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Interpreting Changes in Minimum Wage Incidence Rates

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Abstract

Statutory minimum wages increased substantially in New Zealand between 2000 and 2008. Where less than three per cent of workers were being paid the minimum wage in the late 1990s, this figure increased to more than ten per cent of workers by 2008. However, it is not obvious how this rise in the minimum wage incidence rate should be interpreted. The problem is that minimum wages can have behavioural effects. A higher wage floor could reduce the proportion of minimum wage workers in an economy by eliminating low-wage jobs. Recent New Zealand experience provides a unique opportunity for estimating this behavioural impact. The substantial gap between adult and teenage minimum wages was eliminated immediately in 2001 for 18 and 19 year-olds and gradually by 2008 for 16 and 17 year-olds. We find little evidence of an overall behavioural effect. Increases in incidence rates were not diminished by losses in low-wage employment. However, we find compelling evidence that minimum wage incidence for an age group is reduced by increases in minimum wages for neighbouring age groups.

JELClassification: J080; J380; J880

1. Introduction

The minimum wage incidence rate can be defined as the proportion of workers who receive hourly earnings at or below the statutory minimum wage. This incidence rate is commonly reported and often interpreted as a measure of the binding nature of this legislated wage floor.[1] Yet, changes to this incidence rate over time can be difficult to interpret. We identify three fundamental forces behind observed changes

[1] For example, see US studies by Bernstein and Schmitt (2000) and the Bureau of Labor Statistics (2007), plus related annual reports going back nearly two decades (e.g., Haugen and Mellor, 1990), and European studies by Delado *et al*. (1996) and Gutiérrez Hevia and Schwartz (2008).

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to this rate. The first two can occur because of a rise in the minimum wage. Firstly, the 'mechanical effect' occurs in the absence of any alteration to the underlying wage distribution. Secondly, the 'behavioural effect' results from an associated loss in low-wage employment. Finally, the residual 'other labour market effects' arise from all other factors that alter the position or shape of the wage distribution over time. By isolating these behavioural effects, this study provides an alternative way of estimating the possible disemployment effects of the minimum wage.

As we will see, this approach requires a very specific policy setting. We need observations on minimum wage changes that vary across the population. This allows us to eliminate common time-specific factors that might influence these incidence rates. The recent experience of New Zealand offers such an opportunity. In the late 1990s, this country had age-differentiated minimum wages with a substantially lower wage floor for 16 to 19 year-olds. The evidence is that neither the teenage nor adult minimum wages were particularly binding during this period. Following a change in government in 1999, New Zealand substantially raised its minimum wages through 2008. The real adult minimum wage increased by over 30 per cent. The government entirely eliminated the lower minimum wage for teenagers by 2008, but the timing for the phase-in of these changes varied between younger (16 and 17 year-olds) and older teenagers (18 and 19 year-olds). The real minimum wage for teenagers was raised by nearly 120 per cent over this period.

These large and varied increases in minimum wages across distinct age groups provide an ideal setting for estimating the three sources for observed changes in minimum wage incidence rates. We find evidence of large mechanical effects from these wage floor increases. In the absence of any behavioural or other labour market effects, the average annual minimum wage increases in our sample would have raised the incidence rate by approximately seven percentage points. Approximately two-thirds of this mechanical effect was offset by rightward shifts in the wage distribution, resulting in a net increase in the average annual minimum wage incidence rate of over two percentage points.

We find little evidence in our regression results of any direct behavioural effects on these minimum wage incidence rates, suggesting that the large increases in minimum wages between 1997 and 2008 did not reduce low-wage employment. This finding is consistent with earlier results reported by Hyslop and Stillman (2007). They used similar data over a shorter sample period (1997 to 2003) that captured only the earliest increases in minimum wages during this policy shift in New Zealand. Although Hyslop and Stillman examined a wider array of minimum wage effects in the labour market (e.g., hours of work, educational enrolments, unemployment and economic inactivity), they did not use incidence rates as a way of isolating the behavioural effects of higher minimum wages. Unlike Hyslop and Stillman, this present study focuses of simple measures of age-group minimum wage incidence rates rather than individual observations of various labour market outcomes. Because our analysis is restricted to aggregate data, it is not strictly comparable to the disaggregate study of Hyslop and Stillman.

We find consistent evidence that the minimum wage incidence rate of an age group is negatively influenced by the minimum wages of slightly younger and older age groups. Some of these indirect behavioural effects are even larger and more significant when we allow for more than a one-year response period. Our explanation for this finding is that higher minimum wages for other age groups, which might be seen by employers as substitutes for the individuals in question, may lead to increases in non-minimum-wage employment for these individuals.

The remainder of this paper is organised as follows: section 2 of this paper briefly discusses the recent changes to statutory minimum wages in New Zealand. Section 3 describes the methodology for separating the observed changes in the minimum wage incidence rates into its various components. Section 4 presents our regression results. Finally, section 5 summarises our findings and draws some conclusions from this study.

2. Descriptive Statistics: Recent Changes in Minimum Wages and Incidence Rates in New Zealand

Table 1 shows the legislated changes to nominal minimum wages in New Zealand between 1997 and 2008. Before 2001, the teenage minimum wage was set at 60 per cent of the adult rate. Following the elections in November 1999, the Labour Government embarked on a programme that steadily raised real minimum wages and eventually eliminated the gap between the teenage and adult wage floors. This resulted in annual increases in legislated minimum wages in each year between 2000 and 2008, prior to the election defeat of the Labour Government in November 2008.

Table 1 - Changes to Legislated Minimum Wages in New Zealand 1997 to 2008

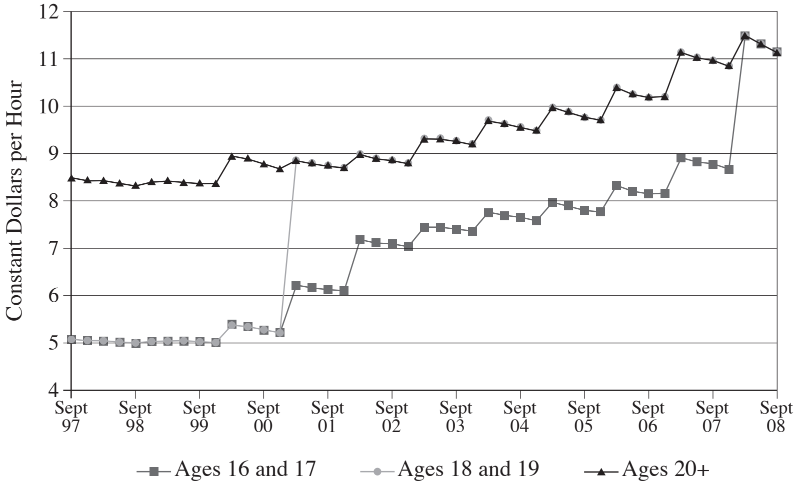
	Age Group		
Date of Legislated Change	*Ages 16-17*	*Ages 18-19*	*Ages 20+*
March 1997	$4.20	$4.20	$7.00
March 2000	$4.55	$4.55	$7.55
March 2001	$5.40	$7.70	$7.70
March 2002	$6.40	$8.00	$8.00
March 2003	$6.80	$8.50	$8.50
April 2004	$7.20	$9.00	$9.00
March 2005	$7.60	$9.50	$9.50
March 2006	$8.20	$10.25	$10.25
April 2007	$9.00	$11.25	$11.25
April 2008	$12.00*	$12.00	$12.00

Notes: The asterisk * for April 2008 indicates that this was the minimum wage for 16 and 17 year-olds after three months or 200 hours of work accumulated across all employers following their 16th birthdays. A lower minimum wage existed for this age group (80 per cent of this figure or $9.60) if they were otherwise classified as 'New Entrants'.

