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Wage Formation and the Swedish Labour Market Reforms 2007-2009

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1 Introduction

The current liberal-conservative Swedish government has implemented substantial labour market reforms with the aim of raising employment. The reforms comprise an introduction of an earned income tax credit (EITC) in several steps, a reduction in unemployment benefits and reductions in payroll taxes.

The potential effects of these reforms have been hotly debated. It particular, there has been much disagreement over the mechanisms through which the reforms are likely to affect employment. The Swedish Fiscal Policy Council (2010) has emphasised the importance of effects on wage formation. Despite being supported by economic theory, this view has been considered controversial. Henrekson (2010) argues that the EITC has not led to lower wages and therefore to lower hiring costs. His view is that the main effect of the EITC is to boost the disposable incomes of the already employed.

There exist a number of empirical studies on Swedish data which highlight the likely effects of the labour market reforms. Two earlier studies have examined the effects of changes in unemployment benefit levels. Carling et al. (2001) found that the cuts in the unemployment benefit replacement rate by five percentage points in 1996 led to an increase in the job-finding rate of the unemployed of about ten per cent. Bennmarker et al. (2005) found significant, negative effects of the benefit hikes in 2001-2002 on the job-finding rate among men but not among women. At the macro level, Forslund et al. (2008) and Westermark (2008) found significant positive effects of the level of unemployment benefits on wages.

Turning to the tax reforms, the literature may be divided into three strands: studies of the effects of changes in marginal taxes and progressivity, studies of the effects of the tax credit and studies of the effects of changes in payroll taxes. Within the first strand, Holmlund and Kolm (1995) found that declines in tax progressivity raise wage pressure and therefore contribute to higher equilibrium unemployment. Forslund and Kolm (2004) could not, however, confirm these findings. Holmlund and Söderström (2008) estimated dynamic income effects of exogenous changes in tax rates and progressivity using a large panel of taxpayers 1991-2002. While they did not find any significant effect for women, for men the long-run elasticity of taxable income with respect to the net-of-tax rate (one minus the marginal tax rate) was found to lie within the range .1-.3.

Within the second strand, SNS (2008), Finansdepartementet (2009, 2010) and Flood (2010) have simulated models of labour supply and concluded that the EITC reforms are likely to have substantial positive effects on both employment and total hours worked. Edmark et al. (2010) estimated short-run effects on labour supply, but found no significant effects. Their empirical strategy was to use the fact that the EITC varies across municipalities, thereby

generating some exogenous variation. It is likely, however, that this variation is too small to help identify effects.

Finally, within the third strand, Bennmarker et al. (2009) studied whether the payroll tax reductions given to firms in the north of Sweden in 2002 had any effects on employment and the average wage bill per employee. While they detected no significant effects on the former variable, they found positive effects on the latter in their most credible specification.

A drawback of most of the studies mentioned is that they fail to take into account effects operating via wage formation.[1] This is somewhat surprising as the issue has been much debated. The objective of this report is to empirically assess the effects of the labour market reforms 2007-2009 on wage formation. We estimate wage equations for individuals, using detailed micro data from the LINDA database over the period 2004-2009.

We base the empirical analysis on a theoretical framework that allows us to identify several channels through which the reforms may have affected wage formation. First, a lower after-tax unemployment insurance replacement rate (net replacement rate) may have led to wage restraint. Second, a reduction in average taxes has led to a more progressive tax scheme which is also likely to have lowered wages. Third, the reductions of payroll taxes may have had a wage-raising effect.

The presentation is organised as follows. Section 2 describes the reforms relevant to wage formation 2007-2009. Section 3 summarises the theoretical framework. Section 4 discusses our empirical strategy and how to take the theory to the data. Section 5 describes the data. Results are presented in Section 6. Section 7 concludes.

2 The labour market reforms of 2007-2009

The labour market reforms 2007-2009 comprise a decrease in unemployment benefits and tax reforms: notably the introduction of an EITC, rises in the threshold for paying the state income tax and reductions in payroll taxes. The reforms are described chronologically below.

As of January 1 2007, the replacement rate of the income-dependent unemployment benefits was made dependent on unemployment duration. An unemployed worker now has a before-tax replacement rate of 80 percent for the first 200 days. After 200 days the replacement rate drops to 70 percent for the next 100 days (250 days for parents of minors). After that, an unemployed worker receives 65 per cent of the earlier wage indefinitely within the job and activity guarantee. These changes imply a gradually falling replacement rate for those below the maximum benefit level, which is SEK 680. Earlier the maximum benefit level for the first 100 days of unemployment was SEK 730,

[1] Kolm and Tonin (2011) have analysed the effects of EITC in a theoretical framework and argue that such tax credits lower wages.

but it was also reduced to SEK 680 on January 1 2007, so that the maximum benefit level is now the same throughout the unemployment spell.

Since the maximum benefit level has been held constant in nominal terms since 2002, there has been a gradual reduction of the replacement rate for high-income earners as their wages have increased. There has been a similar erosion of the replacement rate for those who are not members of an unemployment insurance fund and therefore do not receive an income-dependent benefit, but only the minimum benefit level of SEK 320, which has also been held nominally fixed.

Turning to the tax reforms, an EITC was introduced on January 1 2007. The design of the EITC is simple: all working individuals receive the tax credit, regardless of civil status or number of children in the household. The tax credit implies that income up to a certain level is not taxed at all and income above this threshold level is taxed less than prior to the reform. As a share of income, low-income earners received the largest tax cuts. In addition to the EITC, a number of reforms targeted at specific groups were implemented in 2007. The reforms likely to be most relevant to wage formation are the reductions in payroll taxes for those below 25 as of January 1 2007 (from 32.4 to 21.3 per cent). Then also so-called start jobs for long-term unemployed were introduced as a complement to traditional labour market programmes: no pay-roll taxes have to be paid for employees on new start jobs.

In 2008, the only change to taxes on income from labour was an expansion of the EITC, effective as of January 1.

The government expanded the EITC further as of January 1 2009. In particular, people above the age of 65 obtained a significantly higher tax credit than younger workers. The government also raised the threshold for paying the state income tax by SEK 18 100 annually. This lowered the marginal tax rate by 20 percentage points for about 180 000 individuals (Swedish Fiscal Policy Council 2009). There was also a general reduction in the payroll tax rate of one percentage point from January 1 2009. From the same date, the subsidy to employers for new start jobs was doubled (implying a reduction of the wage cost by double the amount of the ordinary pay-roll tax). There was also an additional cut in payroll taxes for young people (from 21.3 to 15.5 per cent) and the reductions were extended also to 25-year olds.

In addition to affecting the after-tax replacement rate the tax reforms have affected the progressivity of the tax system. As discussed by Forslund (2008), the introduction of the EITC has mainly lowered average taxes while leaving marginal tax rates more or less intact.

3 Effects of the reforms: theory

To assess the effects of the labour market reforms theoretically, we draw on the search and matching model of Cahuc and Zylberberg (2004). In this section, we summarise the theoretical mechanisms. The full model is reported in detail in Appendix A1.

The model describes an economy that consists of a large number of identical firms and workers. Firms produce a homogenous good using labour as the only input. Households choose how much to work and consume the good supplied by firms in a perfectly competitive market. The government levies income taxes on labour and payroll taxes on firms. Unemployed workers search for employment and the number of successful matches depends on the number of vacancies posted by firms and the number of unemployed workers competing for jobs. Wages are set in so-called Nash bargaining between the worker and the firm. One can show that in equilibrium, the real wage of each worker can be represented by the following function:

$$w = w(\rho, \mu, \theta, \tau_F; r, q, \lambda). \tag{1}$$

Expression (1) states that the hourly real wage of the worker depends on the after-tax replacement rate, ρ; the progressivity of the tax system, μ; the ratio of vacancies to unemployment, θ; the payroll tax rate, τ_F; the subjective discount rate, r; the job separation rate, q; and the relative bargaining power of workers, λ.

The theory suggests that the implemented reforms can affect the wage through: (i) the net replacement rate, ρ; (ii) tax progressivity, μ; and (iii) the payroll tax rate, τ_F.

