ then when $4 < w \leq 5$.

For reasons that will become clearer in the data section (coarseness of the wage data), a useful way of modeling $f(. , w)$ in a flexible way is to use dummy variables indicating in which "dollar bin" the minimum wage $W_{m,pt}$ lies. More specifically, I assume that:

$$f(W_m, w) = \Sigma_k \pi_k(w)D_{k,pt}, \quad (5)$$

where $D_{k,pt}$ are a set of "dollar bin" indicator variables defined as:

$D_{k,pt} = 1$ if $k-.5 < W_{m,pt} \leq k+.5$,

$D_{k,pt} = 0$ otherwise.

The parameters $\pi_k(w)$ then capture the effect of the minimum wage relative to the base category where $W_m = W_L$. The expected effect of the minimum wage on the rescaled survivor function for each of the models considered in Figures 1 to 4 is conveniently summarized by the family of parameters $\pi_k(w)$. The expected size and magnitude of $\pi_k(w)$ for each of the four models discussed above is illustrated in Tables 1a-1d. Note that values of the minimum wage observed in the 1997-2010 data ranges from $5 an hour (in Newfoundland and Alberta in 1997) to $10.25 an hour (in Ontario in 2010). Therefore, I use k=5 as the base value of the minimum wage ($W_L = 5$), and show the expected impacts for k=6 to 10.

3. Data and the Institutional Setting

3a. LFS data

The empirical analysis is based on the public use files of the Canadian Labour Force Survey (LFS) for the years 1997 to 2010. Like the CPS in the United States, the LFS is a large monthly household survey that primarily aims at measuring the labor market activities (employment, unemployment, occupation and industry, etc.) of the population. Once sampled, respondents from households (or dwellings to be more precise) get interviewed for six months in a row. The target sample size is 52,350 households, which yields a monthly sample of about 100,000 individuals age 15 and above.

Since January 1997, a short supplement asking information about wages, union status, firm size, and contract type (permanent vs. temporary) was added to the incoming rotation group of the LFS.[1] Since the wage questions were not asked to self-employed workers, I exclude those from the main analysis samples. I also limit the analysis to

[1] These questions are directly asked to respondents when they are first interviewed in the LFS (incoming rotation group). During subsequent months, respondents are only asked to update their answers in case they have changed job since the last interview.

teenagers (age 15-19) and young adults (age 20-24) who are most likely to be affected by the minimum wage.

Table 2 shows summary statistics for the main analysis samples. Individuals are divided in the four age groups (15-16, 17-19, 20-21, and 22-24) provided in the public use files of the LFS (exact year of age is not available). All statistics are weighted using sample weights since smaller provinces are substantially oversampled in the LFS.

The minimum wage is potentially an important determinant of wages for this particular labor market. 18 percent of all workers ages 15-24 earn a wage equal (or lower) to the minimum wage. This jumps to 45 percent for teenagers age 15-16, but eventually drops to 6.4 percent of individuals age 22-24. Not surprisingly, the average wage is also much larger for young adults than for teenagers. Based on these two observations, the minimum wage is expected to have a much larger impact for teenagers than young adults.

Note also that teenagers are only weakly attached to the labor market. 81 percent of teenagers age 15-16 are enrolled in school during the survey week, and only 26 percent of them have a job.[2] Furthermore, 89 percent of these jobs are part-time (less than 30 hours a week). Teenagers age 17-19 are more than twice as likely to have a job (53 percent employment rate), and less likely to work part time. By the time we get to young adults age 22-24, 71 percent of individuals are employed, most of them are no longer in school, and less than 25 percent of them work part time.

One important feature of the wage data in the LFS is that a large fraction of wages appear to be rounded at the nearest integer value of wages, or at the nearest 10 or 25 cents value. This can be clearly noticed in Figure 5 which shows a histogram of wages for values of to 12 dollars an hour. In Figure 5, there is a very large spike in the wage distribution at integer values of the wage. This is particularly striking at 7, 8, 9 and 10 dollars an hour, which each account for between 7 and 10 percent of all observations. There are also very noticeable spikes at "50 cents" values ($6.50, $7.50, etc.) and less noticeable spikes at "25 cents" values. Estimates of the density of wages (Epanechnikov kernel with default bandwidth) are highly non-monotonic as they try to fit the spikes in the wage data.

[2] During school months (September to June) nearly all 15-16 years old are enrolled in school. The average school enrollment figure reported in Table 2 is lower because all 12 months (including July and August) are included in the sample.

This feature of the wage data is also illustrated in Appendix Table A1. The table shows that almost 50 percent of observations are at integer values of wages, with a further 15 percent at 50 cents values. The table also shows that if wages were uniformly distributed, 88 percent of observations would be at wage values other than those presented in the table (integer values and those ending with a multiple of 10 or 25 cents). In the actual data, this fraction is only 24 percent.

Given the nature of the wage data, it is not useful to precisely model what happens at each possible value of the wage. To do so, one would likely have to introduce a measurement model trying to explain why so many wage values are concentrated at integer values. The simpler solution I use in the rest of the paper is to divide the data into dollar wage bins that range from 49 cents below to 50 cents above each integer value of the wage. For instance, the "6 dollars" wage bin consists of all wage observations going from $5.51 to $6.50.

Note also that since the rounding off happens at nominal values of the wage, the empirical analysis will proceed in nominal terms in the sense that I will model the impact of changes in the nominal value of the minimum wage on the rescaled survivor function of nominal wages. The consequences of working in nominal instead of real terms should be limited since average inflation was only 2.1 percent over this period. All models also include year dummies to capture overall inflation. Persistent real differences in wages across provinces (i.e. differences in percentage terms) can also be captured by a combination of province dummies and province-specific trends.

3b. Minimum wage in Canada

In Canada, most industries are covered under provincial labor legislation.[3] Furthermore, since 1996 the federal government has decided that the minimum wage for workers covered under the federal labor legislation would simply be the prevailing provincial minimum wage. Therefore, the minimum wage is solely set at the provincial level for the time period considered in this paper (1997 to 2010).

[3] Industries that are more "national" in nature (communications, transportation, etc.) are covered under the federal legislation. These industries typically employ few workers at the minimum wage.

Figure 6a plots the real value of the minimum wage in the four largest provinces: Quebec, Ontario, Alberta, and British Columbia. As indicated in Table 2, 86 percent of all observations are in these four provinces. Figure 6a shows a substantial amount of variation in the minimum wage in these four provinces. Minimum wages in Quebec and Ontario tend to closely follow each other. They declined in both provinces between 1997 and the mid-2000s, and have been increasing since then. The only difference between the two provinces is that minimum wages are a little higher in Quebec during the mid-2000s, and then substantially higher in Ontario than in Quebec since 2009.

Alberta used to have the lowest minimum wage in the country despite also having the highest income per capita. Following a number of large increases starting in 2005, it has now mostly caught up with Ontario and especially Quebec in recent years. The situation is completely the opposite in British Columbia. The minimum wage was the highest there for most sample years. But after remaining constant at $8.00 for the last ten years (see Figure 6b in nominal terms), the BC minimum wage was the lowest in the country by 2010.

Unlike the four largest provinces, the minimum wages in the other six provinces all closely follow each other between 1997 and 2010 (see Figure 6b, and nominal figures in Figure 6d). In all cases, the real value of the minimum wage is more or less constant between 1997 and 2005, and then increases rapidly from around $6.50 to around $8.50 between 2005 and 2010. Therefore, there is limited variation to be exploited from the data on the six smaller provinces. Given that sample sizes for particular age groups at particular wage values get fairly small in these provinces, for efficiency reason I will weight all regressions using sample weights (the sum of sample weights in the province-year for the province-year level regressions shown in equation 4). The added benefit from weighting is that it also puts more weight on the large provinces where there is more variation in the minimum wage.

