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The aim in this section is to go back to viewing evaluation through the prism of economic theory.
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Of course the key problem here is the "all else being equal" assumption. This is where econometric methods come in as well as the issues relating to identification.
Contrasting Treatment effect models and Structural models

- Structural Models aim to separate “deep” preference and technology parameters that can be thought of as being invariant to policy, from budget constraints.
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- The interpretation of the results is explicitly reliant on theory in a way that all assumptions on which the interpretation is predicated are explicitly stated.
- The effects of a policy is then estimated and the mechanisms by which it operates (income and substitution effects for example) are uncovered.
By contrast the treatment effects models lead to an overall estimate in such a way that the effect will *not be invariant* to changes in circumstances.
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The Marginal Treatment Effect is a step towards linking the heterogeneous treatment effects model to the notion of a structural parameter because the estimate we obtain does not depend on the instrument or the specific circumstances that led to treatment choice. However, a full structural model, leading to the identification and estimation of policy invariant parameters requires a complete specification of the underlying economic models.
Suppose an evaluation wishes to ask the question of how an intervention, such as training will affect earnings.
Randomised Experiments and earnings

- Suppose an evaluation wishes to ask the question of how an intervention, such as training will affect earning.
- The evaluation approach is to offer training randomly to a subset of a group of volunteers.
Let $S$ stand for earnings, $R$ for randomisation status $(0,1)$ and $P$ for work status sometime after the experiment.
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Now consider what the randomised experiment identifies

$$E(S_i|R_i = 1) - E(S_i|R_i = 0) =$$

$$[E(S_i|R_i = 1, P_i = 1) - E(S_i|R_i = 0, P_i = 1)] \Pr (P_i = 1|R_i = 0)$$

$$+ [\Pr (P_i = 1|R_i = 1) - \Pr (P_i = 1|R_i = 0)] E(S_i|R_i = 1, P_i = 1)$$

Thus earnings increases will occur because of increased employment (the last term) and/or because of the increased earnings of those employed.
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This would require a model (theory) of employment.
We can start by a very simple argument in the simplest possible labour supply model under piece-wise linear taxes.
A simple structural model of labour supply

Reading: Meghir and Phillips, Labour Supply and Taxes, in Mirrlees Review

- We can start by a very simple argument in the simplest possible labour supply model under piece-wise linear taxes.
- Suppose labour supply (hours worked) can be written as

\[ h = a + b \log w + c\mu + u \]

where \( w \) is the hourly wage rate, \( \mu \) is non-labour income and \( u \) is unobservable tastes for work.
A simple structural model of labour supply

Now consider a tax system that gives rise to a convex budget set (no fixed costs, constant or increasing marginal tax rates with earnings)
To simplify notation we take a system with two tax brackets: one has a marginal tax rate of zero 0 and one of $t$. 

The optimal choice of hours of work is given by:

$$h = a + b \log[(1-t)w] + c[\mu + tA] + u$$

The structural parameters here are $a$, $b$, $c$ and the distribution of $u$. 

![Graph showing the relationship between after-tax income, hours, and tax brackets](image)
To simplify notation we take a system with two tax brackets: one has a marginal tax rate of zero and one of $t$.

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[Diagram showing labor supply and tax reform model]
Now consider a reform that changes the tax rate from $t_1$ to $t_2$. Suppose for the sake of argument that the new tax rate is randomised. What treatment effect would we estimate according to this simple model?
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Following the randomised experiment we would compute the effect of the tax rate change as the change in the average hours worked, i.e. $\bar{h}_2 - \bar{h}_1$ or we might also normalise by the size of the tax change: $\frac{\bar{h}_2 - \bar{h}_1}{t_2 - t_1}$. Given the randomisation this is the causal effect of this tax reform. What is the external validity of this estimate.
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In our language, how does this relate to the structural parameters
In this model individuals can decide to work on the zero tax segment, exactly on the kink or above the kink.
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The kink has a positive mass because all those individuals with \( u \) such that
\[
    a + b \log w + c\mu + u \geq A/w
\]
and
\[
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Let the proportions on each of these segments be $p_0(t)$, $p_k(t)$, $p_2(t)$ where the $t$ denotes the tax rate under which they took this decision.
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A change in the tax rate from $t_1$ to $t_2$ cannot change $p_0(t)$ so long as it does not become negative and the slope after the tax kink becomes steeper than the segment before. Hence the composition of preferences and wages is also invariant to this type of reform. This follows from the convexity of indifference curves.
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However it is possible that $p_k(t)$ and hence $p_2(t)$ change.
Average hours (assuming that everyone works) can be written as

\[ E(h) = E(h| h < A/h)p_0 + \frac{A}{w}p_k + E(h| h > A/h)p_2 \]
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Now consider how the treatment effect can be written in terms of the model. (\( \Delta_t \) means the change induced by a change in \( t \), e.g.