4 Empirical strategy

4.1 Taking the model to the data

We study individuals who are employed at least once during the sample period. This implies that the relevant replacement rate should be based on the unemployment benefit the employed worker would obtain if he were to become unemployed, i.e. the outside option.

In what follows we let W denote the nominal wage, while w denotes the real wage. In the empirical work, we start out from a nominal wage equation on the form:

$$W_{it} = \widetilde{W}(\rho_{it}, \mu_{Eit}, \theta_t, p_t), \tag{2}$$

where p is the price level, and subscript *i* indicates the individual and subscript *t* the time period. Let ω_{it}^e denote the expected gross nominal wage, i.e. the nominal wage rate times working time, and u_{it}^e the expected unemployment duration of each worker. The after-tax replacement rate and the elasticity capturing income tax progressivity, ρ_{it} and μ_{Eit}, respectively, are defined as:

$$\rho_{it} = \frac{B_{it}(\omega_{it}^e,\ u_{it}^e) - \tilde{T}_U(B_{it})}{\omega_{it}^e - \tilde{T}_E(\omega_{it}^e)} \tag{3}$$

$$\mu_{Eit} = \frac{\left(1 - \tilde{T}_E'(\omega_{it}^e)\right)}{\left(1 - \tilde{T}_E(\omega_{it}^e)/\omega_{it}^e\right)}, \tag{4}$$

where B_{it} denotes nominal unemployment benefits and $\tilde{T}_U$ and $\tilde{T}_E$ denote nominal taxes on unemployment benefits and income from work, respectively. Since the level of unemployment benefits depends on income and decreases over time, B_{it} is a function of the expected gross wage but also of the expected unemployment duration of each worker.

Because of lack of data on payroll taxes for individuals, we attempt to control for the reduction in payroll taxes for young people by including a dummy that assumes the value one if the individual is younger than 25 in 2007 and 2008, and younger than 26 in 2009. This is a crude approximation but the best we can do in the absence of knowledge of the individual's workplace.[2]

4.2 Endogeneity issues

A challenge when estimating wage equations of the form (2) is the endogeneity of the replacement rate and progressivity to the wage level. To make the replacement rate and the progressivity variable exogenous to the wage, we use wage forecasts when computing these variables. We proceed as follows.

We begin by computing the growth of each employee's nominal wage per unit of time from year $t-1$ to t:

$$\gamma_{it} = \frac{W_{it} - W_{it-1}}{W_{it-1}}, \tag{5}$$

where W_{it} denotes each individual's wage in period t. The average wage growth is the arithmetic mean of these values, i.e. $\gamma_{Wt} = \frac{1}{N}\sum_{i=1}^{N}\gamma_{it}$. We then compute the expected individual wage per unit of time in year t as:

$$W_t^e = (1+\gamma_{Wt})W_{it-1}^e. \tag{6}$$

This process in repeated for each sample year. Each year each individual's predicted wage per unit of time is extrapolated using aggregate wage growth from the preceding year. The result is a set of predicted individual wages.

We then base the replacement rate and our measure of progressivity in equation (2) on these predicted values, i.e. we estimate:

$$W_{it} = W(\rho_{it}(\omega_{it}^e), \mu_{it}(\omega_{it}^e), \theta_t), \tag{7}$$

where $\omega_{it}^e = W_{it}^e l_{t-1}$.

Since the replacement rate also is a function of the expected unemployment duration, we need to make some assumptions along this dimension, too. We assume that expected unemployment is given by the mean number of days in unemployment in the wage decile of the worker.

[2] The interest rate, *r*, the separation rate, *q* and the bargaining strength of workers, λ, have also been excluded from the estimations.

There is also a theoretical rationale for why the predicted, rather than the actual, wage should enter as an argument on the right-hand-side of (7). Recall that since we are studying employed workers, they base their outside option in wage bargaining on the replacement rate they perceive that they would obtain in the event of unemployment. This replacement rate is in turn a function of the wage that the worker obtains when he becomes unemployed. When bargaining over the wage, the worker must therefore form some expectation about his wage in the future if he is separated from his job. It may be reasonable to assume that the worker would base such an expectation on his current wage and extrapolate it in accordance with the overall evolution of wages.

4.3 Econometric specification

We estimate wage equations in first differences, i.e. on the form:

$$\Delta lnW_{it} = \alpha + \beta\Delta\rho_{it} + \gamma\Delta\mu_{it} + \delta\Delta\theta_t + \phi\Delta p_t + \sum_j \varphi_j x_{ijt} + \epsilon_{it}, \quad (5)$$

where Δp is the rate of CPI inflation and the $x_j : s$ denote $j = 1, \dots, J$ control variables. By estimating first differences we may account for individual fixed effects as well as individual characteristics that vary over time by including a set of control variables.[3] The rate of inflation enters as a regressor as we choose to estimate the wage equation with the nominal and not the real wage as dependent variable.

In our estimations we control for a range of factors typically found to affect the wages of individual employees. Instead of labour market tightness, we include the unemployment rate at the municipality level to control for the state of the labour market. Provided that there is a stable Beveridge curve (relationship between vacancies and unemployment) at the municipal level, there is a one-to-one relationship between labour market tightness and unemployment. The full set of explanatory variables is described in detail in Section 5.1.

As a benchmark, we estimate (5) over the period 2006-2009. In addition, we estimate equations separately for each year and for different quartiles of the wage distribution.

5 Data

5.1 The Dataset

We use data from the LINDA database, including register data and survey-based information on wages. The database contains a large sample of individuals 18-64 years of age. We select individuals who were employed at least once during the period 2004-2009 and follow them over time. The

[3] A first-difference model is equivalent to a fixed-effect model in levels.

database holds detailed information on a number of factors typically found to affect earnings at the individual level. These include age, working time, civil status, educational level, educational type, place of birth and earlier unemployment. We also have information on unemployment in the municipality. Throughout the analysis, our dependent variable is the nominal wage per unit of time, scaled as a yearly wage.

5.2 Descriptive statistics

Table 1a shows the evolution of key variables over time. In addition to mean values, we include standard deviations as well as minimum and maximum values of the variables. In what follows, the net replacement rate and progressivity are based on wage forecasts according to the description in Section 4.2 unless otherwise stated.

The mean wage has been increasing over time and, as can be seen from the maximum and minimum values, there is large wage dispersion in the sample. Consistent with our priors, the mean net replacement rate has decreased over time. The average after-tax replacement rate was .710 in 2005 but decreased to .582 in 2009. We see that the maximum value exceeded the before-tax upper bound of .8 prior to 2007. This is a consequence of the basic tax deduction. Consistent with the lower average taxes implied by the introduction of the EITC, we see that progressivity increases (the elasticity variable capturing progressivity falls) somewhat over the period 2005-2008. In 2009, progressivity decreases slightly. Marginal tax rates are somewhat higher for the employed than for the unemployed throughout the sample period.[4] We proceed by plotting the evolution of mean wages, replacement rates and progressivity for each quartile of the wage distribution. To this end, we identify which quartile each individual belongs to a given year and compute the mean wage, replacement rate and progressivity within that quartile.

[4] Note that the marginal tax rate in unemployment is computed as the hypothetical marginal tax rate that would pertain to the individual if he were to become unemployed. We therefore interpret these tax rates as the rates that would apply in different labour market states rather than actual tax rates on the employed and unemployed.