Figure 1 shows the result of the legislated changes in minimum wages in terms of their effective quarterly levels relative to the Consumer Price Index between September 1997 and September 2008. Over this eleven-year period, the real adult and teenage minimum wages increased by 31.3 per cent and 118.9 per cent, respectively.

These increases started in March 2000, but did not occur evenly for younger and older teenagers. Beginning in March 2001, 18 and 19 year-olds became eligible for the adult minimum wage. This resulted in a substantial and immediate increase of over 69 per cent in the real minimum wage for this age group. Unlike older teenagers, the minimum wage for 16 and 17 year-olds was only gradually raised to parity with the adult rate from this date. Their minimum wage was lifted to 70 per cent of the adult rate in March 2001, 80 per cent in March 2002 and finally to 100 per cent in April 2008.[2] This resulted in relatively large increases in the effective minimum wage for 16 and 17 year-olds in these three years.

Figure 1 - Adult and Teenage Minimum Wages in Constant Dollars September 1997 to September 2008



Notes: No minimum wage existed for teenagers prior to March 1994. See the notes at the bottom of table 1 for an explanation for the different minimum wages that face 16 and 17 year-olds beginning in April 2008. All legislated hourly minimum wage rates in this figure were adjusted to constant dollars using the Consumer Price Index with a base period of June 2006.

Data from the annual Income Supplements to the Household Labour Force Surveys (HLFS) are used to produce minimum wage incidence rates for workers. The HLFS is a survey of the resident population conducted in the March, June, September and December quarters of each year. It surveys about 16,000 households nationwide each quarter. The Income Survey is an annual supplement to the HLFS, which solicits detailed information on sources and amounts of income received by members of each household, and has been attached to the June quarter of the HLFS since 1997.

[2] The minimum wage for 16 and 17 year-olds who are deemed to be ‘new entrants’ or in qualified training programmes continued to be set at 80 per cent of the adult rate after April 2008. However, this sub-minimum wage disappears once these younger teenagers have either accumulated three months or 200 hours of work experience across all employers since their 16th birthday, or completed their training programmes.

The period from 1997 to 2008 covers three years prior to the recent changes in the minimum wage, along with the remaining years over which these changes have been gradually introduced.

One of the first practical issues to consider is how minimum wage workers should be defined. Previous studies have defined minimum wage incidence in a number of ways. Haugen and Mellor (1990) used data from the Current Population Survey (CPS) in the United States for this purpose. The CPS asks workers to report their hourly wage if this is how they are paid by their employers. The authors defined minimum wage workers as those receiving an hourly wage exactly equal to or less than the statutory minimum wage. They found that approximately one-third of these individuals reported receiving a wage rate below the minimum wage. The authors concluded that, even among wage earners, there is reason to suspect some measurement error. This approach of defining minimum wage workers as those earning exactly the minimum wage or below has been replicated in a series of annual reports on the characteristics of US minimum wage workers (e.g., see Bureau of Labor Statistics, 2007). Healy and Richardson (2006) used a similar definition for minimum wage incidence in Australia with data from Household, Income and Labour Dynamics in Australia (HILDA) Survey, and also found a relatively high proportion of workers earning less than the federal minimum wage.

Alternative approaches have also been used in defining minimum wage workers. Dolado *et al*. (1996) summarised a large number of studies on the impact of minimum wages in Europe. Without being very specific, they defined minimum wage workers as those being "... paid at or close to the minimum wage" (p.325). Presumably this allows for some range of values on either side of the legal minimum wage. Similarly, Leigh (2007) considered minimum and sub-minimum wage workers to be those earning between 100 and 120 per cent and 50 and 100 per cent of the Australian federal minimum wage, respectively.

Bernstein and Schmitt (2000) defined minimum wage workers as those receiving hourly earnings exactly equal to the minimum wage and up to one dollar above this amount. This suggests that the authors considered workers reporting an hourly wage below the legal minimum to be invalid observations of true minimum wage workers (e.g., due to possible exemptions from the federal minimum wage).[3]

Since the HLFS does not contain separate information on the wage rates for workers who are paid on an hourly basis, we use an hourly earnings measure which comes from dividing usual, regular earnings in the main job by usual, regular hours worked in that job over the relevant time period (e.g., weekly, fortnightly, monthly or annually). It may therefore be possible for individuals to report hourly earnings below the minimum wage due to simple measurement error.[4]

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[3] There are very few legal exemptions to the minimum wage in New Zealand. One such exemption relates to persons with recognised disabilities that significantly slow down their work and make them incapable of earning the minimum wage (Department of Labour, 2009).

[4] We remove possible cases of measurement error by eliminating observations on individuals who report usually working more than 60 hours per week, receiving overtime earnings in excess of their usual weekly earnings, or receiving usual earnings from all their wage and salary jobs in excess of total household income. In two Australian studies, Harding and Richardson (1999) and Healy and Richardson (2006) chose to keep those with excessively long usual workweeks in their samples, but to 'top code' weekly hours of work at 40 and 50, respectively, in computing hourly earnings.

To test the robustness of our findings, we employ two definitions for minimum wage incidence. Firstly, our 'narrow' measure classifies someone as a minimum wage worker if he or she receives hourly earnings exactly equal to or less than the current statutory minimum wage for their age group. Secondly, our 'broad' measure defines a minimum wage worker as someone who receives hourly earnings up to 5 per cent above the current minimum wage. HLFS data are used to estimate annual minimum wage incidence rates using both definitions from 1997 to 2008.[5] These incidence rates are computed among all workers for the five age groups used in this study – those aged 16 or 17, 18 or 19, 20 to 24, 25 to 44 and 45 to 64. These incidence rates are displayed in tables 2a and 2b. There are a total of 145,877 observations on workers and their hourly earnings over this period, or over 12,000 per year.[6] The average minimum wage incidence rates are 4.96 per cent and 6.59 per cent for the narrow and broad definitions, respectively. However, there are substantial increases in both incidence rates after 2000. The narrow incidence rate varied between approximately 2.5 and 3.6 per cent before 2001, but increased to over 10.3 per cent by 2008. The broad incidence rate varied between 3.0 and 4.2 per cent before 2001, but increased to over 14.7 per cent by 2008.