\[
\Delta_t [p_2(t)] = p_2(t_1) - p_2(t_2)
\]

\[
E(h|t_2) - E(h|t_1) \equiv \Delta_t [E(h|t)] = A \times \Delta_t [p_k(t)E(\frac{1}{w}|t, h(t) = \frac{A}{w})]
\]

\[
+ a\Delta_t [p_2(t)] + b\Delta_t [p_2(t)E(\log w|t, h(t) > \frac{A}{w})]
\]

\[
+ c\Delta_t [p_2(t)E(\mu|t, h(t) > \frac{A}{w})]
\]

\[
+ b\Delta_t [p_2(t)\log(1 - t)] + cA\Delta_t [p_2(t)t] + \Delta_t [p_2(t)E(u|t, h(t) > \frac{A}{w})]
\]
In the simplest world of proportional taxation with no tax allowances ($A = 0$ and $p_2(t) = 1$), we get

$$E(h|t_2) - E(h|t_1) = b\Delta_t \left[ \log(1 - t) \right]$$

which does have external validity and indeed identifies the wage effect (but not the income effect).
Treatment Effects and Structural Parameters in the Labour Supply Example

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Nevertheless our use and interpretation of such a parameter is limited by the lack of an interpretative framework and by external validity.

Our ability to learn from data is limited without a theoretical framework with which to interpret the results.
The Cowles agenda also expressed in Marschak is to find ways of identifying the structural parameters. This will allow to identify the impact of policy in many different contexts. Orcutt & Orcutt (reading list) advocate running experiments with an express aim at identifying structural models. In the example provided above, this would imply assigning randomly different wages (through variation in taxes) and different levels of non-labour income to identify the structural labour supply model.
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Two Alternative Evaluations of Tax Credits

- A difference in Differences approach:
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Two Alternative Evaluations of Tax Credits

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- A Structural Approach:
Two Alternative Evaluations of Tax Credits

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The Earned Income Tax Credit in the US is effectively a negative marginal tax rate for low earning individuals.
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The general form of benefit looks as in the graph below.
The UK system is similar but also imposes the condition that individuals have to work at least 16 hours.
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The budget constraint under the UK system looks like...
Earned Income Tax Credit

- Under the US system the budget constraint looks like:

![Graph showing the budget constraint with take-home pay on the y-axis and hours of work on the x-axis. The diagram illustrates how the take-home pay changes as hours of work increase.](image-url)
The specific parameters of the programme differ depending on the demographic composition of the household.
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Earned Income Tax Credit

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- In the UK it started as a benefit for families with children.
- In the US it replaced the AFDC (Aid for Families with Dependent Children) and aimed to improve work incentives, while helping poorer families with children.
- The key idea is that the programme transfers income to the working poor.
- The labour supply theory predicts that such a wage subsidy will encourage participation into work but could reduce the hours of work as shown in the figure depicting the UK system.
We can now think what is needed to evaluate such a programme or changes to it.
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One approach is a difference in differences method as followed by Eissa and Liebman.
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They exploit an expansion of the system.
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They exploit an expansion of the system.