Table 1a Descriptive statistics, 2005-2009

	Year	2005	2006	2007	2008	2009
Monthly wage	Mean	24 205	25 115	25 795	27 115	27 991
	St Dev	11 591	12 171	12 229	12 527	12 590
	Min	10 000	12 000	12 000	12 000	12 000
	Max	1 043 707	1 232 252	960 882	736 626	668 145
Net replacement rate	Mean	.710	.687	.630	.603	.582
	St Dev	.129	.133	.131	.132	.133
	Min	.032	.023	.019	.024	.031
	Max	.860	.859	.795	.795	.795
Progressivity	Mean	.871	.868	.858	.851	.864
	St Dev	.090	.088	.097	.100	.092
	Min	.672	.666	.647	.641	.637
	Max	1	1	1	1	1
Marginal tax, employment	Mean	.387	.390	.365	.363	.344
	St Dev	.092	.091	.106	.111	.105
	Min	0	0	0	0	0
	Max	.587	.587	.592	.591	.587
Marginal tax, unemployment	Mean	.338	.338	.338	.338	.339
	St Dev	.041	.040	.039	.038	.039
	Min	0	0	0	0	0
	Max	.377	.377	.377	.375	.376
Local tax rate	Mean	.316	.316	.316	.315	.316
	St Dev	.009	.009	.010	.011	.011
	Min	.289	.289	.289	.289	.289
	Max	.342	.342	.342	.341	.342
Local unemployment	Mean	5.857	5.319	3.865	3.712	5.958
	St Dev	1.646	1.490	1.186	1.196	1.794
	Min	2.266	2.063	1.256	.946	1.780
	Max	14.124	11.516	8.918	9.435	13.831
Hours worked	Mean	89.612	89.776	89.818	89.704	89.745
	St Dev	21.532	21.475	21.388	21.654	21.602
	Min	1	.55	1	.375	1
	Max	100	100	100	100	100
Age	Mean	42.073	42.000	41.926	41.936	41.936
Male	Mean	.500	.506	.501	.503	.503
Observations		11 9438	11 9236	124 426	122 977	119 296

Notes: Net replacement rate, progressivity and marginal tax rates are based on wage predictions. Local unemployment is calculated as the unemployment to population ratio.

Figure 1 Mean wages within the four quartiles, 2004-2009

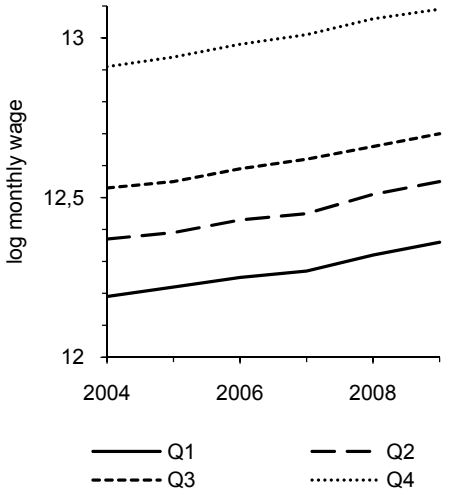


Figure 2 The wage distributions 2006-2009, actual wages

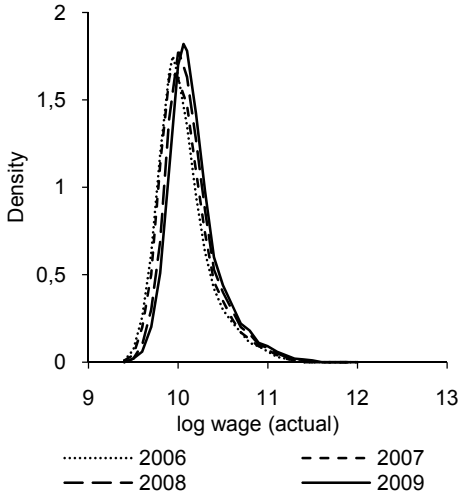


Figure 3 Mean replacement rates within the four wage quartiles, 2005-2009

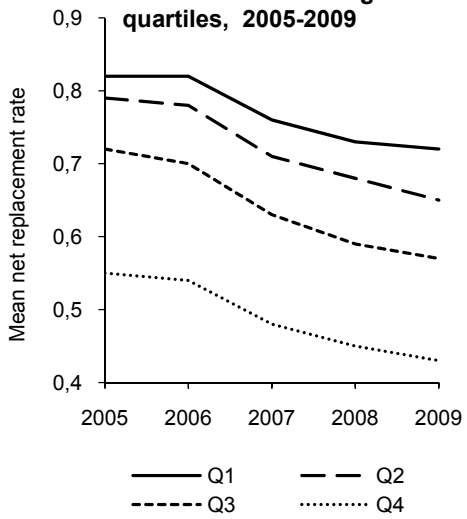
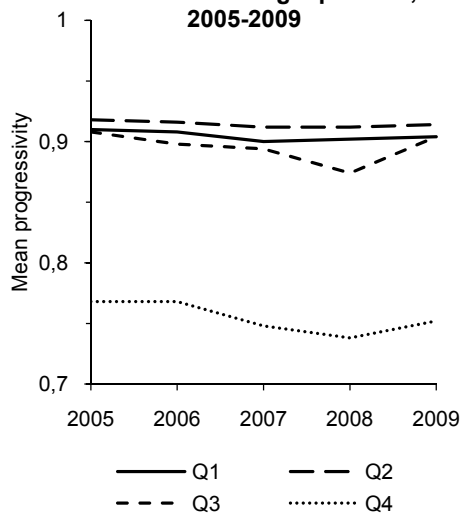


Figure 4 Mean progressivity within the four wage quartiles, 2005-2009



Mean log wages for the four quartiles over the sample period are displayed in Figure 1. The plot shows that mean wages have been increasing across the entire wage distribution during the sample period. There is a small kink in the trend for the bottom 50 percent of the distribution as the trends for Q1 and Q2 seem slightly steeper following 2007, but the change is hardly visible.

An alternative to studying plots of mean wages is to look at how the distribution of wages has evolved over time. The density function for each year 2006-2009 is depicted in Figure 2. The graph suggests that the wage distribution moved very little between 2006 and 2007, i.e. at the time of the launch of the EITC and the reform to unemployment benefits. In particular at the low end of the distribution it seems that wages increased less between 2006 and 2007 than in the subsequent years. This observation is consistent with the hypothesis that the large reforms of 2007 were conducive to wage restraint.

The net replacement rates, displayed in Figure 3, are falling over time for all quartiles. The decrease is particularly pronounced for the lower quartiles in the income distribution, i.e. low-income earners who have the highest replacement rates. For the quartile with the highest incomes, the change is smaller. This is due to the fact that the reforms to the unemployment insurance only affected those that reach the upper bound on benefits.

The evolution of the progressivity variable for different quartiles of the wage distribution is plotted in Figure 4. Progressivity has gone up (the elasticity capturing progressivity has fallen) for all four quartiles 2005-2008, but most so for the quartile with the highest wages (as this group has received a cut in the average tax rate due to the EITC, but in most cases no reduction in the marginal tax rate). Moreover, we see that progressivity is in fact higher (the elasticity lower) for individuals in the first quartile than for individuals in the second quartile. This is partly due to the fact that individuals in the first quartile, who start paying taxes, have a high marginal tax rate compared to the average tax rate (which is approximately zero close to the threshold for starting to pay tax). The plot also captures how mean progressivity decreased for the top two quartiles in 2009. This is due to the higher threshold for payment of the state income tax.

Descriptive statistics for wage growth in 2006-2009 are given in Table 1b. Wages grew at an average rate of 4.4 percent between 2005 and 2006, 4.1 percent between 2006 and 2007, 5.8 percent between 2007 and 2008 and by 3.7 percent between 2008 and 2009. These numbers are higher than the wage increases according to the official statistics (*Konjunkturlönestatistiken)*, which instead reports 3.1, 3.3, 4.3 and 3.4 percent for the same years. In contrast to the data in Konjunkturlönestatistiken the figures in Table 1b include the career wage increases that individuals receive as they become older, but which do not raise the average wage of the collective of wage earners (as new cohorts with low wages enter at the same time as earlier cohorts with high wages retire).[5]

To highlight to what extent our wage growth figures are driven by outliers, we report average wage growth rates after having removed individuals with extremely high or low wage growth each year at the bottom of the table.

[5] Consistent with this argument, note that the numbers in Table 1b do not square with the wage growth rates that would be obtained if one were to compute the wage growth from the mean wages in Table 1a, i.e. the increases in the wages depicted in Figure 1. The reason is that the statistics in Table 1b are based only on individuals who remain in the sample for two consecutive years. By contrast, the mean wages in Figure 1 comprise individuals who are in the sample only that year. The career effects described above are thus mitigated by the entry of low-income earners a given year when looking at the quartile means in Figure 1.