Note that after the recent increases in the minimum wage, the average minimum wage in Canada relative to average manufacturing wages is now at its highest value since 1978. This is illustrated in Appendix Figure A1 which shows the evolution of the relative minimum wage in both Canada and the United States. This provides an additional reason for "updating" estimates of the minimum wage on employment and wages in an era where minimum wages are more likely to "bind" than in the 1980s and 1990s.

4. Difference-in-differences Estimates

Table 3 reports standard difference-in-difference estimates of the effect of the minimum wage on employment and wages for the different age groups. All models include a full set of province and year dummies, as well as additional controls indicated at the bottom of the table. In the case of employment, these models are a special case of the distribution regression (equation 4) where w=0. For the sake of comparison with U.S. studies, I also report estimates when the average wage is used as outcome variable. I show robust standard errors as well as standard errors clustered at the province level to account for possible serial correlation over time (Bertrand, Duflo, and Mullainathan, 2004).[4]

The estimated effect of the minimum wage on the employment rate, the unemployment rate, and average wages of teenagers age 15-16 is reported in Panel A of Table 3. Consistent with the evidence in Table 2 that about half of these workers earn exactly the minimum wage, the estimated effect on average wages is large and statistically significant. The effect varies from 0.7 to 0.9 depending on specifications, which is close to a one-to-one effect.

The estimated effect on employment is always negative and significant. Since the employment rate for this group is only 25.7 percent (Table 2), the elasticity of employment with respect to the minimum wage ranges from 0.43 to 0.98 depending on the specification being used. By contrast, the effect of the minimum wage on the unemployment rate is never statistically different from zero.

Turning to older teenagers age 17-19, the negative employment effect in column 1 is not robust to the inclusion of province-specific time trends or province-specific unemployment rates in columns 2 to 4. By contrast, the effect of the minimum wage on average wages is large and significant for all four specifications presented in the table. So although the minimum wage clearly "binds" for this group of workers, there is no

[4] The clustered standard errors may be seriously biased since there are only 10 clusters. An alternative is to use Newey-West standard errors where autocorrelation is only allowed for up to a certain number of years. These standard errors are typically smaller than the clustered standard errors, suggested that the latter are, if anything, conservative.

evidence that this comes at the cost of significant job losses among minimum wage workers.

Turning to young adults, Panel C and D of Table 3 show that in the traditional difference-in-differences specification with no controls besides province and year dummies, the effect of the minimum wage on employment is negative and marginally significant (depending on how standard errors are computed). The interpretation of these negative effects is questionable, however, since the minimum wage does not have a statistically significant effect on average wages. This is not surprising since Table 2 shows that young adults are much less likely to earn the minimum wage than teenagers. This evidence suggests that negative employment effects in column 1 may be spurious consequences of a failure to control for other important control variables.

The remainder of Panels C and D confirms that as in the case of teenagers age 17-19, the employment effects become insignificant once province-specific trends and unemployment rates are added to the specifications in columns 2 to 4. Unlike the case of older teenagers, the effect of the minimum wage on average wages is a clear zero once province-specific trends are included. So in that case the zero employment effects are not that informative since minimum wages do not have much of an impact on average wages. There may still be some impacts, however, at specific points along the wage distribution, an issue I will investigate in detail in the next section.

In summary, the difference-in-differences estimates confirm earlier findings that the minimum wage has a negative effect on the employment of teenagers in Canada. The results add some credibility to these earlier findings by showing that the minimum wage also has a very large impact on the wages of this group of workers.

That said, it is important to keep in mind that this effect is limited to 15-16 years old who only account for a very small share of employment in Canada. Indeed, Table 2 shows that only 25 percent of individuals in this group have a job, and that 90 percent of these jobs are part-time. The minimum wage does not appear to have much of an impact on the employment of older teenagers (age 17-19) who are more strongly attached to the labor market. Overall, the recent data analyzed in Table 3 suggests that the minimum wage only has a modest impact on the employment of teenagers and young adults in Canada.

5. Distribution regression Estimates

The main empirical contribution of this paper is to estimate distribution regressions showing the impact of changes in the minimum wage at various points of the wage distribution. I estimate the log-odds version of the model and reports marginal effects in the tables.[5] The results are first reported for teenagers age 15-16 in Table 4. The specification used in these models is that same as in column 4 of Table 3 (province dummies, year dummies, and province-specific trends and unemployment rates are included as control variables) except that the minimum wage is captured by a set of dummies shown in equation (5) instead of the linear specification used in Table 3. The standard errors are clustered at the provincial level.

Since the sample size gets fairly small at the province-year-wage bin level, I also present results where all teenagers are pooled together in Table 5. All models also include dummies for the age group (15-16 vs. 17-19). Likewise, Table 6 reports similar estimates for all young adults pooled together.

To help the interpretation of the results, the estimates are reported in a format similar to the theoretical predictions presented in Tables 1a to 1d. Remember from the discussion of Table 1a-d and related graphs that results on the first column of Tables 4-6 are standard employment effects (with dummies instead of a linear specification of the minimum wage). Results on the main diagonal of the tables are particularly important as they indicate whether we have a "pure" truncation model (negative elements on the diagonal) or a spike in the distribution at the minimum wage (positive elements on the main diagonal). Elements of the results matrix to the right and above the main diagonal should be zero except perhaps for some positive spillover effects close to the main diagonal.

Broadly speaking, the results for teenagers age 15-16 are consistent with a "spike model" with some disemployment effects (Figure 3 and Table 1c). Consistent with Panel A of Table 3, the results reported in the first column of Table 4 indicate negative employment effects. In all cases, the effect of having a minimum wage higher than the

---

[5] Estimating marginal effects directly using a linear specification yields very similar results.

base case (minimum wage of $5) is negative, and it is significant at the 95 percent level in two cases. Note, however, that the effect is not monotonic as it tends to decline above 8 dollars.

Consistent with the existence of a spike at the minimum wage, the estimates on the main diagonal are all positive, and significant at the 95 percent level in three cases out of five. These effects are also economically important, especially at values of the minimum wage up to 8 dollars an hour. The average estimate of about 0.06 represents about 25 percent of the fraction of all teenagers who have a job. Thus, the results suggest that an increase in the minimum wage (relative to the 5 dollars base) "pushes up" about a quarter of teenagers to the new value of the minimum wage, while a substantial fraction of them also move out of employment (first column).

There is little evidence of spillover effects for this group since none of the estimates just to the right of the main diagonal are positive and significant. Note that this does not completely rule out spillover effects since some of those may be occurring within the coarsely defined wage bins (one dollar intervals). But the results still rule out spillover effects going more than 50 cents (half a wage bin) above the minimum wage. Note that, as expected, almost all of the estimates in the upper right diagonal are not statistically significant. There are a few exceptions at higher values of the wage ($11 or $12 an hour) but these results are questionable given the very small fraction of 15-16 years old making these kinds of wages (around 1 percent of the sample according the last row of the table).

The results for all teenagers pooled together (Table 5) are broadly similar to those for teenagers age 15-16. The first columns indicate negative and significant employment effects that are now fairly monotonic. Fitting a linear function to the estimated effects yields an estimate of -0.12 which lies, as expected, in between the employment effect estimates reported in column 4 of Table 3 for 15-16 (-0.026) and 17-19 (0.004) year olds.

Likewise, the estimates on the main diagonal are always positive, and are statistically significant in three cases out of five. In most cases, the estimates are substantially larger than the employment effects in the first column. This suggests that increases in the minimum wage mostly "push up" workers to the new minimum instead of reducing their employment level. This is once again consistent with the model where there is both a spike in the distribution and some disemployment effects. As in the case of 15-16 year olds, there are no significant spillover effects. Furthermore, the anomalous negative results at higher wages now disappear thanks to larger samples at the top end of the distribution.