Their comparison group was the group of childless women who were not eligible for the programme.
The expansion they are considering increased the subsidy rate from 11% to 14% and increased the maximum income to which the subsidy rate applied from $5000 to $6080.
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The phase-out rate was reduced from 12.22% to 10%. This made individuals between $11,000 and $15,000 now eligible for some credit.
<table>
<thead>
<tr>
<th>TABLE II</th>
<th>LABOR FORCE PARTICIPATION RATES OF UNMARRIED WOMEN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-TRA86 (1)</td>
</tr>
<tr>
<td>A. Treatment group:</td>
<td></td>
</tr>
<tr>
<td>With children</td>
<td>0.729 (0.004)</td>
</tr>
<tr>
<td>[20,810]</td>
<td></td>
</tr>
<tr>
<td>Control group:</td>
<td></td>
</tr>
<tr>
<td>Without children</td>
<td>0.952 (0.001)</td>
</tr>
<tr>
<td>[46,287]</td>
<td></td>
</tr>
<tr>
<td>B. Treatment group:</td>
<td></td>
</tr>
<tr>
<td>Less than high school, with children</td>
<td>0.479 (0.010)</td>
</tr>
<tr>
<td>[5396]</td>
<td></td>
</tr>
<tr>
<td>Control group 1:</td>
<td></td>
</tr>
<tr>
<td>Less than high school, without children</td>
<td>0.784 (0.010)</td>
</tr>
<tr>
<td>[3958]</td>
<td></td>
</tr>
<tr>
<td>Control group 2:</td>
<td></td>
</tr>
<tr>
<td>Beyond high school, with children</td>
<td>0.911 (0.005)</td>
</tr>
<tr>
<td>[5712]</td>
<td></td>
</tr>
<tr>
<td>C. Treatment group:</td>
<td></td>
</tr>
<tr>
<td>High school, with children</td>
<td>0.764 (0.006)</td>
</tr>
<tr>
<td>[9702]</td>
<td></td>
</tr>
<tr>
<td>Control group 1:</td>
<td></td>
</tr>
<tr>
<td>High school, without children</td>
<td>0.945 (0.002)</td>
</tr>
<tr>
<td>[16,527]</td>
<td></td>
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This raises the issue of whether the assumptions underlying the difference in differences estimator can possibly be valid.

The next point to note is that the estimated effect is a complicated function of the underlying structural parameters, the baseline and reformed tax system and the distribution of wages.
We illustrate this with the simplest possible model: one where the individual just chooses whether to work or not.
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\begin{align*}
U_w & = a_0 + a_1 Y_w \\
U_{nw} & = b_0 + b_1 Y_{nw} + v
\end{align*}
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\[ U^w = a_0 + a_1 Y^w \] (tax credit, wage) \hspace{1cm} \text{Work} \]

\[ U^{nw} = b_0 + b_1 Y^{nw} \] (out of work benefits) + \nu \hspace{1cm} \text{Unemployed} \]
Earned Income Tax Credit (Eissa and Liebmann)

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- Her utility is

\[ U^w = a_0 + a_1 Y^w (\text{tax credit, wage}) \quad \text{Work} \]

\[ U^{nw} = b_0 + b_1 Y^{nw} (\text{out of work benefits}) + \nu \quad \text{Unemployed} \]

- Assuming no aggregate growth the impact will depend on the is

\[
\text{Effect} = \int \{ \Pr [\nu < (a_0 - b_0) + a_1 Y^w (\text{new credit, wage}) - b_1 Y^{nw} (\text{benefits})] - \Pr [\nu < (a_0 - b_0) + a_1 Y^w (\text{old credit, wage}) - b_1 Y^{nw} (\text{benefits})] \} dF(w)
\]
The UK had a similar expansion to the tax credit system in 1998.
Assume the individual can choose to work one of $H = \{0, 10, 20, 30, 40\}$ hours.
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Her hourly wage rate is \( W \).
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At each such point the individual obtains a level of income, which is the result of taxes and benefits that correspond to each level of pre-tax earnings $W \times H$. 
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Denote this level of income by \( Y^H(W, T) \) where \( T \) denotes the set of parameters that describe the tax and benefit system.
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Denote this level of income by \( Y^H(W, T) \) where \( T \) denotes the set of parameters that describe the tax and benefit system.

Denote the utility of working a particular level of hours by

\[
U^H = a^H(Q) + b^H(Q)Y^H(W, T) + \nu^H = G^H(M) + \delta^Hf + e^H
\]

where \( a^H \) and \( b^H \) may depend on household characteristics \( Q \) such as the number and age of children. We summarize \( M = [Q, W, T] \).
The term $e^H$ reflects unobserved heterogeneity specific to an hours level. $f$ reflects an unobserved component affecting preferences through the parameter $\delta^H$. 
The term $e^H$ reflects unobserved heterogeneity specific to an hours level. $f$ reflects an unobserved component affecting preferences through the parameter $\delta^H$.