Table 1b Wage growth with and without outliers, 2006-2009

	2006	2007	2008	2009
Mean	.044	.041	.058	.037
St Dev	.120	.125	.124	.119
Min	-2.086	-1.940	-2.004	-2.196
Max	2.477	1.754	2.014	2.310
Mean, restricted:				
dlnW<.5	.039	.037	.054	.033
dlnW<.25	.029	.025	.042	.025
dlnW<.10	.010	.005	.017	.008
dlnW>-.5	.046	.044	.061	.040
dlnW>-.25	.051	.050	.066	.045
dlnW>-.10	.059	.058	.074	.054
-.5<dlnW<.5	.042	.040	.057	.037
-.25<dlnW<.25	.036	.034	.050	.034
-.10<dlnW<.10	.026	.024	.035	.027

Note: dlnW denotes the annual change in the nominal wage. The bottom rows display average wage growth each year given that outliers, defined by the restriction in the leftmost column, have been removed.

Table 1c reports descriptive statistics for the evolution of wages, the net replacement rate and progressivity over the sample period. In addition to levels and growth for the entire sample, each variable is broken down into quartiles. Over the period 2006-2009, wages are increasing in all quartiles of the distribution except for the low-income earners in the first quartile who actually display negative wage growth 2006-2007. The net replacement rate has decreased over time in all quartiles over the sample period. The decreases are of an order of magnitude consistent with the figures reported by the Swedish Fiscal Policy Council (2010). Following the great reforms of 2007, the net replacement rate fell by 7.2 percentage points on average. Between 2006 and 2007, the drop in the net replacement rate was greatest for the middle income earners in quartiles two and three and lowest for the individuals in the first quartile. The finding that the decrease in the replacement rate has been greatest in the middle of the income distribution is consistent with the calculations of the Swedish Fiscal Policy Council (2010).[6]

5.3 How accurate are the wage predictions?

As discussed in Section 4.2, we base the net replacement rate and the progressivity variable on wage forecasts. Since these predictions are key elements when computing the reform variables it is crucial to understand their properties.

[6] See Swedish Fiscal policy Council (2010), Table 11.1, p. 270.

Table 1c The evolution of wages, the net replacement rate and progressivity by wage quartiles, 2006-2009

	Quartile	2006	2007	2008	2009
Wage level	All	25 115	25 795	27 115	27 991
	1	17 369	17 685	18 718	19 387
	2	20 787	21 325	22 462	23 354
	3	24 394	25 176	26 330	27 242
	4	37 993	39 057	40 983	42 106
Wage growth	All	.044	.041	.058	.037
	1	.009	-.006	.028	.007
	2	.035	.033	.055	.037
	3	.049	.050	.061	.041
	4	.074	.078	.083	.057
Net replacement rate level	All	.697	.630	.603	.582
	1	.810	.752	.728	.711
	2	.774	.701	.671	.647
	3	.698	.622	.589	.568
	4	.533	.476	.448	.426
Net replacement rate change	All	-.016	-.072	-.032	-.024
	1	-.002	-.058	-.020	-.017
	2	-.014	-.076	-.033	-.025
	3	-.022	-.081	-.039	-.025
	4	-.023	-.068	-.033	-.026
Progressivity level	All	.868	.858	.851	.864
	1	.906	.898	.900	.902
	2	.914	.910	.910	.911
	3	.896	.891	.871	.902
	4	.767	.745	.736	.750
Progressivity change	All	-.004	-.012	-.009	.012
	1	-.001	-.007	.002	.002
	2	-.000	-.002	.001	.003
	3	-.008	-.006	-.019	.032
	4	-.007	-.031	-.016	.010

Notes: The columns display mean levels and the mean growth in the wage, the net replacement rate and progressivity for the full sample and the four wage quartiles. The wage quartiles are computed from the distribution of the monthly wage. Q1 denotes the bottom quartile at the lower end of the wage distribution and Q4 the top quartile at the high end of the wage distribution.

Figure A2 in the Appendix plots the distribution of actual and predicted wages for each year 2006-2009. The graphs show that the distributions of the wage predictions closely mimic the actual distributions. Figure A2 depicts scatter plots of actual and predicted wages. The observations are distributed around the 45-degree line, indicating that, on average, the predictions come close to the actual realisations.

To further assess the accuracy of the predictions, we compute the descriptive statistics displayed in Tables 1a and 1c when the reform variables are based on actual wages rather than forecasts. The results are displayed in the Appendix. Tables A1 and A2 are the counterparts of Tables 1a and 1c, respectively. The

results suggest that on the aggregate level, the wage forecasts are a good predictor of the actual realisations. The mean net replacement rates and progressivity variables in Table A1 hover around the same values as in Table 1a. It seems, however, that both variables are consistently somewhat higher when based on actual wages as in Table A2. At the more disaggregate level, comparing Tables 1c and A2 suggest that there is no clear pattern indicating whether the forecasts tend to over- or underestimate the net replacement rate and progressivity when studying quartiles. This indicates that the expectation errors are evenly distributed across wage quartiles.

6 Results

The results from estimating wage equations in first differences as in equation (5) on the sample 2006-2009 are displayed in Table 2. We start by running simple linear regressions of the change in the log wage on the reform variables in columns (1)-(3) and then add various controls in columns (4)-(11).

We find that an increase in the after-tax replacement rate (captured by the variable *drho*) has a significant, positive association with wage growth in all the regressions. The magnitude of the coefficient is .33-.55, indicating that ceteris paribus a ten-percentage-points reduction of the after-tax replacement rate is consistent with 3-5 percent lower wage growth. Lower progressivity (captured by a higher value of the variable *dprog*) has a significant positive association with wage growth. The effect is, however, quite small: a ten-percentage-points fall in the variable (i.e. in the elasticity of the after-tax wage income with respect to the pre-tax income) is associated with only 0.2-0.4 percent higher wage growth.

Among the control variables included in most of the specifications, we find that inflation, captured by the variable *dlnp*, has a significant, positive effect on wage growth. The dummy *u(t-1)*, capturing workers who were unemployed at least once in the previous year, tends to be negative, but is insignificant in all but two specifications. Wages are negatively associated with the change in unemployment in the municipality, captured by the variable *durate*. Throughout the estimations we control for gender by including the dummy variable *male*. We do not find any significant gender differences in wage growth except in the specification in column (8). We allow for the possibility that age affects wages non-linearly by including both the variable *age* and age squared (*age2*). Wage growth is decreasing in age in all specifications but in a non-linear fashion. In what follows, the specification in column (5) will be treated as a benchmark.

Column (6) suggests that when we try to control for the reduction in payroll taxes by including a dummy (*payroll*) that assumes the value one if the individual is younger than 25 in 2007 or 2008 and younger than 26 in 2009, the estimated coefficient is insignificant. We are thus unable to document any effects of the reduction in payroll taxes by including such a dummy.

Table 2 Wage equations in first differences, 2006-2009. Dependent variable: dlnW

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
dlnp				.725***	.724***	.723***	.718***	.647***	.740***	.514***	
				(.018)	(.018)	(.018)	(.018)	(.020)	(.018)	(.021)	
drho	.343***		.332***	.369***	.368***	.368***	.444***	.490***	.365***	.547***	.395***
	(.006)		(.006)	(.006)	(.006)	(.006)	(.006)	(.008)	(.006)	(.004)	(.007)
dprog		.111***	.028***	.040***	.040***	.040***	.025***	.039***	.040***	.040***	.034***
		(.003)	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)
u(t-1)				-.001	-.001	-.001	-.004***	.006***	-.001	.001	-.001
				(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)
durate				-.001***	-.001***	-.001***	-.001***	-.003***	-.000**	-.007***	-.001***
				(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)
male				-.000	-.000	-.000	.000	-.005***	.000		-.000
				(.000)	(.000)	(.000)	(.000)	(.000)	(.000)		(.000)
age				-.001***	-.002***	-.002***	-.002***	-.004***	-.002***	-.005***	-.002***
				(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.001)	(.000)
age2					.000***	.000***	.000***	.000***	.000***	.000***	.000***
					(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)
payroll						.002					
						(.002)					
dhours							.001***				
							(.000)				
Full-time employed	No	No	No	No	No	No	No	Yes	No	No	No
Entre-preneurs excluded	No	No	No	No	No	No	No	No	Yes	No	No
Individual Fixed Effects	No	No	No	No	No	No	No	No	No	Yes	No
Year dummies	No	No	No	No	No	No	No	No	No	No	Yes
N	382 549	382 548	382 548	382 545	382 545	382 545	382 545	291 656	374 789	382 545	382 545
R2	.031	.005	.031	.048	.049	.049	.060	.078	.049	.084	.050

Notes: All regressions include controls for educational level, region of birth, civil status and education type. The constant is not reported. Robust standard errors are reported within parenthesis. ***: significant at the 1 percent level; **: significant at the 5 percent level; *: significant at the 10 percent level.