Consistent with Panels C and D of Table 3, very few of the estimates for young adults reported in Table 6 are statistically significant. One exception is when the minimum wage is equal to $6. Taken at face value, the estimates suggest that raising the minimum wage from $5 to $6 reduces the employment rate by 0.021 and pushes up a similar fraction of workers (0.021) to the higher value of the minimum wage. These effects are modest relative to the employment rate of young adults, but significant nonetheless. Moving to the right, there are also some clear spillover effects as the probability of working and earning at least $7 increases by 0.018.

More disturbingly, however, the effect of raising the minimum wage is negative and significant higher up in the wage distribution. In fact, the fraction of the population working and earning at least $11 (or $12) declines by more than the overall employment effects displayed in the first column of the table. Taken at face value, this suggests that the minimum wage increases employment at the bottom end of the distribution, but <u>decreases</u> employment at the upper end. This suggests that the results at $6 are likely spurious consequence of omitted province-year specific factors. By contrast, the estimates in the rest of the table are never statistically significant, suggesting that, consistent with Table 3, the minimum wage has no discernable effects on the wage and employment distribution of young adults.

Relative to the standard difference-in-differences estimates reported in Section 4, there are a few interesting new findings that come from the distribution regressions reported in Tables 4 to 6. First the results add to the credibility of the difference-in-difference estimates by showing that, for teenagers, the minimum wage has an impact at lower end of the distribution --where it should have an impact--, but no impact at the top end of the distribution –where it should not have an impact--.

Second, the results indicate that two popular models for the wage and employment effects of minimum wages, the truncation and spike models, make strong predictions that are not supported in the data. A mix of these two models with a spike at the minimum wage but some negative employment effects provide a relatively good description of the actual data. Finally, there is no evidence of important spillover effects in these wage data.

6. Conclusion

The paper proposes a new distribution regression approach to model the effect of the minimum wage on the joint distribution of wages and employment. The approach complements the standard difference-in-differences approach that has been extensively used in the literature by showing in which part of the distribution the effects of the minimum wage is concentrated. The suggested approach also provides an additional way of testing the validity of the difference-in-differences design by testing whether the minimum wage has an impact at the upper end of the distribution. A further contribution of the paper is to present up-to-date estimates of the effect of the minimum wage in Canada in an era of relatively high minimum wages.

In the case of teenagers, the main substantive finding is that the effect of the minimum wage is consistent with a model where there is both a spike in the distribution at the minimum wage, and some disemployment effects. There is no evidence of important spillover effects in these wage data. Furthermore, the minimum wage has no effects at the top end of the wage distribution, which adds to the credibility of the research design. For young adults, however, the minimum wage has no discernable effect on the distribution of wages and employment.

The main methodological advance of the paper is to integrate two separate literatures (employment and wage distribution effects of the minimum wage) using a common framework where the effect of the minimum wage on the scaled survivor function is estimated using distribution regressions. The procedure is easy to implement and could be applied in a variety of other settings.

REFERENCES

Allegretto, S., A Dube, and M. Reich. 2011. Do minimum wages really reduce teen employment? Accounting for heterogeneity and selectivity in state panel data. *Industrial Relations* 50 (April):205-240.

Autor, D.H., A. Manning and C.L. Smith (2009), "The Role of the Minimum Wage in the Evolution of U.S. Wage Inequality over Three Decades: A Modest Re-Assessment" MIT Working Paper, September.

Baker, M., D. Benjamin, and S. Stanger. 1999. The highs and lows of the minimum wage effect: A time-series cross-section study of the Canadian law. *Journal of Labor Economics* 17 (April):318–50.

Bertrand, M., E. Duflo, and S. Mullainathan. 2004. *Quarterly Journal of Economics* 119 (February): 249-75.

Card, D. E., and A. B. Krueger. 1995. *Myth and Measurement: The New Economics of the Minimum Wage*. Princeton: Princeton University Press.

Campolieti, M., T. Fang, and M. Gunderson. 2005. Minimum wage impacts on youth employment transitions, 1993–1999. *Canadian Journal of Economics* 38 (February):81–104.

Campolieti, M., M. Gunderson, C. Riddell. 2006. Minimum wage impacts from a pre-specified research design: Canada, 1981–1997. *Industrial Relations* 45 (April):195–216.

DiNardo, J., N.M. Fortin and T. Lemieux (1996), "Labor Market Institutions and the Distribution of Wages, 1973-1992: A Semiparametric Approach", *Econometrica* 64, pp. 1001-46.

Dube, A., T.W. Lester, and M. Reich. 2010. Minimum wage effects across state borders: Estimates using contiguous counties. *Review of Economics and Statistics* 92 (November):945-64.

Grenier, G., and M. Séguin. 1991. L'incidence du salaire minimum sur le marché du travail des adolescents au Canada: Une reconsidération des resultats empiriques. *L'Actualité Économique* 67 (June):123–43.

Lee, D.S. (1999), "Wage Inequality in the United States during the 1980s: Rising Dispersion or Falling Minimum Wage", *Quarterly Journal of Economics* 114, pp. 977-1023.

Table 1a: Effect of increasing the minimum wage above $5 in a pure truncation model

	Effect of the minimum wage on the probability of being employed and earning at least:						
	0	6	7	8	9	10	11
Min. wage:							
6	-	-	0	0	0	0	0
7	--	--	-	0	0	0	0
8	---	---	--	-	0	0	0
9	----	----	---	--	-	0	0
10	-----	-----	----	---	--	-	0

Table 1b: Effect of increasing the minimum wage above $5 in a pure "spike" model

	Effect of the minimum wage on the probability of being employed and earning at least:						
	0	6	7	8	9	10	11
Min. wage:							
6	0	++	0	0	0	0	0
7	0	++	++	0	0	0	0
8	0	++	++	++	0	0	0
9	0	++	++	++	++	0	0
10	0	++	++	++	++	++	0

Table 1c: Effect of increasing the minimum wage above $5 in a “spike” model with some disemployment effects

	Effect of the minimum wage on the probability of being employed and earning at least:						
	0	6	7	8	9	10	11
Min. wage:							
6	-	++	0	0	0	0	0
7	-	+	++	0	0	0	0
8	--	+	+	++	0	0	0
9	--	-	+	+	++	0	0
10	---	-	-	+	+	++	0

Table 1d: Effect of increasing the minimum wage above $5 in a “spike” model with some disemployment and spillover effects

	Effect of the minimum wage on the probability of being employed and earning at least:						
	0	6	7	8	9	10	11
Min. wage:							
6	-	++	+	0	0	0	0
7	-	+	++	+	0	0	0
8	--	+	+	++	+	0	0
9	--	-	+	+	++	+	0
10	---	-	-	+	+	++	+

Table 2: Summary Statistics for Individuals Age 15-24, 1997-2010 LFS

	All ages	15-16	17-19	20-21	22-24
Province:					
Quebec	23.1	23.2	23.1	23.1	23.2
Ontario	38.6	39.4	38.7	38.3	38.3
Alberta	11.0	10.7	10.8	10.9	11.4
BC	13.0	12.6	12.9	13.4	13.2
Others	14.2	14.1	14.5	14.4	14.0
Education:					
Less than HS	38.7	94.2	48.6	13.5	11.0
Exactly HS	20.1	0.5	25.1	28.5	21.8
Some post-sec.	36.2	5.3	26.3	56.4	51.9
Bacc. and above	5.0	0.0	0.1	1.6	15.4
Percentage:					
Female	49.0	48.1	48.8	49.0	49.8
Employed	55.9	25.7	53.3	64.8	71.5
Part-time	44.8	89.1	64.5	37.7	24.3
Unemployed	8.9	8.5	10.0	8.9	8.0
In school	49.8	80.8	61.0	39.3	26.2
At or below min wage	18.0	45.2	30.6	11.4	6.4
Average real hourly wage	10.35	7.63	8.30	10.52	12.39
Average minimum wage	7.38	7.38	7.38	7.38	7.38
Observations:	2,692,586	571,789	855,121	529,312	736,364

Notes: Data for all individuals age 15-24 from the 1997-2010 Labour Force Survey, except for self-employed workers who are excluded from the sample. Average hourly wages are in constant 2002 dollars.

