Dynamic Female Labor Supply

Zvi Eckstein and Osnat Lifshitz

Pittsburgh, USA
Why Do We Study Female Employment (FE)?
Because they contribute a lot to US GDP Per Capita...

![Graph showing US GDP Per Capita in 2000 Prices with Actual GDP Per Capita and GDP Per Capita FE at 1964 level.]

- Actual GDP Per Capita:
  - 1964: 16000
  - 2004: 38290 (245%)

- GDP Per Capita FE at 1964 level:
  - 1964: 25000
  - 1968: 20000
  - 1972: 18000
  - 1976: 15000
  - 1980: 15000
  - 1984: 17000
  - 1988: 19000
  - 1992: 23000
  - 1996: 28000
  - 2000: 33000
  - 2004: 38000

- 1964 to 2004 increase: 40%
Central Question

Why Did Female Employment (FE) Rise Dramatically?
Because Married FE Rose.....!
Who among the Married?
The Educated (HSG-CG) Females!
Why did *Married* Female Employment (FE) Rise Dramatically?
Main Empirical Hypotheses

- **Education increase** (Becker)

- **Wage increase/Gender Gap decline**

- **Fertility decline**

- **Marriage decline/Divorce increase**

- **Other**
Education Increase

Educational Composition of Married Females

- HS Graduates
- HS Dropouts
- Some College
- College Graduates
- Post College

Women by cohort ➡️ Men composition s.s. ➡️ Men by cohort
Wage increase – Gender Gap decline

**Annual Wages of Full Time Workers**

- **Males**
- **Females**

**Female to Male Wage Ratio** (right axis)

- 1962
- 1966
- 1970
- 1974
- 1978
- 1982
- 1986
- 1990
- 1994
- 1998
- 2002
- 2006
Fertility Decline

Mean Number of Children - Married Females

Children under 18

Children under 6
Decrease in the Fertility of Married Women

Mean Number of Children Under 18 by Cohort - Married Females
Marriage Declines – Divorce Increases

Marital Status Composition of Females

- Married
- Single (Never Married)
- Divorced

What are the *Other* Empirical Hypotheses?

- **Social Norms**  

- **Cost of Children**  

- **Technical Progress**  
  Goldin(1991), Greenwood et. al.(2002),

Will show up as a *cohort* effects..
Employment rates by Age

Post baby-boomers Cohort’s FE stabilized
An Accounting Exercise

- Measure female’s employment due to:
  - Education increase
  - Wage increase/Gender Gap decrease
  - Fertility decline
  - Marriage decline/Divorce growth

- The “unexplained” is Others

Lee and Wolpin, 2008
An Accounting Exercise

- Need an empirical model
- Use Standard *Dynamic* Female Labor Supply Model
  – Eckstein and Wolpin 1989 (EW): “old” model

Sketch of the Model

- Extension of Heckman (1974)
- Female maximizes PV utility
  - Chooses employment \( p_t = 1 \) or \( 0 \)
  - Takes as given:
    - Education at age 22
    - Husband characteristics
    - Processes for wages, fertility, marital status
- Estimation using SMM and 1955 cohorts from CPS
The woman chooses employment in order to maximize:

\[
E_t \left[ \sum_{k=0}^{T-t} \delta^j U(p_{t+k}, x_{t+k}, K_{t+k-1}, N_{t+k,j} (j = 1..J), S, M_{t+k}) \right]
\]

\[
p_t = 1 \quad \text{Employed}
\]

\[
x_t \quad \text{Consumption}
\]

\[
K_{t-1} \quad \text{Experience}
\]

\[
N_{tj} \quad \text{Children age group } j
\]

\[
S \quad \text{Schooling;}
\]

\[
M_t = 1 \quad \text{Married}
\]

\[
U_t = \alpha_1 p_t + x_t + \alpha_2 p_t x_t + \alpha_3 p_t K_{t-1} + \sum_{j=1}^{J} \alpha_{4j} N_{tj} p_t + \alpha_5 p_t S + f(N_{tj})
\]
The household's budget constraint:

\[
((1 - \alpha)(1 - M_t) + \alpha)(y_t^w p_t + y_t^h M_t) = x_t + \sum_{j=1}^{J} c_j N_{tj} + bp_t
\]

- \(y_t^h\) Husband's earnings
- \(y_t^w\) Wife's earnings
- \(c_j\) Goods cost per child of age \(j\);
- \(b\) Fixed cost if working;
- \(\alpha\) Fraction of income consumed by the wife.
The Mincerian (Ben-Porat; Griliches) female’s earning function

\[ \ln y_t^w = \beta_1 + \beta_2 K_{t-1} + \beta_3 K_{t-1}^2 + \beta_4 S + \beta_5 t + \epsilon_t. \]