In column (7) we control for the change in hours worked (as a percentage share of full-time employment; the variable *dhours*) and find significant positive effects of the variable. This suggests that those who have started to work more have experienced higher wage growth. These results should, however, be interpreted with caution as hours worked are likely to be endogenously affected by the reforms.

The results in column (8) display the outcome when estimating the benchmark model in column (5) only on those who work full time. Column (9) gives the results when part-time workers again are included but entrepreneurs are excluded. In column (10) we add individual fixed effects, which in this first-difference specification is equivalent to allowing for individual trends. Finally,

in column (11) we add year dummies. We see that the estimated coefficients for the reform variables are robust to these alterations.

To study the possibility of variations in these effects over time we next estimate cross-sectional models of annual wage growth for different years. The results are displayed in Table 3. Columns (1)-(2) display the results for 2006, columns (3)-(4) the results for 2007, columns (5)-(6) the results for 2008 and columns (7)-(8) the results for 2009. These estimations comprise a simple, linear regression of wage growth on the net replacement rate and the benchmark displayed in column (5) in Table 2.

Table 3 Wage equations in first differences, 2006, 2007, 2008 and 2009. Dependent variable: dlnW

Year	2006		2007		2008		2009	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
drho	.448***	.468***	.372***	.377***	.399***	.399***	.354***	.355***
	(.014)	(.015)	(.013)	(.013)	(.012)	(.013)	(.013)	(.013)
dprog		.005		.068***		.034***		.029***
		(.008)		(.008)		(.007)		(.005)
u(t-1)		-.003**		-.002*		.002		.000
		(.001)		(.001)		(.002)		(.002)
durate		-.001		-.000		-.001		-.002***
		(.001)		(.001)		(.001)		(.000)
male		.004***		.010***		-.007***		-.008***
		(.001)		(.001)		(.001)		(.001)
age		-.002***		-.002***		-.002***		-.002***
		(.000)		(.000)		(.000)		(.000)
age2		.000***		.000***		.000***		.000***
		(.000)		(.000)		(.000)		(.000)
N	92 640	92 639	96 228	96 227	96 605	96 605	970 75	97 074
R2 adj	.041	.054	.031	.055	.038	.050	.032	.041

Notes: All regressions include controls for educational level, region of birth, civil status and education type. The constant is not reported. Robust standard errors are reported within parenthesis. ***: significant at the 1 percent level; **: significant at the 5 percent level; *: significant at the 10 percent level.

The results are fairly robust over time and consistent with the previous estimations. The coefficient for the net replacement rate hovers around 0.4. Lower progressivity (a higher value for the elasticity variable *dprog*) has a significant, positive effect in all regressions post 2007. The estimated effect is, however, considerably larger in 2007 than in the other two post-reform years.

Table 4 Wage equations in first differences 2009, excluding outliers. Dependent variable: dlnW

dlnW	<.5	<.25	<.10	>-.5	>-.25	>-.10	(-.5,.5)	(-.25,.25)	(-.10,.10)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
drho	.315***	.270***	.239***	.284***	.232***	.187***	.242***	.137***	.039***
	(.011)	(.011)	(.012)	(.010)	(.010)	(.009)	(.008)	(.005)	(.003)
dprog	.034***	.036***	.039***	.018***	.002	-.009**	.023***	.008**	-.004**
	(.004)	(.005)	(.005)	(.005)	(.004)	(.004)	(.004)	(.003)	(.002)
u(t-1)	-.000	-.004***	-.009***	.001	.004***	.008***	.000	.001	-.001
	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)
durate	-.002***	-.001*	.000	-.003***	-.003***	-.002***	-.002***	-.001***	-.000*
	(.001)	(.000)	(.001)	(.000)	(.001)	(.000)	(.000)	(.000)	(.000)
male	-.009***	-.010***	-.013***	-.005***	-.003***	-.000	-.006***	-.006***	-.005***
	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.000)
age	-.001***	.000*	.003***	-.003***	-.004***	-.005***	-.002***	-.001***	.000
	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)
age2	.000***	-.000**	-.000***	.000***	.000***	.000***	.000***	.000***	-.000
	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)
N	96 674	94 394	84 185	96 674	95 449	91 647	96 274	92 769	78 758
R2 adj	.038	.036	.050	.035	.036	.044	.032	.065	.024

Notes: All regressions include controls for educational level, region of birth, civil status and education type. The constant is not reported. Robust standard errors are reported within parenthesis. ***: significant at the 1 percent level; **: significant at the 5 percent level; *: significant at the 10 percent level.

Previous unemployment has a significant, negative effect only in 2006 and 2007. The change in the unemployment rate is significant only in 2009. Finally, males tend to have higher wage growth in 2006 and 2007, but lower wage growth in 2008 and 2009.

To check the robustness of our results we rerun the first-difference regressions excluding outliers defined as observations entailing very large wage increases or very large wage cuts or both. It is debatable whether one should in fact remove outliers as this removes information, but we include a set of such regressions as a sensitivity analysis. The cut-off points are defined as changes in log wages of .5 (64.8 percent), .25 (28.4 percent) and .1 (10.5 percent). The results for 2009 are displayed in Table 4 (similar results were obtained for other years). Excluding only large wage rises or only large wage cuts in columns (1)-(6) reduces the coefficient for changes in the net replacement rate to .2-.3. Excluding both large wage rises and large wage cuts as in columns (7)-(9), implies even larger reductions in the coefficient. Confining the regressions to observations with wage changes in the interval from -10 percent to +10 percent reduces the coefficient drastically to .04, but it is still highly significant.

Table 5 Wage equations in first differences for different quartiles, 2007, 2008 and 2009. Dependent variable: dlnW

Year	2007				2008				2009			
Quartile	1	2	3	4	1	2	3	4	1	2	3	4
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
drho	.702***	.196***	.151***	.554***	.679***	.182***	.152***	.534***	.418***	.108***	.136***	.452***
	(.049)	(.021)	(.016)	(.033)	(.034)	(.016)	(.017)	(.032)	(.037)	(.013)	(.014)	(.032)
dprog	.089***	.171***	.056***	-.190***	-.099***	.102***	.047***	-.128***	-.026	.055**	.029***	.008
	(.026)	(.029)	(.008)	(.023)	(.030)	(.027)	(.007)	(.020)	(.030)	(.022)	(.005)	(.012)
u(t-1)	.000	-.013***	-.029***	-.088***	-.003	-.015***	-.027***	-.108***	-.002	-.018***	-.039***	-.104***
	(.002)	(.002)	(.004)	(.011)	(.002)	(.002)	(.004)	(.011)	(.002)	(.003)	(.005)	(.014)
durate	.001	-.001	.003*	.006***	-.004*	-.005***	-.005***	-.006**	-.004***	-.003***	-.006***	-.006
	(.002)	(.001)	(.002)	(.002)	(.002)	(.002)	(.002)	(.003)	(.001)	(.001)	(.001)	(.001)
male	.021***	.025***	.016***	.005**	.001	.005***	.009***	.006***	.000	.005***	.012***	-.004*
	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)
age	-.005***	-.000	.003***	.009***	-.003***	.001**	.003***	.009***	-.005***	.002***	.004***	.012***
	(.001)	(.001)	(.001)	(.001)	(.000)	(.000)	(.001)	(.001)	(.000)	(.000)	(.001)	(.001)
age2	.000	-.000*	-.000***	-.000***	.000***	-.000***	-.000***	-.000***	.000***	-.000***	-.000***	-.000***
	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)
N	21 148	24 401	25 098	25 580	21 348	24 182	25 290	25 785	21 887	34 655	25 120	25 412
R2 adj	.125	.077	.057	.086	.075	.030	.040	.084	.078	.024	.050	.083

Notes: All regressions include controls for educational level, region of birth, civil status and education type. The constant is not reported. Replacement rate and progressivity are based on predictions of the wage distribution in t-1. Robust standard errors are reported within parenthesis. ***: significant at the 1 percent level; **: significant at the 5 percent level; *: significant at the 10 percent level.