Table 2a - Minimum Wage Incidence Rates in New Zealand: Narrow Incidence in Percentage Terms: June 1997 to June 2008

		Ages:				
Year	*All*	*16 or 17*	*18 or 19*	*20 to 24*	*25 to 44*	*45 to 64*
1997	3.58	4.99	2.39	5.99	3.12	3.47
1998	2.67	6.20	0.96	4.00	2.33	2.55
1999	2.66	7.80	1.27	4.43	2.62	1.77
2000	2.45	3.03	0.71	4.08	2.22	2.46
2001	2.79	8.94	17.10	3.17	1.94	1.81
2002	4.03	16.95	24.03	5.90	2.48	2.26
2003	4.07	19.22	21.93	6.83	2.38	2.14
2004	4.67	22.71	23.26	5.67	3.16	2.88
2005	4.64	17.78	30.17	5.78	2.66	3.24
2006	7.33	18.26	28.34	10.86	5.62	5.57
2007	8.73	29.77	37.23	12.31	6.46	6.18
2008	10.35	69.43	36.71	13.85	6.73	6.41
97-08	4.96	19.42	19.46	6.88	3.47	3.58
n	145,877	4,973	5,256	14,327	71,711	49,610

[5] The earnings data that we use from the HLFS Income Supplements include both proxy responses and imputations. Although both could affect the reliability of the hourly earnings measures, they are less likely to be a serious problem where the focus is on year-to-year changes in aggregate minimum wage incidence rates. Hyslop and Stillman (2007, pp. 206-207) found some evidence of sample selection bias in omitting proxy and imputed responses in their individual-level analysis. We find no impact on our key findings in this study when we include in our regression models the aggregate proportions of proxy and imputed responses for different age groups over time.

[6] We removed from our sample individuals aged less than 16 and more than 65. In addition, we eliminated observations on individuals who reported being disabled, retired or self-employed, and those not receiving positive earnings or working positive hours. Because the Minimum Wage Act 1983 makes reference only to 'workers' and 'employees', minimum wage protection does not appear to extend to the self-employed. In addition, the self-employed are notoriously prone to measurement error in their reported earnings and tend to display idiosyncratic behaviour. Like previous Australian studies (see, Harding and Richardson, 1999; Healy and Richardson, 2006; and Leigh, 2007), we believe that these reasons justify the exclusion of the self-employed from this analysis.

Table 2b - Minimum Wage Incidence Rates in New Zealand: Broad Incidence in Percentage Terms: June 1997 to June 2008

		Ages:				
Year	*All*	*16 or 17*	*18 or 19*	*20 to 24*	*25 to 44*	*45 to 64*
1997	4.23	5.87	2.66	7.04	3.72	4.09
1998	2.95	6.72	0.96	4.80	2.57	2.73
1999	3.02	8.87	1.52	4.81	2.97	2.10
2000	2.99	5.81	2.14	5.03	2.54	2.88
2001	4.22	12.56	29.22	5.03	2.87	2.49
2002	4.96	24.03	28.35	7.45	2.96	2.63
2003	5.21	30.21	27.05	8.03	2.95	2.63
2004	5.84	32.13	26.96	6.88	3.77	3.75
2005	5.64	22.17	32.54	6.92	3.36	4.12
2006	10.46	29.91	41.04	16.68	7.59	7.78
2007	12.38	36.36	48.48	19.55	9.27	9.03
2008	14.72	78.39	52.74	21.49	9.94	9.94
97-08	6.59	25.32	25.51	9.44	4.54	4.85
n	145,877	4,973	5,256	14,327	71,711	49,610

Notes: Data in this table were taken from the 1997 to 2008 HLFS Income Supplements. Minimum wage workers are defined as those receiving usual, regular-time hourly earnings either at or below the statutory minimum wage for their age group in effect at the time of the survey (table 2a), or 5 per cent above this age-relevant minimum wage or below (table 2b).

As expected, increases in minimum wage incidence rates were vastly different across the age groups. Younger teenagers experienced large increases in minimum wage incidence in 2001, 2002 and after 2006. These correspond to the large statutory increases in minimum wages for this age group, and the gradual elimination of the lower youth rate in three of these four years. Older teenagers experienced the largest single annual increase in minimum wage incidence with the elimination of their lower youth rate in 2001. Adult workers only began to experience appreciably higher incidence rates after 2005. By 2008, minimum wage incidence rates for workers aged 20 to 24, 25 to 44 and 45 to 65 were at least double any figure prior to 2006 for these adult age groups. These relative differences in incidence rates in response to age-specific changes in minimum wages are the keys to decomposing the incidence patterns observed in tables 2a and 2b.

3. A Methodology for Interpreting Changes in Minimum Wage Incidence Rates

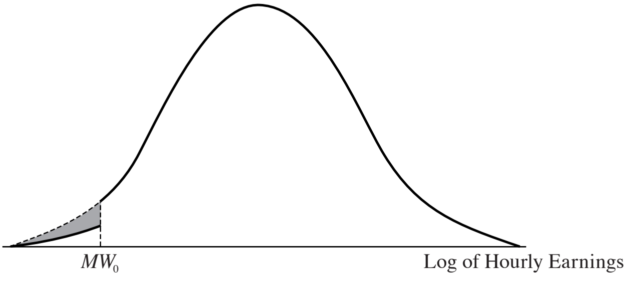
Year-to-year changes in minimum wage incidence rates for group i (ΔP_{it}) are the sum of three distinct factors. Mechanical effects (ΔP_{it}^{M}) capture the impact on the incidence rate from a rise in the minimum wage assuming a constant wage distribution. Behavioural effects (ΔP_{it}^{B}) measure the reduction in the incidence rate from any disemployment effects associated with a higher minimum wage. Other labour market effects (ΔP_{it}^{O}) summarise all remaining factors that could alter the position or shape of the wage distribution between periods.

$$\Delta P_{it} = \Delta P_{it}^{M} + \Delta P_{it}^{B} + \Delta P_{it}^{O} \qquad (1)$$

All of these differences are with respect to the observed minimum wage incidence rate for this group in the previous year (e.g., $\Delta P_{it} = \Delta P_{it} - \Delta P_{it\text{-}1}$)

To motivate our approach, consider the hypothetical log-wage distribution in figure 2. The current minimum wage is given by MW_0. The lightly-shaded area depicts the possible loss in low-wage jobs as a result of this wage floor. Note that some jobs with wages below this minimum wage survive. If all jobs with wages below the minimum wage were eliminated, then the shaded area would cover this entire region to the left of MW_0 (i.e., the wage distribution would be effectively censored at this wage floor). The minimum wage incidence rate is then the ratio of non-shaded area under the wage distribution at and to the left of MW_0 relative to the area under this entire wage distribution.

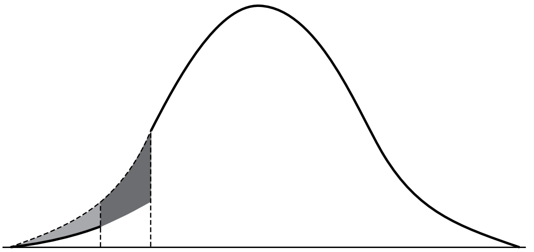
Figure 2



The mechanical effect is easy to estimate when we rule out any behavioural or other labour market effects that might influence changes in this incidence rate. This can be done by simply imposing next year's higher minimum wage MW_1 on the current wage distribution (see figure 3). Because this higher minimum wage did not exist in the earlier period, it shouldn't result in any behavioural effects.[7] Also, because both the current and next year's minimum wage are being imposed on the same wage distribution, we can rule out other labour effects impacting this incidence rate. The mechanical effect is simply the hypothetical increase in the incidence rate in moving from MW_0 to MW_1 for a given wage distribution. It's the ratio of the combined shaded and non-shaded areas under the wage distribution between these minimum wages relative to the area under the entire wage distribution.

