DISCUSSION PAPER SERIES

IZA DP No. 2337

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September 2006

Forschungsinstitut
zur Zukunft der Arbeit
Institute for the Study
of Labor

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# ABSTRACT

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Parts of the Dutch tax reform 2001 are directed towards fiscal partners in a household and aim at lowering the marginal tax burden of the partner with the lowest (potential) labour income. An important goal of the reform is to increase the employment rate of these partners, which are in majority women. The Dutch Labour Force Survey 1992−2003 shows that the growth of the employment rate of married women after 2001 was larger than for a comparable group of single women. A statistical analysis using a model that accounts for measurement error shows that the growth of the employment rates of women without young children is in line with the predicted effect of the tax reform.

JEL Classification: C20, H31, J22

Keywords: tax reform, employment, evaluation

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## 1. Introduction

The Dutch tax reform 2001 increased the financial incentive to accept paid work. Parts of the tax reform are directed towards fiscal partners in a household and aim at lowering the marginal tax burden of the partner with the lowest (potential) labour income. In particular, the transferability of the tax free amount between partners was abolished. Although this part of the firm increased the general tax burden it lowered the *marginal* tax burden of partners in households with a first earner with a high income. So the Dutch tax system moved from a breadwinner model into the direction of an individual based tax model.

This study evaluates the incentive of women with a fiscal partner to accept paid work relative to single women. Although the tax reform increased the financial incentives for all tax payers, largely due to lower tax rates, we are interested in the effect of the aforementioned 'emancipation' part of the reform. Simulation studies (Graafland and de Mooij, 1998, Van Soest and Das, 2001) have shown that the employment rate of women with a fiscal partner should increase with about 1%-point more than the employment rate of single women.

Did the 'emancipation' part of the tax reform lead to a higher growth of the employment rate of married women relative to single women? First of all, we consider the *growth* rate as during the period under investigation the employment rate of women has been growing strongly. It would therefore be difficult to consider the level of employment before and after the reform. The prediction from theory and simulation studies is that the 'emancipation' part of the reform increased the growth of the employment rate of married women. Secondly, we use a *control group* to correct for influences other than the tax reform. This is important due to the downturn of the business cycle. Our maintained hypothesis is that influences other than the tax reform impact both groups of women, i.e. married and single women, with the same magnitude. As the reform was not set up as a (natural) experiment we can only show the growth of the employment rate of married women, relative to single women, to be in line with the predictions.

The data source for this study is the Dutch Labour Force Survey (DLFS) 1992-2003. We formulate a simple model for the growth of the employment rate. Besides uncertainty in the model due to model misspecification we allow for a second source of uncertainty: measurement error. Although the DLFS is a large survey the sampling error leads to measurement error. As we consider the growth of the employment rate the measurement error leads to correlation over time. We use this information to derive the correct variance of the difference-in-difference estimator. We test the hypothesis that the correlation over time is caused by measurement only.

## 2. Model

*A model with misspecification*

Define $f_t^g$ as the fraction of employed women of age 25 to 54 for group *g* at year *t*, with *g* equals *m* for married and *s* for single women. Define $\Delta f_t^g = f_t^g - f_{t-1}^g$ as the first difference in time. We are interested in the difference between married and single women, $\Delta f_t^m - \Delta f_t^s$, and in particular we want to test whether the increase of the employment rate after the tax reform was larger for married women. Due to the limited time span of the DLFS we have 11 observations only. We keep the model as simple as possible (i.e. an error correction model is clearly beyond the scope of the study):

$$\Delta f_t^m - \Delta f_t^s = \alpha_0 + \alpha_1 x_t + \varepsilon_t \tag{1}$$

with $x_t$ a dummy for the time period after the tax reform. We assume the error term $\varepsilon_t$ to be uncorrelated over time. This seems a strong assumption as in economic processes error terms are mostly correlated over time. We argue that the assumption may be realistic in this case. In economic processes error terms are expected to be correlated over time due to the business cycle. In this model however we use the group of single women as a control group. So the underlying assumption is that the employment probabilities of both groups of women, married and singles, are equally affected by the business cycle. Below we will allow for correlation over time, but the correlation will be the results of measurement error only.