Table 3: Traditional OLS Estimates of the Effect of the Minimum Wage on Employment, Unemployment, and Wages

	(1)		(2)		(3)		(4)	
A: Age 15-16								
Employment	-0.034		-0.015		-0.032		-0.026	
	(0.008)	*	(0.005)	*	(0.007)	*	(0.006)	*
	[0.012]	*	[0.005]	*	[0.008]	*	[0.010]	*
Unemployment	0.002		0.002		0.003		0.000	
	(0.002)		(0.002)		(0.003)		(0.002)	
	[0.005]		[0.003]		[0.003]		[0.003]	
Wage	0.798		0.892		0.716		0.748	
	(0.082)	*	(0.089)	*	(0.051)	*	(0.053)	*
	[0.172]	*	[0.187]	*	[0.038]	*	[0.059]	*
B: Age 17-19								
Employment	-0.025		0.001		-0.003		0.004	
	(0.011)	*	(0.005)		(0.010)		(0.006)	
	[0.013]		[0.007]		[0.005]		[0.009]	
Unemployment	0.003		-0.002		-0.002		-0.005	
	(0.003)		(0.002)		(0.005)		(0.003)	
	[0.002]		[0.002]		[0.005]		[0.004]	
Wage	0.653		0.787		0.497		0.556	
	(0.124)	*	(0.129)	*	(0.063)	*	(0.055)	*
	[0.306]	*	[0.317]	*	[0.065]	*	[0.105]	*
Province dummies	YES		YES		YES		YES	
Year dummies	YES		YES		YES		YES	
Prov. unempl. rate	NO		YES		NO		YES	
Prov.-specific trends	NO		NO		YES		YES	

Notes: 140 observations. Estimates are weighted by the population in the province. Heteroskedasticity-robust standard errors are in parentheses. Standard errors clustered at the province level are in square brackets.
"*" indicates statistical significance at the 95 percent level.

Table 3: Continuation

	(1)		(2)		(3)		(4)	
C: Age 20-21								
Employment	-0.014		0.000		-0.004		0.001	
	(0.007)		(0.004)		(0.008)		(0.006)	
	[0.005]	*	[0.003]		[0.004]		[0.003]	
Unemployment	0.008		0.003		0.008		0.005	
	(0.002)	*	(0.001)	*	(0.003)	*	(0.002)	*
	[0.002]	*	[0.001]	*	[0.004]	*	[0.002]	*
Wage	0.378		0.573		-0.060		0.021	
	(0.198)		(0.196)	*	(0.125)		(0.111)	
	[0.487]		[0.497]		[0.190]		[0.224]	
D: Age 22-24								
Employment	-0.013		0.000		-0.003		0.001	
	(0.005)	*	(0.004)		(0.008)		(0.005)	
	[0.008]		[0.008]		[0.010]		[0.012]	
Unemployment	0.005		-0.003		-0.001		-0.004	
	(0.003)		(0.001)	*	(0.003)		(0.002)	*
	[0.003]		[0.001]	*	[0.004]		[0.001]	*
Wage	0.402		0.611		-0.153		-0.064	
	(0.228)		(0.224)	*	(0.163)		(0.147)	
	[0.528]		[0.524]		[0.305]		[0.320]	
Province dummies	YES		YES		YES		YES	
Year dummies	YES		YES		YES		YES	
Prov. unempl. rate	NO		YES		NO		YES	
Prov.-specific trends	NO		NO		YES		YES	

Notes: 140 observations. Estimates are weighted by the population in the province. Heteroskedasticity-robust standard errors are in parentheses. Standard errors clustered at the province level are in square brackets. "*" indicates statistical significance at the 95 percent level.

Table 4: Distribution regression Estimates of the Effect of the Minimum Wage
Teenagers age 15-16 only (marginal effects)

	Effect on the Probability of being employed and earning at least:							
	0	6	7	8	9	10	11	12
MW = 6	-0.020 *	0.074 *	0.011	-0.010	-0.012	-0.008	-0.006 *	-0.004 *
	(0.010)	(0.012)	(0.022)	(0.019)	(0.007)	(0.005)	(0.002)	(0.002)
MW = 7	-0.030	0.047 *	0.061	0.005	-0.002	-0.001	-0.004	-0.003
	(0.016)	(0.020)	(0.055)	(0.022)	(0.012)	(0.007)	(0.002)	(0.002)
MW = 8	-0.048 *	0.025	0.030	0.054 *	-0.006	-0.007	-0.007 *	-0.006 *
	(0.023)	(0.027)	(0.058)	(0.023)	(0.010)	(0.007)	(0.003)	(0.003)
MW = 9	-0.035	0.039	0.041	0.078 *	0.021	-0.002	-0.006	-0.005
	(0.021)	(0.025)	(0.063)	(0.024)	(0.020)	(0.008)	(0.003)	(0.003)
MW = 10	-0.017	0.060 *	0.079	0.115 *	0.049	0.028 *	-0.002	-0.002
	(0.014)	(0.019)	(0.057)	(0.025)	(0.032)	(0.012)	(0.003)	(0.003)
Proportion:	0.255	0.249	0.218	0.130	0.068	0.035	0.014	0.010

Notes: 140 observations. Estimates are weighted by the population in the province. All models also include controls for the provincial unemployment rate and province-specific linear trends. The base category for the minimum wage is $5. Estimates are based on log odds regressions where coefficients have been transformed in marginal effects.
Standard errors clustered at the province level in parentheses.
"*" indicates statistical significance at the 95 percent level.

Table 5: Distribution regression Estimates of the Effect of the Minimum Wage:
All teenagers age 15-19 (marginal effects)

	Effect on the Probability of being employed and earning at least:														
	0		6		7		8		9		10		11		12
MW = 6	-0.010		0.133	*	0.016		-0.013		-0.015		-0.001		0.001		-0.017
	(0.012)		(0.016)		(0.033)		(0.034)		(0.018)		(0.022)		(0.017)		(0.086)
MW = 7	-0.026		0.097	*	0.096		0.013		0.009		0.025		0.011		0.042
	(0.019)		(0.027)		(0.076)		(0.041)		(0.035)		(0.031)		(0.020)		(0.102)
MW = 8	-0.057	*	0.059		0.042		0.099	*	0.002		0.014		0.004		-0.004
	(0.025)		(0.033)		(0.082)		(0.043)		(0.025)		(0.031)		(0.020)		(0.110)
MW = 9	-0.057	*	0.061	*	0.041		0.137	*	0.055		0.021		0.003		-0.013
	(0.026)		(0.032)		(0.087)		(0.043)		(0.038)		(0.033)		(0.021)		(0.110)
MW = 10	-0.053	*	0.072	*	0.075		0.200	*	0.111		0.098	*	0.011		0.006
	(0.020)		(0.026)		(0.078)		(0.047)		(0.061)		(0.039)		(0.021)		(0.099)
Proportion:	0.422		0.414		0.381		0.248		0.152		0.093		0.046		0.034

Notes: 140 observations. Estimates are weighted by the population in the province. All models also include controls for the provincial unemployment rate and province-specific linear trends. The base category for the minimum wage is $5. Estimates are based on log odds regressions where coefficients have been transformed in marginal effects.
Standard errors clustered at the province level in parentheses.
"*" indicates statistical significance at the 95 percent level.