[7] This assumes that employers do not eliminate low-wage jobs due to the expectation of a higher minimum wage in the following year. This seems reasonable in New Zealand, since minimum wage rises are usually announced three to six months prior to their enactment in March of each year. Hyslop and Stillman (2007) found evidence of 'announcement effects' in their analysis of the recent changes to minimum wages in New Zealand using quarterly data. Because we use annual data, any announcement effects in our study would have to occur one year before legislated changes. The vast majority of newspaper coverage of the two major changes to teenage minimum wages in March 2001 and March 2008 occurred within six months of their implementation. In fact, the Government announced in June 2000 that it was going to drop impending reforms to the minimum wage scheduled for the following year (Pacheco and Naiker, 2006), and only reinstated these changes at the end 2000. Given the annual gaps in our data and media coverage of impending changes to minimum wages, we believe that it is unlikely that announcement effects need to be considered in our analysis.

Figure 3



The actual, observed change in minimum wage incidence can also be depicted in figure 3 (ignoring for the time being any changes in the shape or position of the wage distribution between years). It's the ratio of the non-shaded area under the wage distribution between MW_0 and MW_1 relative to the area under the entire wage distribution. The behavioural effect is represented by the darkly-shaded area between these minimum wages. This is the loss in low-wage jobs as a consequence of this higher minimum wage. The larger this behavioural effect, the smaller the observed change in the actual minimum wage incidence rate relative to the earlier mechanical effect. Thus, we can re-write equation 1 in the following way:

$$\Delta P^{*}_{it} = \Delta P_{it} - \Delta P^{M}_{it} = \Delta P^{B}_{it} + \Delta P^{O}_{it} \quad (2)$$

The difference between the actual change in minimum wage incidence and the estimated mechanical effect is expressed as ΔP^{*}_{it}. This difference can come from either the behavioural effects associated with the minimum wage or any other labour market factors that may have changed the position or shape of the wage distribution between periods. The difficult part of this analysis is disentangling these two final components.

Suppose that the behavioural effect for group i in period t is a linear function of the change in this group's actual minimum wage ΔMW_{it} over the time period and an additive i.i.d. disturbance term ε_{it}.

$$\Delta P^{B}_{it} = \beta \Delta MW_{it} + \varepsilon_{it} \quad (3)$$

The slope coefficient β measures the behavioural response in terms of the possible loss in low-wage jobs and the corresponding reduction in minimum wage incidence. A negative value on β suggests the existence of these disemployment effects.

Other labour factors that alter the shape or position of the wage distribution can be captured by a complete set of group-specific and time-specific dummy variables (δ_i, γ_t) and an i.i.d disturbance term v_{it}.

$$\Delta P^{O}_{it} = \delta_i + \gamma_t + v_{it} \quad (4)$$

Substituting equations 3 and 4 into equation 2 we get the following

$$\begin{aligned}\Delta P^*_{it} = \Delta P^B_{it} + \Delta P^O_{it} &= \beta \Delta MW_{it} + \varepsilon_{it} + \delta_i + \gamma_t + v_{it} \\ &= \delta_i + \gamma_t + \beta \Delta MW_{it} + (v_{it} + \varepsilon_{it}) \\ &= \delta_i + \gamma_t + \beta \Delta MW_{it} + u_{it}\end{aligned} \tag{5}$$

The difference between the actual change in the minimum wage incidence rate and the estimated mechanical effect (ΔP^*_{it}) depends on a group-specific effect, a common time-specific effect, the change in the age-relevant minimum wage and a composite disturbance term.

The two-way, fixed-effects specification for equation 5 requires some variation in annual changes in minimum wages over time and between groups in order to identify β. Without this intergroup variation, the common time effects would be perfectly collinear with changes in the minimum wage. This is the reason why New Zealand's age-specific changes in minimum wages over our sample period are essential for this decomposition.

Our methodology has the added advantage of mitigating the possible effects of measurement error associated with minimum wage incidence that are estimated from a random sample of households. The appendix to this paper shows more formally how this regression specification, allowing for first-differencing and controlling for mechanical effects of a rising minimum wage, can eliminate various types of measurement error.

4. Empirical Results

Changes in actual minimum wage incidence rates for all age groups over the sample period can be computed from the data listed in tables 2a and 2b. Sample means for this variable $\Delta \overline{P}$ are shown in the first rows of tables 3a and 3b for the narrow and broad minimum wage incidence definitions, respectively. These mean values were approximately 2.1 and 2.7 percentage points. The positive values are consistent with the substantial increases in minimum wages over our sample period. We also find that changes in the actual minimum wage incidence rates are larger if we allow for longer time gaps between observations. For two-year gaps, these mean changes are nearly 11.6 and 15.4 percentage points using the narrow and broad measures, respectively. For three-year gaps, these means increase further to 12.5 and 16.6 percentage points using these alternative definitions. Changes in incidence rates for time intervals ranging from one to three years will be used in our subsequent regression analysis.[8]

As explained earlier, applying a future minimum wage to this year's wage distribution gives us a measure of the mechanical effect of this policy change. Sample means for this variable ($\Delta \overline{P}^M$) are displayed in the second rows of tables 3a and 3b. If there had been no behavioural or other labour market effects, we estimate that these minimum wage incidence rates would have increased by an average of approximately 6.9 and 7.0 percentage points between adjacent years using our narrow and broad definitions, respectively. These mechanical effects grow with an increase in the time gaps between observations. If minimum wages two years into the future were applied to the current wage distribution, the mean incidence rates would have increased by 20.7 and 23.8 percentage points. These hypothetical increases in incidence rates would be even larger if minimum wages three years into the future were used for this purpose (26.6 and 29.8 percentage-points).

[8] Although 145,877 individual observations on hourly earnings were used to estimate these minimum wage incidence rates in tables 2a and 2b, our regression analyses are based on the smaller numbers of aggregate annual, age-group incidence rates displayed in tables 3a and 3b.

Table 3a - Sample Means for Percentage Point Changes in Actual and Mechanical Minimum Wage Incidence Rates for Varying Time Gaps: Narrow Incidence in Percentage Terms: June 1997 to June 2008

	Time Differences		
Variable	*One Year*	*Two Years*	*Three Years*
$\Delta\bar{P}$	2.058	11.570	12.458
$\Delta\bar{P}^{M}$	6.850	20.708	26.551
$\Delta\bar{P}^{*}=\Delta\bar{P}-\Delta\bar{P}^{M}$	-4.793	-9.138	-14.093
n	55	50	45

Table 3b - Sample Means for Percentage Point Changes in Actual and Mechanical Minimum Wage Incidence Rates for Varying Time Gaps: Broad Incidence in Percentage Terms: June 1997 to June 2008

	Time Differences		
Variable	*One Year*	*Two Years*	*Three Years*
$\Delta\bar{P}$	2.711	15.358	16.614
$\Delta\bar{P}^{M}$	7.017	23.781	29.752
$\Delta\bar{P}^{*}=\Delta\bar{P}-\Delta\bar{P}^{M}$	-4.306	-8.422	-13.138
N	55	50	45

Notes: Sample means are computed across the five age groups: $\Delta\bar{P}$ is the percentage-point change in the actual, observed minimum wage incidence rate between years; $\Delta\bar{P}^{M}$ is the percentage-point change in the mechanical minimum wage incidence rate in applying the future minimum wage to the present wage distribution; and $\Delta\bar{P}^{*}$ is the difference between these two variables. This last variable is the dependent variables used in our subsequent regression analysis.