Budget constraint and wage into utility imply:

Employment:  \[ U^1_t(K_{t-1}, \epsilon_t, \Omega_t) = \alpha_1 + (1 + \alpha_2) \left( \exp\left\{ \beta_1 + \beta_2 K_{t-1} + \beta_3 K_{t-1}^2 + \beta_4 S + \epsilon_t \right\} + \bar{y}_t^h - \sum_{j=1}^{J} c_j N_{ij} - b \right) \]

\[ + \alpha_3 K_{t-1} + \sum_{j=1}^{J} \alpha_4 j N_{ij} + \alpha_5 S + f(N_{ij}) \]

Unemployment:  \[ U^0_t(K_{t-1}, \epsilon_t, \Omega_t) = \bar{y}_t^h - \sum_{j=1}^{J} c_j N_{ij} + f(N_{ij}). \]
Probabilities

Logistic form for: job offer probability, marriage and divorce probability and probability of having a new child

$V_t^1()$ and $V_t^0()$ are the maximum expected discounted utility if the woman at time $t$ works ($p_t = 1$) or does not work ($p_t = 0$), respectively

$$v_t^1(\Omega_t, t) = U_t^1(K_{t-1}, e_t, \Omega_t) + \beta \cdot E\left(V_{t+1}(K_t, e_{t+1}, \Omega_{t+1})|\Omega_t, p_t = 1\right)$$
$$v_t^0(\Omega_t, t) = U_t^0(K_{t-1}, e_t, \Omega_t) + \beta \cdot E\left(V_{t+1}(K_t, e_{t+1}, \Omega_{t+1})|\Omega_t, p_t = 0\right)$$

$$V_t = \max(v_t^0, v_t^1)$$

Solution:

Backward Solution following Eckstein and Wolpin (1989) and Keane and Wolpin (1997)
Estimation: Structural DP model using CPS

- **Estimation EW**: SMM using 1955 cohort CPS data and choice of relevant cross-section moments. Joint estimation of the following equations:
  - Female Employment: dynamic discrete choice model with cross equation restrictions and rational expectations internal consistency (Lucas, 1976, Sargent, 1983: Mix probit with logit FE offer rate)
  - Log wage with endogenous experience (not age).
  - MNL of Children, Marriage, Divorce
  - Random choice of husband conditional of characteristics; Female

- **Alternative**: MNL and Log Wage Alternative - Full Reduced form approximation. (KW, 2006, Del-Boca and Sauer 2008)
Estimation Fit – 1955 cohort FE
Back to Accounting Exercise

For the 1955 cohort we estimated:

\[ p^{55} = P^{55}(S, y^w, y^h, N, M) \quad \text{for each age} \]

Contribution of *Education* of 1945 cohort (*S*\textsuperscript{45}) for predicted FE of 1945 cohort is:

\[ \text{predicted } p^{45} = P^{55}(S^{45}, y^w^{55}, y^h^{55}, N^{55}, M^{55}) \]

*...Education and Wage*

\[ \text{predicted } p^{45} = P^{55}(S^{45}, y^w^{45}, y^h^{45}, N^{55}, M^{55}) \]

*...Etc*
How much of the differences between 1955 cohort and other cohorts accounted by changes in:

(1) Education
(1)+(2) Wage
(1)+(2)+(3) Fertility
(1)+(2)+(3)+(4) Marital Status

The unexplained = Others : cost/utility change at home
Accounting for changes in FE: **1945 cohort**

### Age Group: 28-32 1955: Actual: 69%  Fitted: 69%

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Actual 1945</td>
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<tr>
<td>+ 3 Children</td>
<td>63%</td>
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<tr>
<td>+ 4 Martial Status</td>
<td>63%</td>
</tr>
<tr>
<td>Other</td>
<td>10%</td>
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### Age Group: 38-42 1955: Actual: 78%  Fitted: 76%

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<tr>
<th>Category</th>
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<tr>
<td>+ 4 Martial Status</td>
<td>73%</td>
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<tr>
<td>Other</td>
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Early age total difference 16% - 10% is **Other**
## Decomposition of the change in FE

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<tr>
<th>Age Group: 23-27</th>
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<td>55 Actual: 67%, fitted: 67%</td>
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<tr>
<td><strong>Actual</strong></td>
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Accounting for the change in FE:
Cohorts of 1945, 65, 75 based on 1955

- **Education:** ~60% of the change in FE
- **Wages:** ~10%
- **Fertility:** ~10%
- **Marriage:** ~0%
- **Other:** ~20%
  - 50% at the early ages
  - 0% for older ages
Accounting for the change in FE: Cohorts of 1925, 35: based on 1955 Cohort

- Education: ~ 47% of the change in FE
- Wages: ~ 5%
- Fertility: ~ 3%
- Marriage: ~ 0%
- Other: ~ 45%

- 55% at the early ages
- 35% for older ages

What are the missing factors for “other”? 
What is missing factor for early ages?