Table 6: Distribution regression Estimates of the Effect of the Minimum Wage:
Young Adults Age 20-24 (marginal effects)

	Effect on the Probability of being employed and earning at least:							
	0	6	7	8	9	10	11	12
MW = 6	-0.021 *	0.021 *	0.018 *	-0.016	-0.026	-0.033	-0.041 *	-0.047 *
	(0.008)	(0.010)	(0.009)	(0.012)	(0.018)	(0.020)	(0.016)	(0.017)
MW = 7	-0.031	0.005	0.027	-0.015	-0.040	-0.048	-0.051	-0.056
	(0.017)	(0.015)	(0.019)	(0.018)	(0.036)	(0.036)	(0.036)	(0.037)
MW = 8	-0.045	-0.013	0.003	0.002	-0.057	-0.076	-0.084	-0.090
	(0.024)	(0.022)	(0.023)	(0.020)	(0.037)	(0.048)	(0.048)	(0.049)
MW = 9	-0.031	0.002	0.018	0.018	-0.020	-0.067	-0.085	-0.095
	(0.023)	(0.022)	(0.028)	(0.025)	(0.037)	(0.053)	(0.055)	(0.056)
MW = 10	-0.015	0.019	0.046	0.050	0.020	0.004	-0.057	-0.095
	(0.019)	(0.018)	(0.025)	(0.026)	(0.040)	(0.052)	(0.056)	(0.056)
Proportion:	0.686	0.682	0.665	0.599	0.518	0.447	0.356	0.310

Notes: 140 observations. Estimates are weighted by the population in the province. All models also include controls for the provincial unemployment rate and province-specific linear trends. The base category for the minimum wage is $5. Estimates are based on log odds regressions where coefficients have been transformed in marginal effects.
Standard errors clustered at the province level in parentheses.
"*" indicates statistical significance at the 95 percent level.