The results from estimating the benchmark model for different quartiles of the wage distribution are displayed in Table 5. Columns (1)-(4) display the results for 2007, columns (5)-(8) the results for 2008 and columns (9)-(12) the results for 2009. For each year we display the results for quartiles 1 through 4 where quartile 1 comprises the bottom of the income distribution and quartile 4 comprises the top.

Focusing on the effects of the reform variables, we see that the change in the net replacement rate has a significant, positive effect on wage growth across the board. Interestingly, we see that the magnitude of the effects differ across quartiles. Consistent with our prior, for 2007 and 2008 we find the largest effects in the first quartile. This is likely to result from the fact that low-income earners face a higher unemployment risk than high-income earners, suggesting that the replacement rate is a more important factor for the former group than for the latter. Somewhat surprisingly, we do find very large effects also for the high-income earners in the fourth quartile. In 2009, the effects are even larger for the fourth quartile than for the first.

The empirical results have been subjected to extensive sensitivity analysis. First, we tried alternative wage forecasts when computing the reform variables. By grouping all individuals according to age and education we were able to compute heterogeneous wage growth rates when extrapolating the wage, based on 24 different strata. The results were largely unaffected by this exercise. We also experimented with assigning everyone an expected unemployment spell of 300 days when computing the replacement rate. The main results were robust also to this alteration.

7 Discussion

The most striking result from our study is that decreases in the after-tax unemployment benefit replacement rate, arising either from a lower income tax or less generous unemployment insurance, have a significant, negative association with wage growth. To get a feel for the magnitude of the effect, it is instructive to translate it into an elasticity of the wage with respect to the unemployment benefit. If we have $dlnW_{it} = \hat{\beta} d\rho_{it}$, where $\hat{\beta}$ is our estimated coefficient (the semielasticity of the wage with respect to the replacement rate), it holds that $dW_{it}/W_{it} = \hat{\beta} d(B_{it}/\omega_{it}^{e}) = \hat{\beta}(dB_{it}/B_{it})(B_{it}/\omega_{it}^{e})$. With $\hat{\beta} = .4$ (our most common estimate) and $B_{it}/\omega_{it}^{e} = .7$ (the mean replacement rate in 2006), we obtain the elasticity of the wage with respect to the unemployment benefit as $(dW_{it}/W_{it})/\,(dB_{it}/B_{it}) = .4 \times .7 = .28$. This value is the same as the (minimum long-run) value calculated by Forslund et al. (2008) on the basis of regressions on macro data.[7] Choosing instead $\hat{\beta} = .2$ (as in some of the regressions excluding outliers), the elasticity instead becomes $.2 \times .7 = .14$.

Table 6 shows what our estimates imply for the (partial-equilibrium) effects of the reductions in the net replacement rate on wage changes 2007-2009.[8] If we take the semielasticity of the wage with respect to the replacement rate to be .4, the lowering of replacement rates should have contributed to a 5.2 (2.9 + 1.3+1.0) percent lower average wage in our data in 2009 than would otherwise have been the case. If we instead adopt the lower value for the semielasticity of .2, the contribution would be a 2.5 (1.4 +.6+.5) percent lower average wage in our data in 2009 than without the reforms. We can translate the contributions to the average wage in our data set (which refers to a specific set of persons, thus capturing also career effects associated with ageing) to contributions to the average wage for the collective of all wage earners (where retired cohorts have been replaced by new cohorts of entrants) according to *konjunkturlönestatistiken* by scaling with the ratio between the two measures of wage change. Then the contributions become instead 4.3 (2.4 + 1.1+.8) percent with the higher semielasticity and 2.0 (1.1 +.5+.4) percent with the lower semielasticity. These effects appear quite large, much larger than we had expected.

[7] The wage equation in this study included the before-tax instead of the after-tax replacement rate.

[8] The partial-equilibrium effects do not take into account that lower wages are likely to reduce unemployment. The effects on wages of lower unemployment are, however, small according to our estimates.

Table 6 The wage effects of a lower after-tax replacement rate

	2007	2008	2009
Mean wage change in our data, percent	4.1	5.8	3.7
Change in average replacement rate, percentage points	-7.2	-3.2	-2.4
Contribution to wage change	-2.9	-1.3	-1.0
	(-1.4)	(-.6)	(-.5)
Actual change according to *Konjunkturlönestatistiken*	3.3	4.3	3.4
Adjusted contribution to wage change	-2.4	-1.1	-.8
	(-1.1)	(-.5)	(-.4)

Note: Entries without parenthesis are computed assuming that the semielasticity of the wage with respect to the replacement rate is .4 and entries within parenthesis that it is .2. The adjusted contribution to wage change is computed by scaling down the contribution in the third row with the average ratio between wage changes according to *Konjunkturlönestatistiken* and wage changes in our data (.82).

Table 7 shows the implied effects of the changes in the net replacement rate across quartiles. The results suggest that the changes to the replacement rate were most conducive to wage restraint for the low-income earners in 2007. For the workers in the first quartile, the implied wage effect was -4.1 percent. In 2008 and 2009, the effects were instead largest for the high-income earners.

In addition to the changes to the net replacement rate and progressivity, the government has undertaken reductions in payroll taxes, which by creating a larger room for wage increases are likely to have put upward pressure on wages. We have not been able to include an exact measure of payroll taxes in our estimations, as we would have liked. Our attempt to control for these effects by including a dummy for young people failed to generate any significant results.

However, one could make a crude back-of-the-envelope calculation to illustrate the effects of the payroll tax cuts. There was a reduction in the payroll tax rate for people below the age of 25 by 11.1 percentage points in 2007. In addition, payroll taxes were reduced by 5.8 percentage points for those below the age of 26 in 2009. There was also a general reduction of payroll taxes by one percentage point in 2009.

If all of the tax cuts for young people were to be shifted on to wages, they would rise by 12.8 ((0.169/1.324)×100) percent. People below the age of 26 make up around 12 per cent of employment. Hence, one could calculate an approximate average wage rise of 1.5 (0.12×12.8) percent due to the reductions in the payroll tax rate under these assumptions.[9] Assuming that the general reduction in payroll taxes by one percentage point in 2009 was fully shifted onto wages as well, this would increase the overall wage level by 0.8 ((0.01/1.324) ×100) percent. The total increase in wages due to the payroll tax reductions would thus be 2.3 (1.5+0.8) percent. This is a maximum estimate: the effect would be reduced to the extent that all of the payroll tax reductions are not shifted on to wages.

[9] The government also introduced so-called new start jobs without any payroll taxes for long-term unemployed in 2007. These jobs made up around .4 percent of all jobs. The elimination of a payroll tax of 32.4 percent of the wage creates a room for increases in the wage of the same magnitude. But the effect on the average wage from this would be only around .1 (32 *x* .004) percent. Moreover, this might be an overestimate as the new start jobs replaced other subsidized jobs.

Table 7 The wage effects of a lower after-tax replacement rate by quartile 2007, 2008 and 2009

	Quartile	2007	2008	2009
Change in the net replacement rate				
	1	-0.058	-0.02	-0.017
	2	-0.076	-0.033	-0.025
	3	-0.081	-0.039	-0.025
	4	-0.068	-0.033	-0.026
Estimated semielasticities				
	1	0.702	0.679	0.418
	2	0.196	0.182	0.108
	3	0.151	0.152	0.136
	4	0.554	0.534	0.452
Implied effect				
	1	-.041	-.014	-.007
	2	-.015	-.006	-.003
	3	-.012	-.006	-.003
	4	-.038	-.018	-.012

Notes: The quartile changes in rho are from Table 1c. The estimated semielasticities are from Table 5.