- Childcare cost if working

- Change 1 parameter ($\alpha_4$) – get perfect fit
  - 1945 cohort childcare cost: $5/\text{hour higher}$
  - 1965 cohort childcare cost: $0.23/\text{hour lower}$
  - 1975 cohort childcare cost: $0.34/\text{hour lower}$
What is missing factor for all ages?

- Childcare cost if working
- Value of staying at home
- Change 2 parameters ($\alpha_1, \alpha_4$) – get perfect fit
  - 1935, 1925 cohorts childcare cost: $5/hour higher
  - 1935 cohort leisure value: $3.9/hour higher
  - 1925 cohort leisure value: $3.5/hour higher

*How can we explain results?*
How can we explain results?

- Change in cost/utility interpreted as:
  - Technical progress in home production
  - Change in preferences or social norms

*How do we fit the aggregate employment/participation?*
Aggregate fit Simulation

- Simulate the participation rate for all the cohorts: 1923-1978.
- Calculate the aggregate participation for each cohort at each year by the weight of the cohort in the population.
Aggregate Participation Rate of Women, Ages 23-54
Modeling change in cost/utility of leisure

- **Unobserved heterogeneity** regarding leisure/children
- **Bargaining** power of women changes
- **Household game**: a “new” empirical framework
Labor Supply of Couples: Traditional and Modern Households – "new" Model

- Internal family game (McElroy, 1984, Chiappori, 1998)
The Model: Household Dynamic Game

- Two types of household
  - **Traditional (T):** Husband is Stackelberg leader.
    Every period after state is realized the husband makes the decision before the wife, and then she responds.
  - **Modern (M):** Husband & Wife play Nash.
    Husband & wife are symmetric, act simultaneously after state is realized, taking the other person actions as given.

- Both games are solved as *sub-game perfect*. 
Sketch of Model: Choices

- Employment; Unemployment; Out of LF

- Initially UE or OLF - two sub-periods
  - Period 1: Search or OLF
  - Period 2: Accept a potential offer E or UE

- Initially E – one period
  - Quit to OLF
  - Fired to UE
  - Employment in a “new” wage.
Sketch of Model: Dynamic program

- Max Expected PV as in EW
  - Utility functions are identical for both T and M
  - Characteristics of husband and wife different

- Game solved recursively backwards to wedding
Utility functions:

\[ U_{jt} = u(x_t) + \alpha_j \cdot l_{jt} + f(N_t) \quad l_{jt} = \text{leisure} \]

\[ u(x_t) = \frac{(x_t)^{\gamma_j}}{\gamma_j} \quad f(N_t) = \gamma_0 \cdot N_t + \gamma_2 c_t + \frac{\gamma_1}{\text{age}_t} \left[ \frac{l_{Wt} + l_{Ht}}{N_t} \right] \]

\[ U^1_{Wt} = u\left(1 - \alpha\right)\left(y^W_t + y^H_t \cdot d^1_{Ht}\right) + f(N_t) \]

\[ U^2_{Wt} = u\left(1 - \alpha\right)\left(y^H_t \cdot d^1_{Ht}\right) + f(N_t) + \alpha_W \cdot (l_{Wt} - SC) + \varepsilon^2_{Wt} \]

\[ U^3_{Wt} = u\left(1 - \alpha\right)\left(y^H_t \cdot d^1_{Ht}\right) + f(N_t) + \alpha_W \cdot l_{Wt} + \varepsilon^3_{Wt} \]

\[ U^1_{Ht} = u\left(1 - \alpha\right)\left(y^H_t + y^W_t \cdot d^1_{Wt}\right) + f(N_t) \]

\[ U^2_{Ht} = u\left(1 - \alpha\right)\left(y^W_t \cdot d^1_{Wt}\right) + f(N_t) + \alpha_H \cdot (l_{Ht} - SC) + \varepsilon^2_{Ht} \]

\[ U^3_{Ht} = u\left(1 - \alpha\right)\left(y^W_t \cdot d^1_{Wt}\right) + f(N_t) + \alpha_H \cdot l_{Ht} + \varepsilon^3_{Ht} \]
Sketch of model: Budget constraint