The differences between the actual changes in minimum wage incidence rates and the estimated mechanical changes will be used as the dependent variables in our regression analysis. The sample means for these dependent variables ($\Delta\bar{P}^{*}=\Delta\bar{P}-\Delta\bar{P}^{M}$) are listed in the third rows of tables 3a and 3b for the narrow and broad definitions, respectively. All of these means are negative, indicating that the combined effects of the behavioural and other labour market factors would have decreased minimum wage incidence rates over time. It is easy to interpret these results. On average, next year's minimum wage would have increased minimum wage incidence rates by approximately seven percentage points using both the narrow and broad definitions. Since actual incidence rate increased by between two and three percentage points, the difference must be attributable to either behavioural responses to these policy changes and/or other changes to the shape and position of the wage distribution.

Main Regression Results

We separate the behavioural and other labour market effects by estimating the basic regression model depicted in equation 5. This two-way, fixed-effects specification includes dummy variables for four of the five age groups and ten of the eleven years, and the percentage change in the relevant age-specific minimum wage ΔMW_{it}. Table 4 displays the results from this regression analysis.

Table 4 - Regression Results on Difference between Actual and Mechanical Incidence Rates ($\Delta\bar{P}^*$): One-Year Time Difference: Two-Way Fixed-Effects Estimation

Explanatory Variable	*Narrow Incidence*	*Broad Incidence*
Constant	2.453	1.529
	(2.030)	(1.681)
Ages 16 or 17	-6.398 ***	-5.457 ***
	(1.676)	(1.564)
Ages 18 or 19	-7.175 ***	-5.304 ***
	(1.851)	(1.450)
Ages 20 to 24	-2.511 **	-2.335 **
	(1.098)	(0.932)
Ages 45 to 64	-0.103	-0.150
	(1.190)	(0.901)
Year 1999	1.154	1.618
	(2.671)	(2.284)
Year 2000	-1.775	-1.185
	(2.330)	(2.076)
Year 2001	-2.361	-2.865
	(1.952)	(1.700)
Year 2002	-1.389	-1.650
	(2.035)	(1.907)
Year 2003	-4.151 *	-3.233 *
	(2.144)	(1.768)
Year 2004	-5.180 **	-4.987 **
	(2.126)	(2.130)
Year 2005	-4.287	-4.385
	(3.200)	(2.835)
Year 2006	-8.259 **	-6.182 **
	(3.149)	(2.348)
Year 2007	-8.934 ***	-6.444 ***
	(2.484)	(2.305)
Year 2008	-10.971 ***	-7.377 ***
	(2.449)	(1.688)
Change Minimum Wage – Own Age Group	**0.025**	**0.020**
	(0.027)	**(0.025)**
Mean of Dependent Variable ($\Delta\bar{P}^*$)	-4.793	-4.306
R^2	0.701	0.632
N	55	55

***, **, and * denote being significantly different from zero at a 1, 5 and 10 per cent level using two-tailed *t* test, respectively.

Notes: See the notes at the bottom of table 2b for details on the construction of this dependent variable. White-corrected standard errors are reported. The Baltagi-Wu LBI Test for panel data was used, but the residuals showed no statistical evidence of first-order autocorrelation.

The estimated coefficients on the teenage dummy variables are negative and statistically significant at better than a one per cent level using both incidence definitions. They suggest that, relative to prime-age adults (i.e., the excluded 25 to 44 year-old age group), changes in the teenage wage distributions would have reduced their minimum wage incidence rates by an average of at least five percentage points from one year to the next without these annual increases in statutory minimum wages. The estimated coefficients on the young adult dummy variable (ages 20 to 24) is relatively smaller in magnitude, but still statistically significant at better than a 5 per cent level. They suggest that, relative to prime-age adults, the incidence rate for young adults would decline by an average of at least two percentage points from one year to the next without annual increases in minimum wages.

The estimated coefficients on the time dummies are generally negative and statistically significant after about 2002. This corresponds to a general expansion in the New Zealand economy with real GDP growing above long-term trends and the unemployment declining from over 7 per cent in 1999 to under 4 per cent by 2008. This time pattern suggests that other labour market factors had increasingly larger negative effects on incidence rates during this expansion period. In other words, minimum wage incidence would have generally declined across the age groups as a direct result of this rapid economic growth.

Turning to the key results, we find that the estimated coefficients on the growth rates in nominal minimum wages over the preceding year are positive, but not statistically significant at conventional test levels.[9] Thus, we find no evidence of any behavioural effects associated with changes in age-specific minimum wages. Therefore, as shown earlier in tables 3a and 3b, the mean gaps between actual changes in minimum wage incidence rates and the mechanical effects ($\Delta\bar{P}^* = \Delta\bar{P} - \Delta\bar{P}^M$) of -4.8 and -4.3 percentage points (using the narrow and broad definitions, respectively) can be entirely explained by other labour market factors. Behavioural effects did not play a significant role in these observed patterns.

The Importance of Common Time Effects

Our two-way, fixed-effects specification assumes that the year effects are common to all age groups. This would be inappropriate if business cycle or policy related effects varied across the age groups. A complete interaction between the age-group and time dummies would be impossible, as this would use up all the degrees of freedom in the regression model. To test the robustness of our key results, we instead replace common time dummies with interaction terms between some indicator for cyclical position of the aggregate economy and these age-group dummies. We want to know if the absence of a behavioural effect in our regressions depends on the omission of different cyclical responses across the age groups. Real per capita GDP and the prime-age unemployment rate are alternatively used as our cyclical indicators.

Although these auxiliary regression results are not reported in this paper, they can be quickly summarised. When common time dummies were excluded and age-specific cyclical responses were included, the estimated coefficients on the growth rate in the nominal minimum wage were uniformly negative, but again not statistically significant at a ten per cent level using either real per capita GDP or the prime-age unemployment rate as a cyclical indicator with both the narrow and broad definitions of minimum wage incidence. These results suggest that the absence of any behavioural effects from changes in minimum wage incidence rates do not necessarily depend on the assumption of common time effects across the age groups.[10]

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[9] These are changes in nominal minimum wages between years for a specific age group. Any deflation of these growth rates by the general price or average hourly earnings in the economy are unnecessary because of the inclusion of a complete set of time dummies in these regressions.

[10] It is also possible that the relationship between incidence rates and changes in the minimum wage may not be linear. For example, higher minimum wages may lead to behavioural effects only afterthey reach some unknown threshold. Various nonlinear specifications were specifications were tried (e.g., including the growth rate in the nominal minimum wage and its squared term). In none of these experiments, did we find any evidence of a statistically significant behavioural effect.