The reductions in the payroll tax for young people and the general reduction in 2009 may have had a partially offsetting effect on the tendency to lower wage increases from the reductions in the after-tax replacement rate for unemployed. However, our crude calculations suggest that the wage-raising effects of the payroll tax cuts were not sufficiently large to completely offset the wage-reducing effects of the labour market reforms discussed in this report.

A final *caveat* is in order. Strictly speaking, our results only indicate a strong negative *correlation* between wage increases and the net replacement rate in the case of unemployment. The covariation is stronger and more rapid than we had expected. Further research is needed to establish that the estimated relationship is indeed a *causal* one. However, our results are consistent with the hypothesis that earned income tax credits and lower unemployment benefits have large wage-reducing effects.

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Appendix

A1 Theoretical Model

A1.1 Workers

Each worker is endowed with one unit of time and divides it between working time l and leisure $(1-l)$. Letting w denote the hourly real wage rate per unit of time and ω the gross real wage of a worker (income from work = wage rate x working time), we have $\omega = wl$.

There are two types of taxes in the economy: income taxes, denoted T_E and T_U for the employed and unemployed, respectively, and payroll taxes, denoted T_F. Taxes are assumed to depend on the gross real wage.

The after-tax wage income of a worker, ω_E, is then given by:

$$\omega_E = \omega - T_E(\omega) = wl - T_E(wl). \tag{A1}$$

The cost of the worker to the employer, ω_F, is given by:

$$\omega_F = \omega + T_F(\omega) = wl + T_F(wl). \tag{A2}$$

The progressivity of the income tax is measured by the elasticity of the after-tax wage income with respect to the gross wage, μ_E. The progressivity of the payroll tax is measured by the elasticity of the wage cost to the employer with respect to the gross wage, μ_F. Hence, we have

$$\mu_E \equiv \frac{\partial ln\omega_E}{\partial ln\omega} = \frac{1 - T_E'}{1 - T_E/\omega}$$

$$\mu_F \equiv \frac{\partial ln\omega_F}{\partial ln\omega} = \frac{1 + T_F'}{1 + T_F/\omega}.$$

If $\mu_E < 1$, a one percent increase in the gross wage ω leads to less than a one per cent increase in the after-tax wage income of the worker ω_E, indicating that the income tax is progressive. This occurs when the marginal tax rate, T_E', is greater than the average tax rate, T_E/ω. The lower is the elasticity μ_E, the

more progressive is the income tax. If $\mu_F > 1$, a one percent increase in the gross wage leads to more than a one percent increase in the cost of the worker to the firm, indicating that the payroll tax is progressive. This occurs when the marginal tax rate, T_F', is greater than the average tax rate, T_F/ω. The higher is the elasticity, μ_F, the more progressive is the payroll tax. The tax system is proportional, implying $\mu_E = \mu_F = 1$, when the marginal and average tax rates are equal.

Suppose that the instantaneous utility function of a worker is:

$$v_E = \omega_E \phi(1 - l), \tag{A3}$$

where the function ϕ measures the disutility of labour and has the properties $\phi' > 0$ and $\phi'' \leq 0$.

Suppose that an unemployed worker receives a pre-tax benefit b so that the after-tax benefit is $b_U = b - T_U(b)$. Since hours worked are zero, the utility of an unemployed worker is

$$v_U = b_U \phi(1) = b_U, \tag{A4}$$

where we, without loss of generality, have adopted the normalisation $\phi(1) = 1$.

A1.2 Firms

The representative firm produces a homogenous good using labour as the only input. Each firm has one job slot, which can be either filled or vacant. When the slot is filled, the firm produces the quantity y of the final good, i.e. the production function is $y = f(l)$, where $f'(l) > 0$ and $f''(l) < 0$. There is a fixed cost h of maintaining a vacant position. This cost may be interpreted as a search cost associated with the efforts to find a suitable worker. Finally, jobs are destroyed at the exogenous rate $q > 0$.

A1.3 The matching function

The process through which workers and firms meet is described by a matching function, M. We assume that only the unemployed search for jobs, i.e. there is no on-the-job search. Under this assumption, the matching function maps the number of vacancies, V, and the number of unemployed, U, to outcomes in terms of successful matches between workers and firms, i.e. $M = M(V, U)$. The matching function is assumed to exhibit constant returns to scale.

The probability of filling a vacant job in each period is:

$$\frac{M(V,U)}{V} = M(1, U/V) \equiv m(\theta),$$

where $\theta = V/U$ denotes labour market tightness. The hazard rate, i.e. the rate at which an unemployed worker exits unemployment is given by:

$$\frac{M(V,U)}{U} = \frac{V}{U}\frac{M(V,U)}{V} = \theta m(\theta).$$

A1.4 Value functions

Denoting the value of being employed and unemployed by V_E and V_U, respectively, the following equalities must hold:

$$rV_E = \omega_E \phi(1-l) + q(V_U - V_E) \quad \text{(A5)}$$

$$rV_U = b_U + \theta m(\theta)(V_E - V_U). \quad \text{(A6)}$$

Letting Π_E and Π_V denote the values of a firm's profit streams associated with employing a worker and maintaining the position vacant, respectively, the following conditions must hold:

$$r\Pi_E = f(l) - \omega_F + q(\Pi_V - \Pi_E) \quad \text{(A7)}$$

$$r\Pi_V = -h + m(\theta)(\Pi_E - \Pi_V). \quad \text{(A8)}$$

If we assume free entry, so that $\Pi_V = 0$, (A8) implies $\Pi_E = h/m(\theta)$. Substituting this expression into (A7) yields the following expression for labour demand:

$$\frac{h}{m(\theta)} = \frac{f(l) - \omega_F}{(r+q)}. \quad \text{(A9)}$$

Expression (A9) states that in equilibrium the expected cost of a vacant position on the left-hand-side must equal the present value of filling the vacancy on the right-hand-side.

A1.5 Wage bargaining

Wages are set in decentralized Nash bargaining between a worker and a firm. Firms and workers bargain over hours worked as well as over the hourly wage. Letting $\lambda \in (0,1)$ denote the relative bargaining power of workers, the problem can be written:

$$\max_{w,l} \Lambda = \lambda ln(V_E - V_U) + (1-\lambda) ln(\Pi_E - \Pi_V),$$

where (5) and (7) imply

$$V_E - V_U = \frac{\omega_E \phi(1-l) - rV_U}{r+q}$$

$$\Pi_E - \Pi_V = \frac{f(l) - \omega_F - r\Pi_V}{r+q}.$$

The first-order-conditions with respect to wages and hours worked are:

$$\frac{\partial ln\Lambda}{\partial ln\mathrm{w}} = \lambda \frac{\phi(1-l)\mu_E \omega_E}{\omega_E \phi(1-l) - rV_U} - (1-\lambda)\frac{\mu_F \omega_F}{f(l) - \omega_F} = 0 \qquad \text{(A10)}$$

$$\frac{\partial ln\Lambda}{\partial ln\mathrm{l}} = -\lambda \frac{\phi'(1-l)\omega_E}{\omega_E \phi(1-l) - rV_U} + (1-\lambda)\frac{f'(l)}{f(l) - \omega_F} = 0. \qquad \text{(A11)}$$

A1.6 Equilibrium

Combining (A10) and (A11) gives the contract curve:

$$\frac{\omega_F}{\mu} = f'(l)\frac{\phi(1-l)}{\phi'(1-l)}, \qquad \text{(A12)}$$

where $\mu \equiv \mu_E/\mu_F$ measures the progressivity of the tax system.

By substituting rV_U from (A6) in the first-order-condition for the wage (A10) and using the expression for $V_E - V_U$ obtained when subtracting (A6) from (A5) we obtain the wage curve:

$$\frac{f(l) - \omega_F}{r+q} = \frac{(1-\lambda)}{\lambda\mu} \frac{(\phi(1-l) - \rho)}{\phi(1-l)\big(r+q+\theta m(\theta)\big)} \omega_F, \tag{A13}$$

where ρ is the after-tax replacement rate defined as $\rho = b_U/\omega_E$.