*Sampling error*

The DLFS is a representative sample from the population of Dutch citizens. Despite the large size of our sample with 25 to 30 thousand observations per year we measure the fraction of employed women with uncertainty. Because we measure the left-hand-side variable $y_{it}$ of individual *i* being employed at year *t* as a binary variable which equals 1 in case of employment, the distribution of the variable is binomial. Define $f_t$ as the real underlying employment probability in the population at year $t$, and define $p_t$ as the corresponding sample average. We know that the sample average is an unbiased estimator for the real underlying probability:

$$E(p_t) = f_t \quad with \quad p_t = \frac{1}{n}\sum_{i=1} y_{it} \tag{2}$$

with $n$ is the number of observations in the sample. The variance equals:

$$V(p_t) = \frac{f_t(1-f_t)}{n} \tag{3}$$

The DLFS contains different individuals every year, implying that the sample outcomes are independent over the consecutive years. The variance of the change in the employment rate from year $t$ to year $t$-$1$ equals:

$$V(\Delta p_t) = V(p_t - p_{t-1}) = V(p_t) + V(p_{t-1}) \tag{4}$$

And the variance of the difference in the change between married $m$ and singles $s$ equals:

$$V(\Delta p_t^m - \Delta p_t^s) = V(p_t^m) + V(p_{t-1}^m) + V(p_t^s) + V(p_{t-1}^s) \tag{5}$$

*A model with misspecification and sampling error*

The model of equation (1) cannot be estimated as the true probabilities are unknown. The sampling error in the observed probabilities results in measurement error:

$$p_t^g = f_t^g + \nu_t^g \tag{6}$$

A special feature of the model is that the variance of the measurement error $\nu_t^g$ is given by equation (3) so that we know the size of the measurement error. Substitution of equation (6) in equation (1) gives:

$$\Delta p_t^m - \Delta p_t^s = \alpha_0 + \alpha_1 x_t + \eta_t \quad with \quad \eta_t = \varepsilon_t + (\Delta \nu_t^m - \Delta \nu_t^s) \tag{7}$$

Despite the measurement error Ordinary Least Squares (OLS) results in a consistent estimator for the parameter $\alpha_1$. The measurement error however leads to a correlation of the error term over time. This correlation can be estimated on the basis of the residuals of the OLS estimator. So under the assumption that the error term of equation (1) does not exhibit correlation over time the correlation of the error term of equation (7) is determined only by measurement error. Define:

$$V(\nu_t^g) = \sigma_g^2 \tag{8}$$

with $g=m,s$. The variance of the error term $\varepsilon_t$ can be estimated as follows:

$$V(\varepsilon_t) = V(\eta_t) - 2\frac{1}{T}\sum_{t=1}^{T}\left(\sigma_m^2 + \sigma_s^2\right) \tag{9}$$

in which we use the residuals of the OLS estimator. The different elements of the variance-covariance matrix of $\eta_t$ can now be estimated with:

$$V(\eta_t) = V(\varepsilon_t) + 2\sigma_m^2 + 2\sigma_s^2 \tag{10}$$

$$COV(\eta_t, \eta_{t-1}) = -\sigma_m^2 - \sigma_s^2 \tag{11}$$

$$COV(\eta_t, \eta_{t-2}) = 0 \tag{12}$$

On the basis of this matrix we can calculate the correct variance of the OLS estimator.

## 3. Results

The employment rate of married and single women in the age of 25 to 54 increased strongly during the 1990s (first panel of table 1). A peculiar feature is the continuing increase for married women despite the substantial downturn of the business cycle in the period 2001-2003. The growth of the employment rate of single women clearly slowed down during this period. The central question is: has the difference in the growth rate after the introduction increased? The difference in the growth rate before the tax reform was 0.69%-points, while after the tax reform the difference was 1.37%-points. The difference of the difference is with 0.68%-points however statistically insignificant.