Under these assumptions the probability of observing one particular hours choice $H = h$ is logistic

$$
\Pr(H = h|Q, W, f) = \frac{\exp(G^h(M) + \delta^h f)}{\sum_{H=\{0,10,20,30,40\}} \exp(G^H(M) + \delta^H f)}
$$
There are three key difficulties with this:

1. Wages are not observed for non-workers
2. Wages may depend on the unobserved component of preferences
3. The unobserved component needs to be accounted for

In other words we need to complete the model with a specification of wages and of unobserved heterogeneity.
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Working Families Tax Credit (UK) - Towards a Structural Model

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In other words we need to complete the model with a specification of wages and of unobserved heterogeneity.
We specify a wage model of the form

$$\log W = \gamma'X + \beta(Z) + \gamma f + \varepsilon$$

where $$\varepsilon \sim N(0, \sigma^2)$$ and where $$X$$ will include education and age. Note the presence of $$f$$: This reflects the issue of endogeneity of wages for labour supply and is modelled as a one factor model.
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where $\varepsilon \sim N(0, \sigma^2)$ and where $X$ will include education and age. Note the presence of $f$: This reflects the issue of endogeneity of wages for labour supply and is modelled as a one factor model.

At this point a central issue is whether wages can vary independently of $Q$: This depends on having a (set of) credible instruments $Z$ that affect wages but not labour supply.
In the past we have used the idea that wages vary *differentially* across education and cohort groups, but that preferences do not depend on interactions between time and cohort.
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This is of course the difference in differences assumption used within a structural model, and can be expressed here as follows

\[ a(Q) = a_0 + d_t + a'_1 R \]

and similarly for \( b(Z) \), while

\[ \beta' Z = \beta_0 + \zeta d_t + a'_1 (d_t \times R) \]
Thus, when we know the wage (i.e. for workers) the joint density of wages and the probability of the hours point is given by

$$L^H_{i \neq 0}(f) = \phi \left( \frac{\log W - \gamma'X - \beta(Z) - \gamma f}{\sigma} \right) \times \Pr(H = h|Q, W, f)$$
Constructing the Likelihood Function

- Thus, when we know the wage (i.e. for workers) the joint density of wages and the probability of the hours point is given by

\[ L_i^{H \neq 0}(f) = \phi \left( \frac{\log W - \gamma' X - \beta(Z) - \gamma f}{\sigma} \right) \times \Pr(H = h | Q, W, f) \]

- If the individual is not working, her wage is not known and has to be integrated out (i.e. take the average over all possible wages):

\[ L_i^0(f) = \int_W \phi \left( \frac{\log W - \gamma' X - \beta(Z) - \gamma f}{\sigma} \right) \times \Pr(H = h | Q, W, f) dW \]
The final element of the story is integrating out unobserved heterogeneity.
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Following Heckman and Singer it is now standard to assume that $f$ has discrete distribution with two or three (or more) points of support.
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This means that $f = \{ f_1, f_2, f_3 \}$ say each with unknown probability $p_1, p_2, p_3 = 1 - p_1 - p_2$. All the $f$s and the $p$s need to be estimated.
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The model likelihood becomes

\[
L = \prod_{i \text{ is nonwork}} \sum_{k=1}^{3} p_k L_i^0(f_k) \times \prod_{i \text{ is work}} \sum_{k=1}^{3} p_k L_i^H(f_k)
\]
The final element of the story is integrating out unobserved heterogeneity.

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This means that $f = \{f_1, f_2, f_3\}$ say each with unknown probability $p_1, p_2, p_3 = 1 - p_1 - p_2$. All the $f$s and the $p$s need to be estimated.

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This function is then maximised to obtain the unknown parameters in preferences, the wage equation and the distribution of unobserved heterogeneity.
The reform tended to affect people in many different ways, some more than others.

**FIGURE 3**

*Budget Constraint for Example Lone Parent without Childcare Costs*

- - - WFTC

Family credit

**FIGURE 4**

Budget Constraint for Example Lone Parent with Childcare Costs

- — WFTC (net)
- — Family credit (net)

Notes:
- One child aged under 11.
- Hourly wage £4.39 (median for lone parents).
- Rent £41.10 p.w. (median for social renters with children).
- Childcare at £1.96 per hour.
FIGURE 7
Budget Constraint for Example Woman in Couple with Childcare Costs

- --- WFTC
- Family credit

Family disposable income (£ p.w.)