We also test the robustness of these regression results around the implementation of the Working for Families (WFF) programme between 2005 and 2007. The WFF policy used the tax system to create in-work incentives and family entitlements for single parents and couples with children. Previous studies have found that this programme altered the labour supply behaviour of eligible households (Fitzgerald, Maloney and Pacheco, 2008; and Dalgety *et al*., 2010). We allow for the possible effects of the WFF programme in our regressions by creating a variable that multiplies the estimated proportion of individuals in an age group who are potentially eligible for WFF benefits because of the presence of dependent children in their household with an indicator variable for the gradual phase-in of this programme (zero before 2005, 0.333 in 2005, 0.667 in 2006 and one after 2006). This WFF policy variable can be included in all of our previous regression specifications.

Due to the sheer volume of the regression results, we do not report the full results in this paper. However, they can be easily summarised. The estimated coefficients on the growth rate in the nominal minimum wage were either negative or positive, but never statistically significant at a ten per cent level when this WFF variable was included as a regressor using both the narrow and broad definitions of minimum wage incidence.

Direct and Indirect Minimum Wage Effects

Another possible source of misspecification in our basic regression model is the assumption that only a change in the specific age-relevant minimum wage can influence the incidence rate for a particular age group. Changes in the minimum wages of the other age groups could have indirect behavioural effects on a particular group's incidence rate. For example, an increase in the minimum wage for older teenagers could have behavioural effects on the incidence rate for younger teenagers. If younger teenagers are seen as substitutes for now more expensive older teenagers, then this higher minimum wage for the older group could create more low-wage employment for younger teenagers and increase their incidence rate. On the other hand, if employers base hiring decisions on both the immediate and future wages that they would have to pay younger teenagers as they age and move to higher statutory minimum wages, this could discourage the creation of low-wage jobs for this age group and lower their incidence rate.

Because of differences in annual minimum wage changes across the age groups over our sample period, we can allow for the effects from changes in minimum wages for all age groups on the incidence rates of any particular age group. Table 5 reports results from an alternative specification using our two-way, fixed-effects model, where we include four additional regressors capturing possible minimum wage changes for up to two younger and two older age groups. In our situation, each age group will face changes in minimum wages for at most two other groups: two older age groups for 16 and 17 year-olds; one younger and one older age group for 18 and 19 year-olds; and two younger age groups for adults aged 20 to 24.

Table 5 - Regression Results on Difference between Actual and Mechanical Incidence Rates ($\Delta\bar{P}^{*}$): One-Year Time Difference Two-Way Fixed-Effects Estimation: Allowing for Minimum Wage Changes from All Age Groups

Explanatory Variable	*Narrow Incidence*	*Broad Incidence*
Change Minimum Wage – Youngest Age Group	0.144 (0.097)	0.033 (0.067)
Change Minimum Wage – Next Younger Age Group	-0.058 ** (0.023)	-0.030 * (0.018)
Change Minimum Wage – Own Age Group	**0.016** **(0.030)**	**0.001** **(0.025)**
Change Minimum Wage – Next Older Age Group	-0.070 ** (0.029)	-0.094 *** (0.029)
Change Minimum Wage – Oldest Age Group	-0.551 (0.460)	-0.363 (0.489)
Mean of Dependent Variable ($\Delta\bar{P}^{*}$)	-4.793	-4.306
R^2	0.741	0.658
N	55	55
Sum of these Estimated Coefficients	-0.517	-0.454
F-Statistic (P-Value) on Sum Equal to Zero	1.180 (0.284)	0.800 (0.378)

***, **, and * denote being significantly different from zero at a 1, 5 and 10 per cent level using two-tailed *t* test, respectively.

Notes: See the notes at the bottom of table 2b for details on the construction of this dependent variable. White-corrected standard errors are reported. The Baltagi-Wu LBI Test for panel data was used, but the residuals showed no statistical evidence of first-order autocorrelation. A complete set of age group and time dummies were included in this estimation, but these results are not reported in this table.

The estimated coefficients on the own-age changes in minimum wages are positive under both the narrow and broad incidence definitions, but neither is significantly different from zero. The estimated coefficients on changes in minimum wages for the 'youngest' and 'oldest' other age groups are all statistically insignificant. However, the estimated coefficients on changes in minimum wages for the next closest age groups (both 'next younger' and 'next older') are negative and statistically significant under both the narrow and broad incidence definitions. These findings suggest that any behavioural effects on incidence rates tend to be indirectly related to changes in the minimum wages of adjacent age groups. For example, the results in table 5 suggest that ten percentage-point increases in minimum wages both for younger teenagers and adults aged 20 to 24 will reduce the narrow incidence rate of older teenagers by 0.58 and 0.70 percentage points, respectively. Our explanation hinges on these younger and older age groups being close substitutes in employment for older teenagers. When minimum wages increase for these adjacent age groups, it increases the labour demand for older teenagers and leads to a decline in their incidence rate through the creation of more non-minimum-wage jobs. These indirect effects would be positive if increases in minimum wages for younger and older individuals had created more minimum-wage jobs for older teenagers.

Although the estimated coefficients on the minimum wage variables are individually significant for adjacent age groups in table 5, the sums of the estimated coefficients across all direct and indirect minimum wage effects are not statistically significant. These summations are negative for both narrow (-0.517) and broad definitions (-0.454), but neither one is significantly different from zero at conventional test levels. Thus, we have to conclude that a general increase in the minimum wage does not have an overall statistically significant behavioural effect.

Two and Three-Year Minimum Wage Changes

It is possible that the absence of measureable behavioural effects in the preceding analysis was due to a relatively 'narrow window' for observing such responses. By looking at changes in minimum wages and incidence rates from one year to the next, we are assuming that these effects must occur within the year following these policy changes. Therefore, to check the robustness of our results, we widen this window to allow for changes in incidence rates over both two and three-year time gaps. Tables 3a and 3b display the intermediate steps in constructing these alternative dependent variables. The actual changes in incidence rates using both definitions increase steadily when the time difference increases from one to three years. This is due to steadily increasing effective minimum wages over our sample period.

Table 6 shows the results for the initial regression specification where we allow for a behavioural effect associated with only the change in the minimum wage for a given age group. When these observation windows are widened to two and three years, our sample sizes necessarily decline to 50 and 45 observations, respectively. Across both possible lag periods and both definitions of incidence rates, there is no evidence of the hypothesised disemployment effects. All four estimated coefficients on the minimum wage variable are positive, and those associated with a two-year lag are just significant at a ten per cent level under the broad definition.