A central assumption underlying our evaluation method is that policies other that the tax reform affect both groups of women with the same magnitude. During the observational period child care policy changed gradually. This may affect our results as married women have more often young children. Furthermore, women with young children may want to adjust their job search and job acceptance behaviour because of the tax reform, but in case of restrictions on child care provisions they may not have been able to do so. We investigate this aspect by calculating the employment rates for women with and without young children.

The employment rate of women with young children increased for both married and singles. For both groups the increase slowed down after 2001. For married women the increase slowed down with 0.47%-points, while for single women the increase slowed down with 0.81%-points. The difference of the difference is with 0.36%-points far from statistically significant.

The employment rate of women without young children increased, but now the increase for married women speeded up after 2001 with 0.86%-points. While for single women the increase slowed down with 0.33%-points. The difference of the difference is with 1.19%-points statistically significant at a 10% significance level.

The remaining question is whether the hypothesis on the autocorrelation holds: is the correlation of the error term over time really caused by measurement only? Or, in other words, do equation (11) and (12) hold? First of all, remind that economic processes normally lead to a positive first order autocorrelation as the business cycle causes growth rates to be large for several years in a row, followed by several years of low growth rates. Therefore we may expect the autocorrelation of the error term of equation (1) to be positive. The first order autocorrelation is however clearly negative for all our three models (table 2). In none of the models we reject the hypothesis that the autocorrelation of the error term is caused by measurement only, i.e. we can not reject the hypotheses formulated by equations (11) and (12).

**Acknowledgements**: the author thanks Pierre Koning, Peter Kooiman, Rocus van Opstal and Daniel van Vuuren. The provision of data by Statistics Netherlands is acknowledged.

**Literature**

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**Table 1** **yearly increase of employment rate of women, age 25-54** [a,b]

| Group of all women | 1992-2000 | 2000-2003 | Difference |
|---|---|---|---|
| | %-points | | |
| Married | 1.75 | 1.97 | 0.22 |
| Single | 1.06 | 0.60 | -0.46 |
| Difference | 0.69 | 1.37 | 0.68 |
| | | | (0.56) |
| | | | |
| Women with child <=12 | 1992-2000 | 2000-2003 | Difference |
| Married | 2.40 | 1.93 | -0.47 |
| Single | 2.51 | 1.70 | -0.81 |
| Difference | -0.11 | 0.23 | 0.36 |
| | | | (1.01) |
| | | | |
| Women without child <=12 | 1992-2000 | 2000-2003 | Difference |
| Married | 1.18 | 2.03 | 0.86 |
| Single | 0.86 | 0.53 | -0.33 |
| Difference | 0.31 | 1.50 | 1.19 |
| | | | (0.65) |

[a] Employment rate, persons working 12 hours or more per week as a fraction of the population.
[b] Standard error between parenthesis. The standard error is calculated using the model of section 2. Note that the model includes one explanatory variable only, implying that the OLS estimator is exactly equal to the difference in difference.
Source: Dutch Labour Force Survey 1992-2003.

**Table 2** **First and second order autocorrelation**

| | All women | with child<=12 | without child<=12 |
|---|---|---|---|
| First order autocorrelation | | | |
| predicted (equation 11) [a] | -0.64 | -3.22 | -1.03 |
| observed (OLS residuals) [b] | -1.15 | -1.84 | -0.44 |
| | (1.62) | (5.78) | (2.06) |
| | | | |
| Second order autocorrelation | | | |
| predicted (equation 12) | 0.00 | 0.00 | 0.00 |
| observed (OLS residuals) [b] | 0.46 | -3.22 | -0.77 |
| | (1.19) | (4.89) | (1.64) |

[a] the first order autocorrelation is predicted on the basis of the observed probabilities and sample sizes, see equations (3), (4) and (5).
[b] standard errors between parentheses.
Source: Dutch Labour Force Survey 1992-2003.