Figure 1a: Density of wages for the truncation model

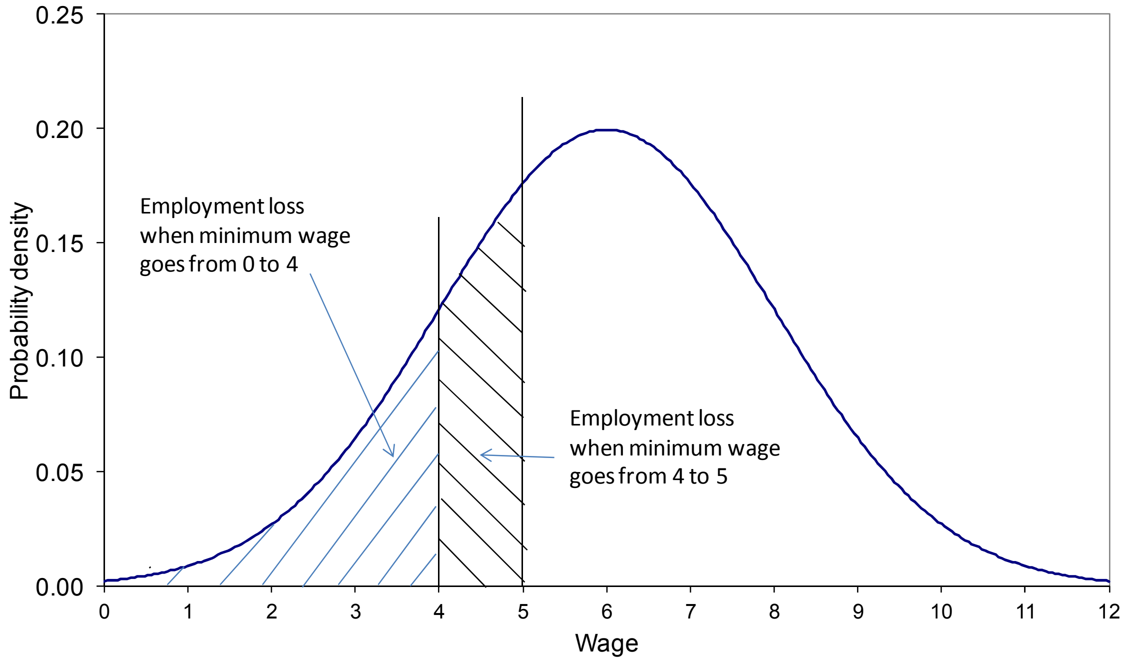


Figure 1b: Scaled survivor function for the truncation model

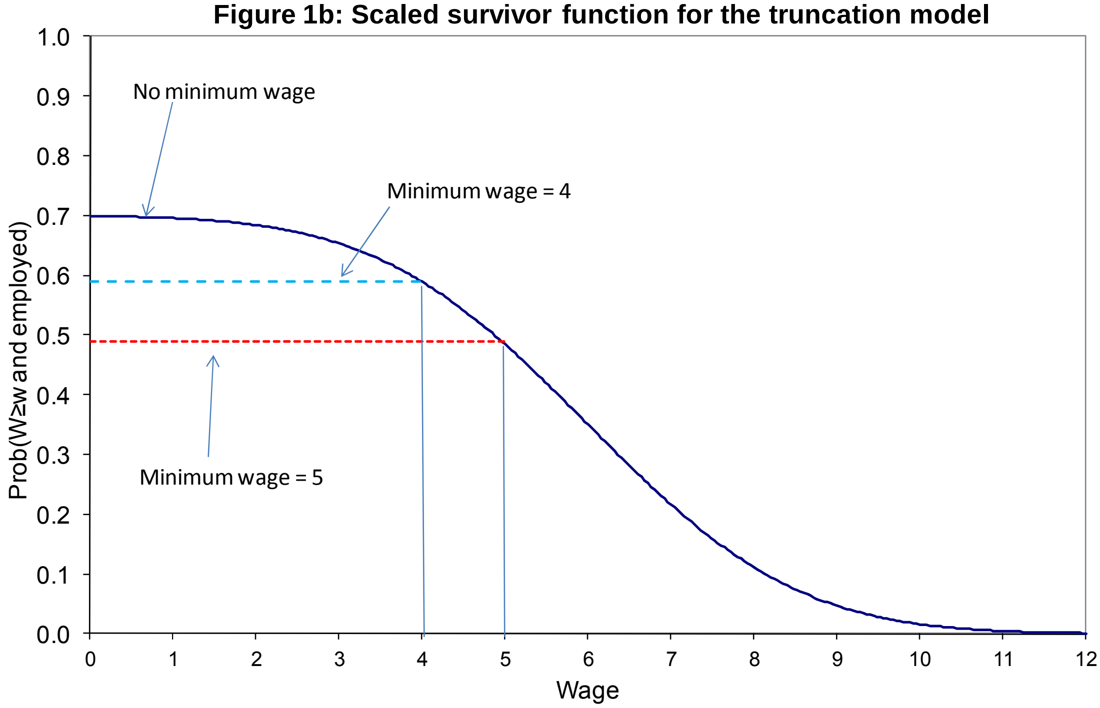


Figure 2a: Density of wages for the pure spike model

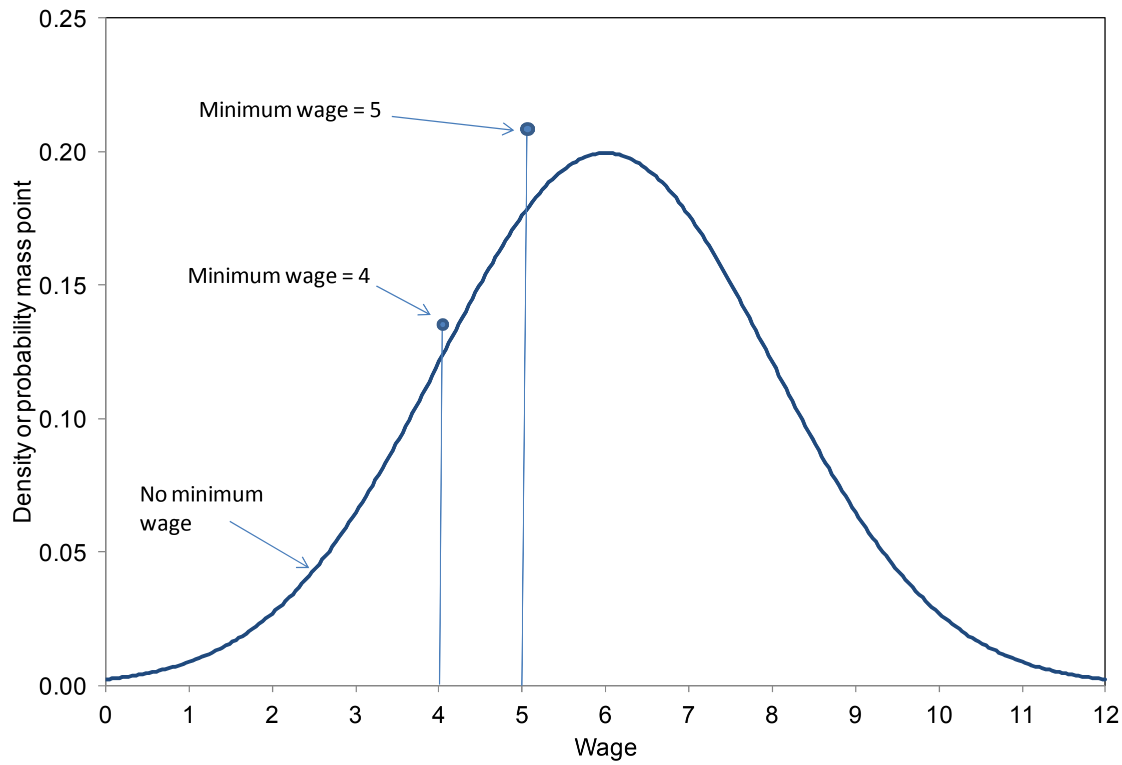


Figure 2b: Scaled survivor function for the pure spike model