Table 6 - Regression Results on Difference between Actual and Mechanical Incidence Rates ($\Delta\bar{P}^{*}$): Two and Three-Year Time Differences: Two-Way Fixed-Effects Estimation

	Two-Year Difference		*Three-Year Difference*	
Explanatory Variable	*Narrow Incidence*	*Broad Incidence*	*Narrow Incidence*	*Broad Incidence*
Constant	6.003	4.837	5.934	4.682
	(3.919)	(3.439)	(4.882)	(4.389)
Ages 16 or 17	-13.258 ***	-11.526 ***	-20.085 ***	-16.343 ***
	(2.474)	(2.367)	(3.153)	(2.995)
Ages 18 or 19	-13.912 ***	-10.925 ***	-20.192 ***	-16.178 ***
	(2.605)	(2.175)	(3.439)	(3.086)
Ages 20 to 24	-4.467 **	-4.200 ***	-6.898 ***	-6.948 ***
	(1.618)	(1.447)	(2.004)	(1.803)
Ages 45 to 64	-0.446	-0.645	-1.161	-0.652
	(1.750)	(1.520)	(2.071)	(1.860)
Year 1999	-2.042	-1.302	-4.988	-5.007
	(4.787)	(4.262)	(4.936)	(4.314)
Year 2000	-7.628 *	-8.475 **	-9.004 *	-9.173 *
	(3.935)	(3.689)	(5.256)	(4.961)

Table 6 - Regression Results on Difference between Actual and Mechanical Incidence Rates ($\Delta\bar{P}^*$): Two and Three-Year Time Differences: Two-Way Fixed-Effects Estimation (continued)

	Two-Year Difference		*Three-Year Difference*	
Explanatory Variable	*Narrow Incidence*	*Broad Incidence*	*Narrow Incidence*	*Broad Incidence*
Year 2001	-8.179 *	-7.429 *	-9.317 *	-8.515 *
	(4.244)	(4.010)	(4.839)	(4.334)
Year 2002	-7.884 *	-7.590 **	-10.849 **	-10.576 **
	(4.019)	(3.649)	(4.890)	(4.878)
Year 2003	-10.658 **	-11.242 ***	-13.030 **	-13.339 ***
	(4.010)	(3.776)	(4.849)	(4.396)
Year 2004	-11.022 **	-10.739 ***	-17.559 ***	-16.143 ***
	(4.173)	(3.620)	(5.173)	(4.588)
Year 2005	-14.976 ***	-13.098 ***	-21.476 ***	-18.039 ***
	(4.412)	(3.818)	(4.801)	(4.401)
Year 2006	-16.325 ***	-13.384 ***	-21.169 ***	-16.448 ***
	(3.965)	(3.421)	(5.300)	(4.732)
Year 2007	-19.551 ***	-15.973 ***		
	(4.566)	(3.818)	–	–
Change Minimum Wage – Own Age Group	**0.071**	**0.072 ***	**0.063**	**0.040**
	(0.042)	**(0.041)**	**(0.056)**	**(0.051)**
Mean of Dependent Variable ($\Delta\bar{P}^*$)	-9.138	-8.422	-14.093	-13.138
R^2	0.797	0.755	0.841	0.797
N	50	50	45	45

***, **, and * denote being significantly different from zero at a 1, 5 and 10 per cent level using two-tailed *t* test, respectively.

Notes: See the notes at the bottom of table 2b for details on the construction of this dependent variable. White-corrected standard errors are reported. The Baltagi-Wu LBI Test for panel data was used, but the residuals showed no statistical evidence of first-order autocorrelation.

Table 7 displays results from the more general specification that allows for a complete set of minimum wage variables across all age groups over these longer adjustment periods. Again, only the indirect effects on incidence rates from adjacent age groups have negative and significant effects. With the regression results using the two-year time lag reported in table 7, three of these four estimated coefficients are statistically significant at better than a one per cent level. The remaining estimated coefficient is significant at better than a five per cent level. These findings reinforce earlier conclusions about indirect behavioural effects that reduce incidence rates for an age group when the minimum wages increase for both slightly younger and older age groups. For example, we estimate that ten percentage-point increases in minimum wages of both young teenagers and young adults will reduce the narrow incidence rate over a two-year period of older teenagers by 1.00 and 1.82 percentage points, respectively. The estimated coefficients on the same variables are negative, and have roughly similar magnitudes in the regression based on a three-year adjustment period. Among the indirect minimum wage effects, the one associated with the next older age group is the only one that is consistently negative and statistically significant across both incidence definitions and all three time gaps. The minimum wage incidence rate for a given age group declines when the minimum wage is increased for the next older age group. There are two potential explanations for this result. Firstly, employers might eliminate minimum wage jobs for the younger age group in anticipation of having to eventually pay these individuals this higher wage when they move to this next age group. Secondly, employers might substitute immediately cheaper younger workers for these more expensive older workers, and yet pay younger workers sufficiently high wages to create non-minimum wage jobs and reduce the incidence rate.

Table 7 - Regression Results on Difference between Actual and Mechanical Incidence Rates ($\Delta\bar{P}^*$): Two and Three-Year Time Differences: Two-Way Fixed-Effects Estimation: Allowing for Minimum Wage Changes from All Age Groups

	Two-Year Difference		*Three-Year Difference*	
Explanatory Variable	*Narrow Incidence*	*Broad Incidence*	*Narrow Incidence*	*Broad Incidence*
Change Minimum Wage –	0.148	0.033	0.040	-0.055
Youngest Age Group	(0.109)	(0.170)	(0.121)	(0.112)
Change Minimum Wage –	-0.100 ***	-0.065 **	-0.085	-0.043
Next Younger Age Group	(0.036)	(0.031)	(0.071)	(0.066)
Change Minimum Wage –	**0.051**	**0.041**	**0.018**	**-0.002**
Own Age Group	**(0.040)**	**(0.033)**	**(0.067)**	**(0.061)**
Change Minimum Wage –	-0.182 ***	-0.209 ***	-0.186 ***	-0.187 ***
Next Older Age Group	(0.048)	(0.042)	(0.065)	(0.062)
Change Minimum Wage –	-0.314	-0.320	-0.406	-0.512
Oldest Age Group	(0.372)	(0.345)	(0.489)	(0.471)
Mean of Dependent Variable ($\Delta\bar{P}^*$)	-9.138	-8.422	-14.093	-13.138
R^2	0.852	0.826	0.866	0.828
N	50	50	45	45
Sum of these Estimated Coefficients	-0.397	-0.520	-0.620	-0.800 *
F-Statistic (P-Value) on Sum	1.160	2.330	1.810	3.340
Equal to Zero	(0.289)	(0.137)	(0.189)	(0.078)

***, **, and * denote being significantly different from zero at a 1, 5 and 10 per cent level using two-tailed t test, respectively.

Notes: See the notes at the bottom of table 2b for details on the construction of this dependent variable. White-corrected standard errors are reported. The Baltagi-Wu LBI Test for panel data was used, but the residuals showed no statistical evidence of first-order autocorrelation. A complete set of age group and time dummies were included in this estimation, but these results are not reported in this table.

It was shown in table 5 that a general increase in the minimum wage had no measurable effect on minimum wage incidence rates when we sum the estimated coefficients across all age groups. Although the sums of the estimated coefficients on these minimum wage variables are consistently negative under both narrow and broad definitions (see, table 7), we can only reject the null hypothesis that this overall effect is zero at slightly better than a ten per cent level for a three-year adjustment period under the broad definition (table 7, fourth column).

5. Conclusions

Minimum wage incidence rates can be defined as the proportion of workers receiving hourly earnings at or below the legal minimum wage. Such incidence rates are easily computed, widely reported, but difficult to interpret. Although an increase in the statutory minimum wage would be expected to increase incidence rates, this outcome could be curbed if employers respond by eliminating low-wage jobs. In addition, other changes can occur to the wage distribution that would alter this incidence rate. Thus, changes to minimum wage incidence rates over time would be the net effect of 'mechanical', 'behavioural' and 'other labour market' factors.