Hours of work

0 10 20 30 40 50

200 250 300 350 400
### TABLE 5
Proportion of Gainers from WFTC

<table>
<thead>
<tr>
<th></th>
<th>Hours of work (banded)</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1–10</td>
</tr>
<tr>
<td><strong>Lone parents</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No pre-school children</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>One or more pre-school</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>children</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All women</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td><strong>Married, partner working</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No pre-school children</td>
<td>30.6</td>
<td>19.0</td>
</tr>
<tr>
<td>One or more pre-school</td>
<td>35.9</td>
<td>12.7</td>
</tr>
<tr>
<td>children</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All women</td>
<td>33.9</td>
<td>16.2</td>
</tr>
<tr>
<td><strong>Married, partner not working</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No pre-school children</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>One or more pre-school</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>children</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All women</td>
<td>.</td>
<td>.</td>
</tr>
</tbody>
</table>

Note: Data are grouped according to observed hours of work for all household members and conditioned on observed childcare expenditure patterns.
**TABLE 7**

Simulated Transitions among Single Parents
(100% take-up of WFTC)

<table>
<thead>
<tr>
<th>Transitions</th>
<th>Pre-reform</th>
<th>Post-reform</th>
<th>Pre-reform %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Out of work</td>
<td>Part-time</td>
<td>Full-time</td>
</tr>
<tr>
<td>Out of work</td>
<td>58.0</td>
<td>0.7</td>
<td>1.5</td>
</tr>
<tr>
<td>Part-time</td>
<td>0.0</td>
<td>18.6</td>
<td>0.5</td>
</tr>
<tr>
<td>Full-time</td>
<td>0.0</td>
<td>0.2</td>
<td>20.6</td>
</tr>
<tr>
<td>Post-reform %</td>
<td>58.0</td>
<td>19.4</td>
<td>22.6</td>
</tr>
<tr>
<td>Change (% points)</td>
<td>−2.2</td>
<td>0.3</td>
<td>1.9</td>
</tr>
<tr>
<td>Transitions</td>
<td>Pre-reform</td>
<td>Post-reform</td>
<td>Pre-reform %</td>
</tr>
<tr>
<td>--------------</td>
<td>------------</td>
<td>-------------</td>
<td>--------------</td>
</tr>
<tr>
<td></td>
<td>Out of work</td>
<td>Part-time</td>
<td>Full-time</td>
</tr>
<tr>
<td>Out of work</td>
<td>32.2</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Part-time</td>
<td>0.3</td>
<td>31.6</td>
<td>0.0</td>
</tr>
<tr>
<td>Full-time</td>
<td>0.4</td>
<td>0.1</td>
<td>35.0</td>
</tr>
<tr>
<td>Post-reform %</td>
<td>33.0</td>
<td>31.8</td>
<td>35.2</td>
</tr>
<tr>
<td>Change (% points)</td>
<td>0.6</td>
<td>−0.1</td>
<td>−0.4</td>
</tr>
</tbody>
</table>
# TABLE 9

Simulated Transitions among Married Women with Unemployed Partners  
(100% take-up of WFTC)

<table>
<thead>
<tr>
<th>Transitions</th>
<th>Pre-reform %</th>
<th>Pre-reform</th>
<th>Post-reform</th>
<th>Pre-reform %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Out of work</td>
<td>Part-time</td>
<td>Full-time</td>
<td></td>
</tr>
<tr>
<td>Out of work</td>
<td>56.8</td>
<td>0.4</td>
<td>0.9</td>
<td>58.1</td>
</tr>
<tr>
<td>Part-time</td>
<td>0.0</td>
<td>22.2</td>
<td>0.4</td>
<td>22.6</td>
</tr>
<tr>
<td>Full-time</td>
<td>0.0</td>
<td>0.1</td>
<td>19.2</td>
<td>19.3</td>
</tr>
<tr>
<td>Post-reform %</td>
<td>56.8</td>
<td>22.8</td>
<td>20.5</td>
<td>100</td>
</tr>
<tr>
<td>Change (% points)</td>
<td>-1.3</td>
<td>0.2</td>
<td>1.1</td>
<td></td>
</tr>
</tbody>
</table>