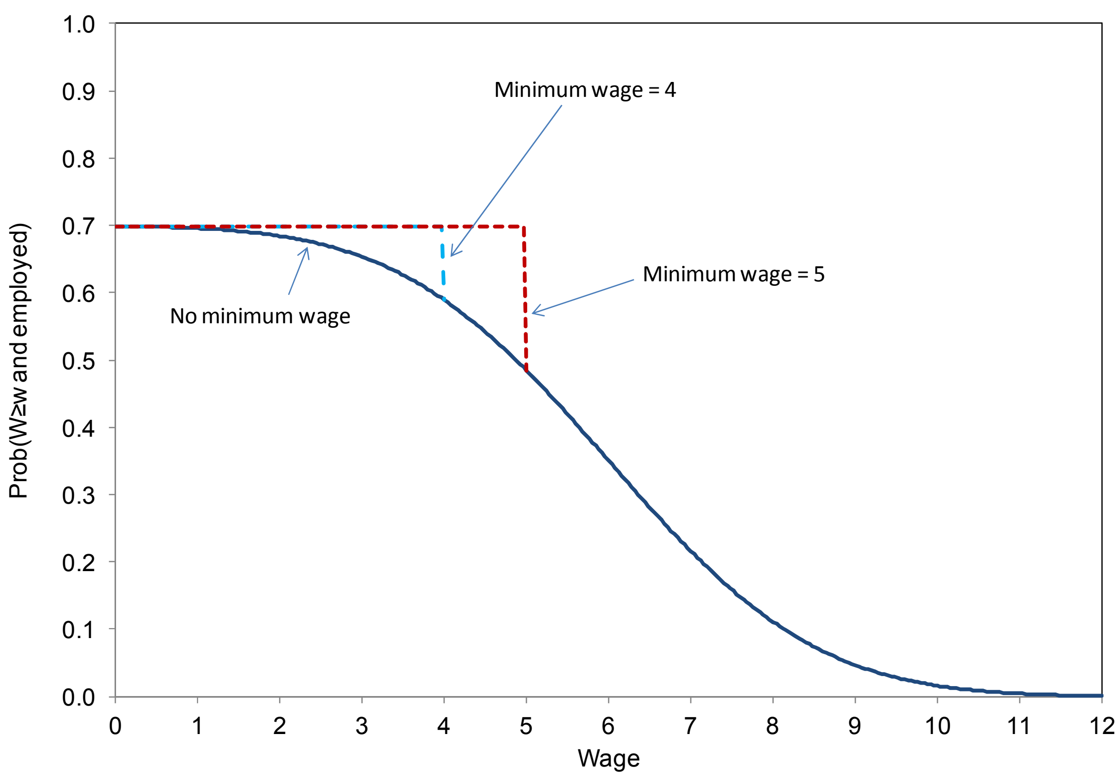


Figure 3: Spike with some disemployment effects

Figure 4: Adding spillover effects

Figure 5: Wage Distribution in the 1997-2010 LFS, Workers Age 15-24

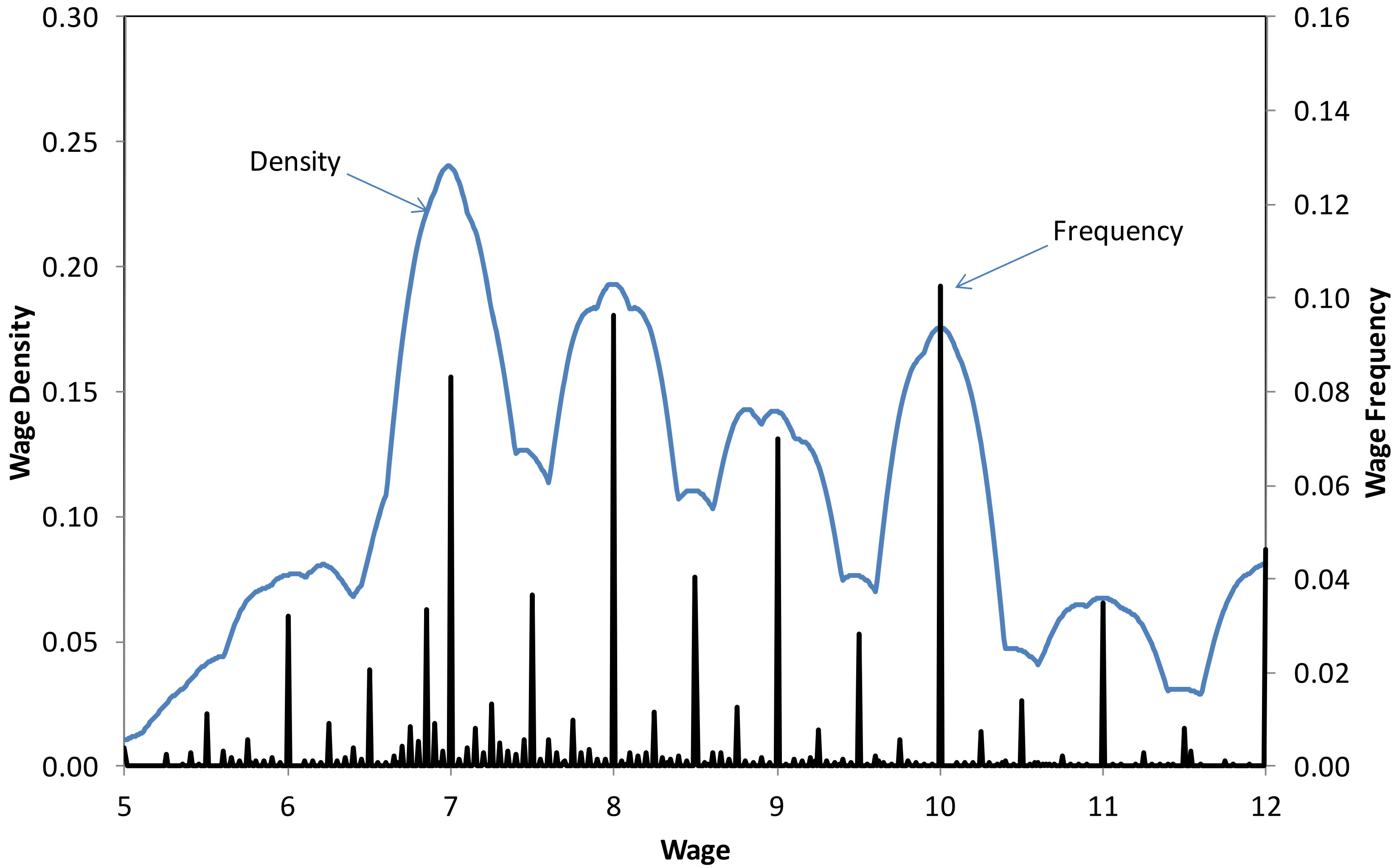


Figure 6a: Real Value of the Minimum Wage ($2002), larger Provinces

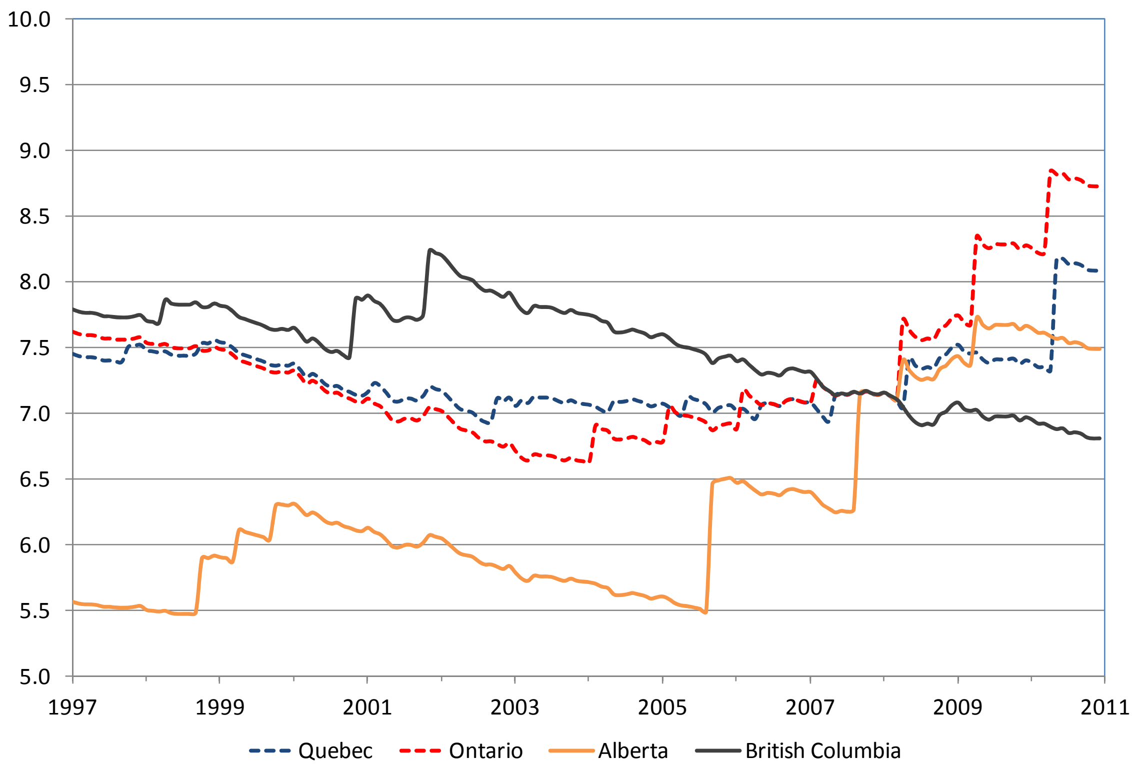
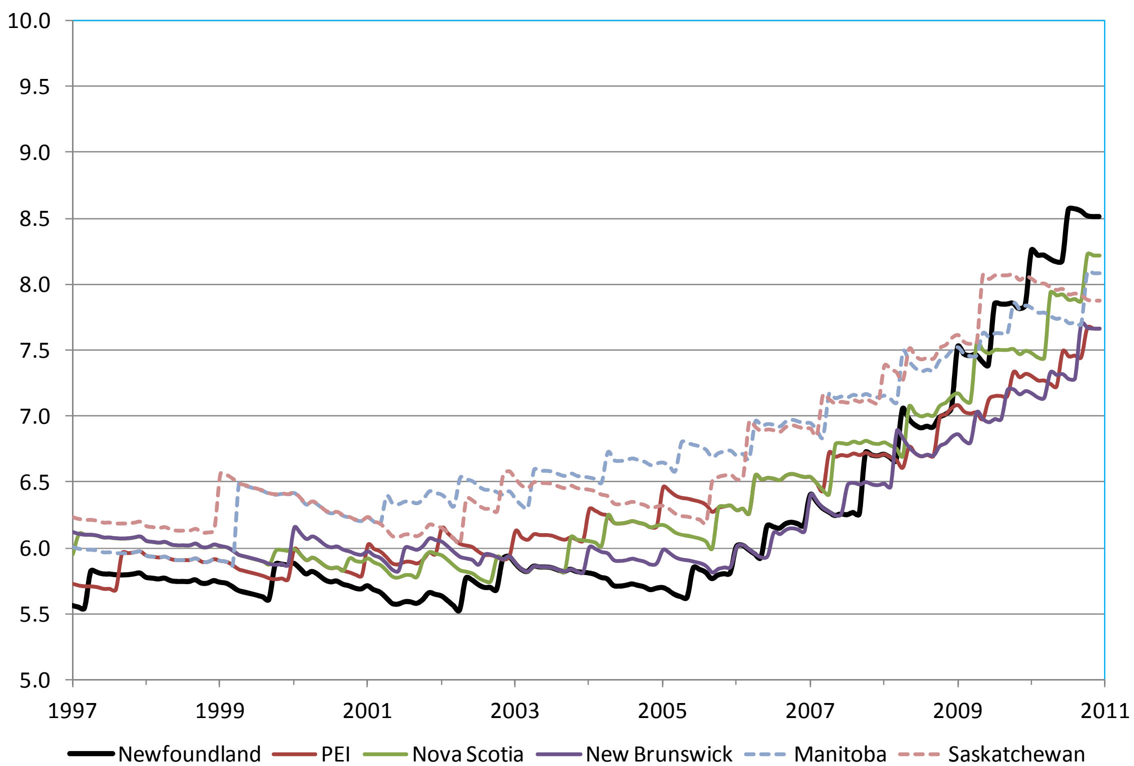