The household budget constraint

\[ y_t^W \cdot d_{Wt}^1 + y_t^H \cdot d_{Ht}^1 = x_t + c_t \cdot N_t \]

\( y_t^W \) and \( y_t^H \) are the wife's and husband's earnings;

\( d_{jt}^a \) equals one if individual \( j = H,W \) chooses alternative \( a \) at time \( t \), and zero otherwise;

\( x_t \) is the joint couple consumption during period \( t \);

\( c_t \) is the goods cost per child, \( c_t = \alpha \cdot \left( \frac{y_t^W \cdot d_{Wt}^1 + y_t^H \cdot d_{Ht}^1}{N_t} \right) \)

\( N_t \) is the number of children in the household.
Sketch of model: Wage and probabilities (EW)

- **Mincerian wage** functions for each $j = H, W$

  \[
  \ln y_t^j = \beta_1^j + \beta_2^j K_{jt-1} + \beta_3^j K_{jt-1}^2 + \beta_4^j S_j + \epsilon_{jt}^1.
  \]

- **Endogenous experience** $k_{jt} = k_{jt-1} + d_{jt}^1$

- Logistic form for job offer probability, divorce probability and probability of having a new child (like EW model).
Logistics form for probability of employment, children and divorce:

$$\Pr(\phi(\Omega_t, P_t)) = \frac{\exp(\phi(\Omega_t, P_t))}{1 + \exp(\phi(\Omega_t, P_t))}$$

**Job Offer Probability**

(function of: constant, schooling, experience and time trend):

$$\phi(\Omega_t, P_t) = \rho_0 + \rho_1 \cdot S + \rho_2 \cdot K_{t-1} + \rho_3 \cdot P_{t-1} + \rho_4 \cdot t$$

**Probability of Having a New Child**

(function of: constant, age of couple, schooling of couple, number of children and age of youngest child):

$$\phi(\Omega_t, P_t) = c_0 + c_1 \cdot age_w + c_2 \cdot age_w^2 + c_3 \cdot age_H + c_4 \cdot S_w + c_5 \cdot S_H + c_6 \cdot N_{t-1} + c_7 \cdot Age\_of\_Youngest$$

**Divorce Probability**

(function of: constant, years of marriage, number of children, husband and wife previous state):

$$\phi(\Omega_t, P_t) = d_0 + d_1 \cdot y\_marriage + d_2 \cdot N_{t-1} + d_3 \cdot P_{H_{t-1}} + d_4 \cdot P_{W_{t-1}}$$
Sketch of Model: Main Result

- **Wives work more in M than T family** because:
  - Husband earnings and offer rates are **larger**
  - In **M family** she faces more uncertainty

(Husband employment and earnings are uncertain when she makes the decision independently)
Estimation: SMM

Data

- **PSID – Panel** - 863 couples who got married between 83-84 - **Cohort of 1960**
- 10 years (40 quarters) sample (at most)

2 sets of moments:

- Mean individual choice of \((E; UE; OLF)\) by duration since marriage.
- Average predicted and actual wage for men and women by duration since marriage.
Estimation Results

- 90% of choices are correctly predicted
- 61% is estimated proportion of T families

- Husbands in T & M have similar labor supply
- Wives participate 9% more in M families
Fit: Employment rate

Male - Predicted
Male - Actual

Female - Predicted
Female - Actual
Actual vs. Predicted Average Wage
Predicted LFP: Traditional and Modern Women

[Graph showing predicted LFP rates for traditional and modern women over quarters since marriage (1983/4)].
Probability of Family type

- **Posterior probability** of M family is:

  - Negatively correlated with: husband age at wedding, number of children, husband is black or Baptist.
  - Positively correlated with: couples education, wife age at wedding; husband is white, Catholic; potential divorce.
Counterfactual: 100% of Families are Modern

- Increase of female participation $\sim 5\%$
- No impact on males
- Participation difference from males $\sim 10\%$. 
Counterfactual: Full Equality - 100% of Families are Modern; Equal Wages & Job Offers for Males and Females

- Males participation decreases by 1.4%
- Females participation increases by 13.7%.
- Difference between males & females participation (3.7%) due to higher risk aversion and higher cost/utility from home for females
Summary of results

- **Education** – 50% of increase in Married FE
- **Other** – 25-35% of increase in Married FE
- **Household game model** for change in **Social Norms (T and M families)** can account to large change in Married FE – 5% to 10%
Concluding remarks

- The two examples demonstrate the gains from using Stochastic Dynamic Discrete models:
  - Dynamic selection method, rational expectations, and cross-equations restrictions are imposed
  - Accounting for alternative explanations for rise in US Female Employment

- Dynamic couples game models are the framework for *future* empirical labor supply
Educational Composition of Males