Substituting the contract curve (A12) into the expression for labour demand (A9), we obtain:

$$\frac{h}{m(\theta)} = \frac{1}{(r+q)} \left(f(l) - f'(l) \frac{\phi(1-l)}{\phi'(1-l)} \mu \right). \tag{A14}$$

Equations (A12), (A13) and (A14) define an equilibrium system of equations that identify three endogenous variables: the wage cost to employers, ω_F, working time, l, and labour market tightness, θ.

Since our aim is to estimate wage equations for individual employees, we treat labour market tightness, θ, as exogenous. For our purposes we can therefore take θ as given in the wage curve (A13).

The contract curve (A12) implicitly defines working time as a function of the progressivity variable and the wage cost:

$$l = l(\mu, \omega_F), \tag{A15}$$

where $l_\mu > 0, l_\omega < 0$.

The wage curve can be written:

$$\omega_F = wl - T_F(wl) = \omega_F(\rho, \mu, \theta, l; r, q, \lambda). \quad \text{(A16)}$$

To arrive at a reduced-form equation for the worker's wage rate per unit of time w, we use equation (A15) for working time l and the fact that the payroll tax is proportional, i.e. $T_F(\omega) = \tau_F \omega$, where τ_F is the payroll tax rate, so that $\omega_F = (1 + \tau_F)\omega$. The resulting equation is:

$$w = w(\rho, \mu, \theta, \tau_F; r, q, \lambda).$$

i.e. equation (1) in Section 3.

A2 Additional Tables

Table A1 Descriptive statistics, 2005-2009. Variables based on actual wages

	Year	2005	2006	2007	2008	2009
Net replacement rate	Mean	.720	.709	.642	.615	.594
	St Dev	.126	.131	.130	.131	.132
	Min	.025	.021	.025	.033	.036
	Max	.862	.860	.795	.795	.795
Progressivity	Mean	.876	.871	.861	.858	.868
	St Dev	.086	.085	.094	.097	.090
	Min	.674	.672	.649	.644	.637
	Max	1	1	1	1	1
Marginal tax, employment	Mean	.381	.384	.359	.353	.336
	St Dev	.090	.090	.105	.110	.105
	Min	0	0	0	0	0
	Max	.587	.592	.592	.587	.591
Marginal tax, unemployment	Mean	.336	.337	.336	.336	.336
	St Dev	.044	.044	.043	.043	.044
	Min	0	0	0	0	0
	Max	.377	.377	.377	.375	.376

Notes: Net replacement rate, progressivity and marginal tax rates are based on actual wages.

Table A2 The evolution of the net replacement rate and progressivity in different quartiles, 2006-2009. Variables based on actual wages

	Quartile	2006	2007	2008	2009
Net replacement rate level	All	.709	.642	.615	.594
	1	.818	.765	.743	.725
	2	.786	.710	.678	.652
	3	.702	.622	.593	.571
	4	.528	.470	.446	.425
Net replacement rate change	All	-.014	-.073	-.030	-.023
	1	.004	-.046	-.013	-.010
	2	-.008	-.075	-.033	-.024
	3	-.022	-.088	-.037	-.027
	4	-.028	-.077	-.034	-.029
Progressivity level	All	.871	.861	.858	.868
	1	.905	.897	.901	.902
	2	.916	.912	.915	.916
	3	.913	.910	.896	.909
	4	.751	.726	.721	.745
Progressivity change	All	-.005	-.012	-.004	.010
	1	-.001	-.007	.004	.003
	2	.001	.000	.006	.006
	3	-.000	.005	.000	.024
	4	-.020	-.046	-.025	.008

Notes: Net replacement rate, progressivity and marginal tax rates are based on actual wages.

A3 Additional Figures

Figure A1 The distribution of actual and predicted wages, 2006-2009

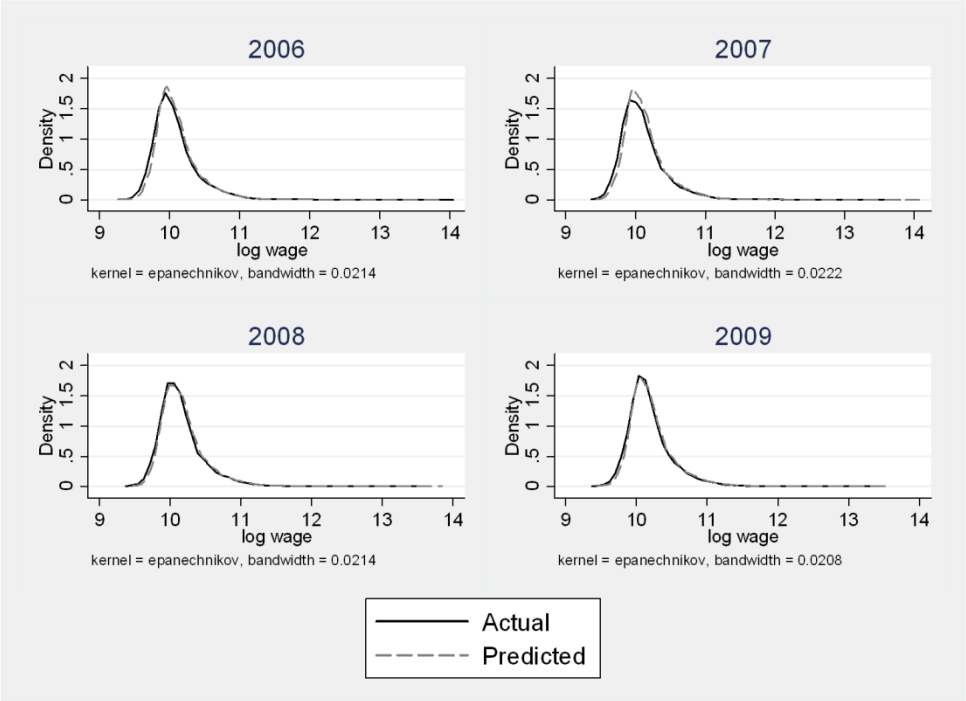
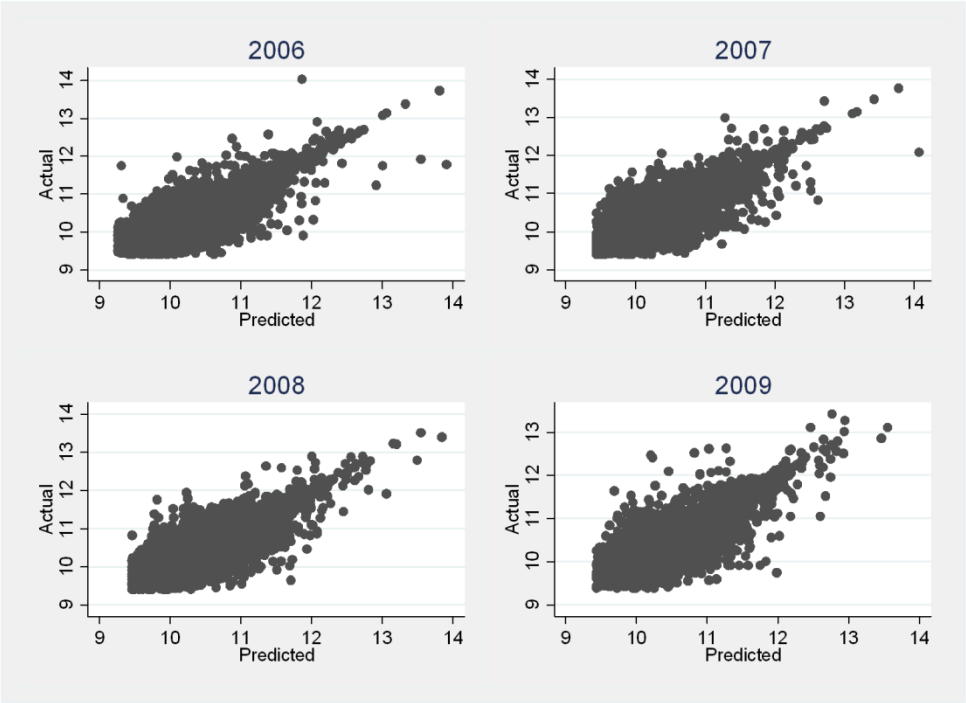


Figure A2 Actual and predicted wages, 2006-2009



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