Figure 6b: Real Value of the Minimum Wage ($2002), other Provinces



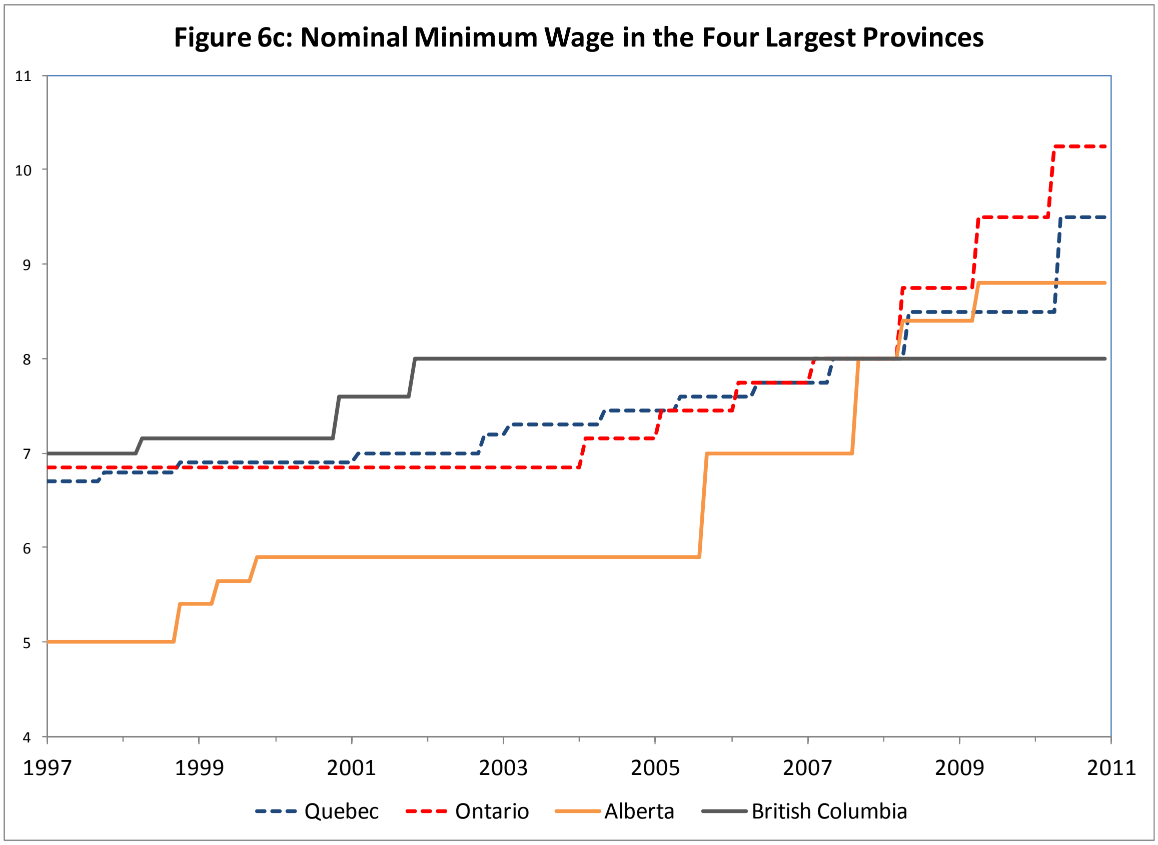


Figure 6c: Nominal Minimum Wage in the Four Largest Provinces
11
10
9
8
7
6
5
4
1997
1999
2001
2003
2005
2007
2009
2011
Quebec
Ontario
Alberta
British Columbia

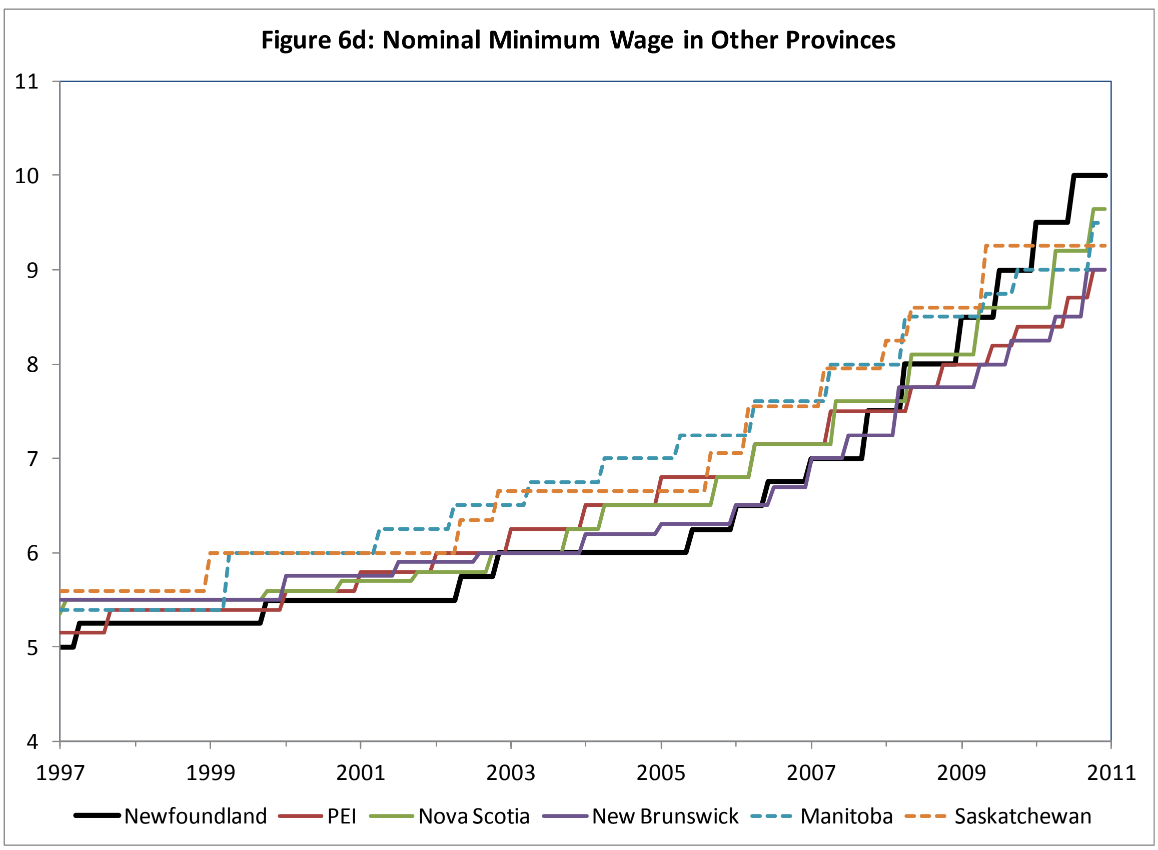


Figure 6d: Nominal Minimum Wage in Other Provinces
11
10
9
8
7
6
5
4
1997
1999
2001
2003
2005
2007
2009
2011
Newfoundland
PEI
Nova Scotia
New Brunswick
Manitoba
Saskatchewan

Appendix Table A1: Heaping in the LFS data

% of workers with wages rounded at the nearest:	Sample			Predicted by uniform distribution
	All	Wage ~= to min wage	Wage = min wage	
Dollar	47.1	49.3	31.4	1.0
50 cents	14.8	14.9	14.2	1.0
25 cents	8.6	8.1	12.5	2.0
10 cents	5.1	4.3	11.1	8.0
Total:	75.7	76.6	69.3	12.0
Other wage values:	24.3	23.4	30.7	88.0
Observations:	1474077	1295951	178126	

Notes: Data for all wage and salary workers age 15-24 from the 1997-2010 Labour Force Survey. Wage categories (dollar, 50 cents, 25 cents, 10 cents) are exclusive. For instance, $7.00 falls under the "dollar" category but none of the others, $7.50 falls under the "50 cents" category but not "25 cents" or "10 cents",
etc.

Appendix Figure A1: The Ratio of Minimum Wages to Average Wages, Canada and the United States, 1975-2010