Although this decomposition of changes to minimum wage incidence rates is conceptually straightforward, the estimation of these three components requires a particular policy setting. The mechanical effect can be easily computed by applying a future (higher) minimum wage to the current wage distribution. The resulting difference between changes in the actual incidence rate and this mechanical effect, however, can be difficult to ascribe to either behavioural or other labour market effects. Recent changes to minimum wage policy in New Zealand provide a unique opportunity for isolating the behavioural component of the minimum wage incidence rate. This country began to steadily increase effective minimum wages after 1999, and eventually eliminated the substantially lower teenage minimum wage. The result was an overall increase in the real minimum wage for adults by over 30 per cent and teenagers by nearly 120 per cent by 2008.

The dependent variable in our regression analysis was the difference between actual changes in minimum wage incidence rates and computed mechanical effects. A complete set of age group and time dummies were used to control for other labour market effects in our main regression specification. The estimated coefficients on changes in minimum wages capture the behavioural effects. Two different definitions of minimum wage incidence rates were used, but the regression results were fairly similar between these narrow and broad definitions.

We find little evidence of any general behavioural effects in minimum wage incidence rates. A rise in the statutory minimum wage increases the incidence rate (the mechanical effect). This is offset by rightward shifts in the wage distribution that generally reduce incidence rates over time (other labour market effects). Although a higher minimum wage could reduce incidence rates by eliminating low-wage jobs, we find no direct evidence of this behavioural effect. We test the robustness of this result in several ways. The absence of an overall behavioural effect in our main two-way, fixed-effects regression is confirmed in alternative specifications that allow for different cyclical and policy responses across the age groups.

The only statistically significant behavioural effects are related to 'crosswage' effects, where higher minimum wages among slightly younger and older age groups reduce the incidence rate for a given age group. This result was consistently found for both the narrow and broad incidence definitions, and across varying time differencing for changes in incidence rates. One explanation for this finding is that higher minimum wages for individuals considered to be close substitutes by employers can lead to higher non-minimum-wage employment for another age group. These 'spill-over' effects might also arise if employers eliminate minimum wage jobs for one age group (e.g., younger teenagers) in anticipation of having to eventually pay them a higher statutory wage (e.g., when they become older teenagers). These indirect minimum wage effects highlight the complicated nature of the employment effects surrounding changes to statutory minimum wages for both researchers and policymakers.

Appendix

We consider the implications of measurement error affecting minimum wage incidence rates within the context of the regression model developed in section 3. Suppose that the incidence rate in adjacent years 0 and 1 have the following form for any age group *i*:

$$P_{i0} = \widetilde{P}_{i0} + \varepsilon_{i0} \qquad P_{i1} = \widetilde{P}_{i1} + \varepsilon_{i1} \tag{A.1}$$

Observed incidence rates are P_{i0} and P_{i1} while true incidence rates are $\widetilde{P}_{i0}$ and $\widetilde{P}_{i1}$. Measurement error (ε_{it}) can vary between years, but as long as it's classical in nature (i.e., zero mean and no serial correlation), then the expected value of the observed change in the incidence rate is equal to the true change in this rate.[11]

$$E(P_{i1} - P_{i0}) = \widetilde{P}_{i1} - \widetilde{P}_{i0} + E(\varepsilon_{i1}) - E(\varepsilon_{i0}) \tag{A.2}$$
$$E(\Delta P_i) = \Delta \widetilde{P}_i$$

Now suppose that measurement is not classical, and contains both an age-specific constant α_i (e.g., related to systematic differences across the age groups in the misreporting of hours of work or the ways in which hourly earnings are constructed) and an age-specific component related to the level of the minimum wage $\eta_i MW_{it}$ (e.g., higher minimum wages could increase 'false non-compliances' due to measurement error, which might vary across age groups). Using the basic regression specification developed in section 3, we could write these incidence rates in the following way, with the composite disturbance terms shown in brackets:

$$P_{i0} = \delta_{i0} + \gamma_0 + \beta MW_{i0} + [\alpha_i + \eta_i MW_{i0} + \varepsilon_{i0}]$$
$$P_{i1} = \delta_{i1} + \gamma_1 + \beta MW_{i1} + [\alpha_i + \eta_i MW_{i1} + \varepsilon_{i1}] \tag{A.3}$$

Taking the difference between observed incidence rates eliminates any fixed age-specific bias, and taking the expectation eliminates classical measurement error.

$$E(P_{i1} - P_{i0}) = \Delta\delta_i + \Delta\gamma + \beta\Delta MW_i + [\alpha_i - \alpha_i + \eta_i \Delta MW_i + E(\varepsilon_{i1}) - E(\varepsilon_{i0})] \tag{A.4}$$
$$E(\Delta P_i) = \Delta\delta_i + \Delta\gamma + \beta\Delta MW_i + [\eta_i \Delta MW_i]$$

Although first-differencing eliminates any time-invariant, age-specific bias, it does not get rid of any bias related to the level of the minimum wage. However, accounting for the 'mechanical effect' of the wage floor can eliminate this remaining bias term. This is because this procedure projects that new higher minimum wage on the old wage distribution, creating an estimate of the increase in false non-compliances associated with this higher minimum wage.

[11] For simplicity in this discussion, we assume that the true incidence rates are nonstochastic.

Start with the first-differencing expression above in equation A.4, and subtract the mechanical from both sides of this expression.

$$E(\Delta P_i^*) = E(\Delta P_i) - E(\Delta P_i^M) = \Delta\delta_i + \Delta\gamma + \beta\Delta MW_i + [\eta_i \Delta MW_i] - E(P_{i1} | Period\ 0\ Wage\ Distribution) + P_{i0} \quad \text{(A.5)}$$

This gives us the expected dependent variable from our regression model ΔP_i^*. The essence of this mechanical effect is that it adds to the current incidence rate an estimate of what would have happened to this rate if the minimum wage had increased to the level prevailing in period 1 (i.e., false non-compliances $\eta_i \Delta MW_i$), in the absence of any behavioural effect using the wage distribution in period 0.

$$E(\Delta P_i^*) = \Delta\delta_i + \Delta\gamma + \beta\Delta MW_i + [\eta_i \Delta MW_i] - \delta_{i0} - \gamma_0 - \beta MW_{i0} - \eta_i MW_{i1} + \delta_{i0} + \gamma_0 + \beta MW_{i0} + \eta_i MW_{i0} \quad \text{(A.6)}$$

Everything associated with this mechanical effect cancels out on the right-hand side, except the age-specific bias term associated with this changing minimum wage. Subtracting this mechanical effect eliminates the remaining bias term from first-differencing in equation A.4.

$$\begin{aligned} E(\Delta P_i^*) &= \Delta\delta_i + \Delta\gamma + \beta\Delta MW_i + [\eta_i \Delta MW_i] - [\eta_i \Delta MW_i] \\ &= \Delta\delta_i + \Delta\gamma + \beta\Delta MW_i \end{aligned} \quad \text{(A.7)}$$

We end up with what we want, a two-way, fixed-effects regression model where β measures the behavioural effect of a change in the minimum wage. Thus, our regression approach has the potential of eliminating both classical and some forms on non-classical measurement error associated with minimum wage incidence rates.

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