- HSD: 50%
- HSG: 35%
- SC: 40%
- CG: 45%
- PC: 25%

## Appliances in U.S. Households, Selected Years, 1980-2001

(Percentage)

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<tr>
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<td>Clothes Washer</td>
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<td>Microwave</td>
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<td>43</td>
<td>45</td>
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<td>50</td>
<td>53</td>
</tr>
</tbody>
</table>
Logistics form for probability of employment, children, marriage and divorce:

\[
\Pr\left(\phi(\Omega_t, P_t)\right) = \frac{\exp\left(\phi(\Omega_t, P_t)\right)}{1 + \exp\left(\phi(\Omega_t, P_t)\right)}
\]

**Job Offer Probability**

(function of: constant, schooling, experience and previous state):

\[
\phi(\Omega_t, P_t) = \rho_0 + \rho_{11} \cdot HSG + \rho_{12} \cdot SC + \rho_{13} \cdot CG + \rho_{14} \cdot PC + \rho_2 \cdot K_{t-1} + \rho_2 \cdot K^2_{t-1} + \rho_3 \cdot P_{t-1}
\]

**Marriage Probability**

(function of: constant, age, schooling, previously divorced):

\[
\phi(\Omega_t, P_t) = m_0 + m_1 \cdot age + m_2 \cdot age^2 + m_3 \cdot S + m_4 \cdot D
\]

**Probability of Having a New Child**

(function of: constant, age, schooling, marital status, number of children and previous state):

\[
\phi(\Omega_t, P_t) = c_0 + c_1 \cdot age + c_2 \cdot age^2 + c_3 \cdot S + c_4 \cdot M_{t-1} + c_5 \cdot N_{t-1} + c_6 \cdot N^2_{t-1} + c_7 \cdot P_{t-1}
\]

**Divorce Probability**

(function of: constant, years of marriage, schooling, number of children, husband wage and previous state):

\[
\phi(\Omega_t, P_t) = d_0 + d_1 \cdot y\_marriage + d_2 \cdot y\_marriage^2 + d_3 \cdot S + d_4 \cdot N_{t-1} + d_5 \cdot y^{H}_{t-1} + d_6 \cdot P_{t-1}
\]
## Estimated Parameters

<table>
<thead>
<tr>
<th>Job offer probability Parameter</th>
<th>Marriage Parameter</th>
<th>Divorce Parameter</th>
<th>Children Parameter</th>
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<tr>
<td>Constant</td>
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<td>2.412</td>
<td>2.412</td>
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<td>Return to Experience</td>
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<td>Return to Age</td>
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<td>Return to Experience^2</td>
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<td>Return to CG</td>
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<tr>
<td>Return to PC</td>
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<td>Marital Status</td>
</tr>
</tbody>
</table>

### Job offer probability Parameter
- **Constant**: 2.412 (0.00)
- **Return to Experience**: -0.001 (0.00)
- **Return to Experience^2**: 0.0007 (0.00)
- **Previous State**: 0.0065
- **Return to HSG**: 0.007 (0.00)
- **Return to SC**: 0.223 (0.00)
- **Return to CG**: 0.486 (0.00)
- **Return to PC**: 0.821 (0.00)

### Marriage Parameter
- **Constant**: 2.412 (0.00)
- **Return to Age**: -0.001 (0.00)
- **Return to Age^2**: 0.0007 (0.00)
- **Divorce**: 0.0065
- **Return to Schooling**: 0.007 (0.00)

### Divorce Parameter
- **Constant**: 2.412 (0.00)
- **Years of marriage**: -0.001 (0.00)
- **Years of marriage^2**: 0.0007 (0.00)
- **Number of children**: 0.0065
- **Previous state**: 0.007 (0.00)
- **Schooling**: 0.223 (0.00)
- **Husband Wage**: 0.486 (0.00)

### Children Parameter
- **Constant**: 2.412 (0.00)
- **Return to Age**: -0.001 (0.00)
- **Return to Age^2**: 0.0007 (0.00)
- **Number of children**: 0.0065
- **Number of children^2**: 0.007 (0.00)
- **Number of children^3**: 0.223 (0.00)
- **Marital Status**: 0.486 (0.00)
- **Schooling**: 0.821 (0.00)
Simulation 1945

Simulated Employment 1945 (changing composition of Education)

- Blue line: fitted
- Pink line: actual

Simulation 1965

Simulated Employment 1965 (changing composition of Education)

- Actual (blue line)
- Fitted (pink line)

Year: 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44
Simulation 1975

Simulated Employment 1975 (changing composition of Education)

- Fitted
- Actual