ECON 452*: *Stata 12/13* Tutorials 8 and 9

TOPIC: **Estimating and Testing the Marginal Probability Effect of the Binary Variable 'dkidslt6'**

DATA: **mroz.dta** (a *Stata*-format dataset created in ***Stata 12/13 Tutorial 8***)

- The ***Stata* commands** that constitute the primary subject of these tutorials are:

probit Used to compute ML estimates of ***probit* coefficients** in probit models of binary dependent variables.

dprobit Used to compute ML estimates of the **marginal *probability* effects** of explanatory variables in probit models.

test Used after probit estimation to compute ***Wald tests*** of linear coefficient equality restrictions on probit coefficients.

lincom Used after probit estimation to compute and test the marginal effects of individual explanatory variables.

margins Used after probit estimation to compute estimates of the **marginal *probability* effects** of both ***continuous*** **and *categorical*** **(*binary*)** explanatory variables.

- The ***Stata* statistical functions** used in this tutorial are:

normalden(*z*) Computes ***value of the standard normal density function (p.d.f.)*** for a given value ***z*** of a standard normal random variable.

normal(*z*) Computes ***value of the standard normal distribution function (c.d.f.)*** for a given value ***z*** of a standard normal random variable.

invnormal(*p*) Computes ***the inverse of the standard normal distribution function;*** if **normal(*z*) = *p*, then invnormal(*p*) = *z***.

❑ Two Probit Models of Married Women's Participation: Specification of Models 2 and 3

We consider two different models of married women's labour force participation.

- **Model 2** was introduced in *Stata 12/13 Tutorial 8*. The **binary indicator variable** $\boldsymbol{dkidslt6_i}$ enters only as an **additive regressor**.

- **Model 3** is a generalization of Model 2: it allows all probit coefficients to differ between (1) married women who currently have one or more pre-school aged children and (2) married women who currently have no pre-school aged children. The **binary explanatory variable** $\boldsymbol{dkidslt6_i}$ enters both **additively and multiplicatively**.

The ***observed dependent variable*** in both models is the binary variable $\boldsymbol{inlf_i}$ defined as follows:

inlf_i = 1 if the i-th married woman is in the employed labour force
= 0 if the i-th married woman is not in the employed labour force

The ***explanatory variables*** in Models 2 and 3 are:

nwifeinc_i = non-wife family income of the i-th woman (in thousands of dollars per year);

ed_i = years of formal education of the i-th woman (in years);

exp_i = years of actual work experience of the i-th woman (in years);

age_i = age of the i-th woman (in years);

dkidslt6_i = 1 if the i-th woman has one or more children less than 6 years of age, = 0 otherwise.

Four of these explanatory variables -- nwifeinc_i, ed_i, exp_i, and age_i -- are ***continuous*** variables, whereas the fifth explanatory variable -- dkidslt6_i -- is a ***binary* indicator (dummy) variable**.

<u>Model 2</u> – binary explanatory variable *dkidslt6$_i$* enters only additively

The **probit index function**, or regression function, **for Model 2** is:

$$x_i^T\beta = \beta_0 + \beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i + \delta_0 dkidslt6_i$$

Remarks: In Model 2, the binary explanatory variable $dkidslt6_i$ enters only additively; only the intercept coefficient in the index function differs between the two groups of married women, those who have pre-school aged children and those who do not.

- In Model 2, the probit index function for ***married women who have no pre-school aged children***, for whom $dkidslt6_i$ = 0, is obtained by setting $dkidslt6_i$ = 0 in the index function for Model 2:

$$\left(x_i^T\beta \,\middle|\, dkidslt6_i = 0\right) = \beta_0 + \beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i + \delta_0 0$$
$$= \beta_0 + \beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i$$

- In Model 2, the probit index function for ***married women who have one or more pre-school aged children***, for whom $dkidslt6_i$ = 1, is obtained by setting $dkidslt6_i$ = 1 in the index function for Model 2:

$$\left(x_i^T\beta \,\middle|\, dkidslt6_i = 1\right) = \beta_0 + \beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i + \delta_0 1$$
$$= \beta_0 + \beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i + \delta_0$$

- In Model 2, the **marginal *index* effect** of the **binary indicator variable *dkidslt6$_i$*** is simply the difference between (1) the index function for ***married women who currently have one or more pre-school aged children***, $\left(x_i^T\beta \middle| \text{dkidslt6}_i = 1\right)$ and (2) the index function for ***married women who currently have no pre-school aged children***, $\left(x_i^T\beta \middle| \text{dkidslt6}_i = 0\right)$:

$$\left(x_i^T\beta \middle| \text{dkidslt6}_i = 1\right) - \left(x_i^T\beta \middle| \text{dkidslt6}_i = 0\right)$$

$$= \beta_0 + \beta_1 \text{nwifeinc}_i + \beta_2 \text{ed}_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 \text{age}_i + \delta_0 - \left(\beta_0 + \beta_1 \text{nwifeinc}_i + \beta_2 \text{ed}_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 \text{age}_i\right)$$

$$= \beta_0 + \beta_1 \text{nwifeinc}_i + \beta_2 \text{ed}_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 \text{age}_i + \delta_0 - \beta_0 - \beta_1 \text{nwifeinc}_i - \beta_2 \text{ed}_i - \beta_3 \exp_i - \beta_4 \exp_i^2 - \beta_5 \text{age}_i$$

$$= \delta_0$$

- In Model 2, the **marginal *probability* effect** of the **binary indicator variable *dkidslt6*** $dkidslt6_i$ is the difference between (1) the conditional probability that $\mathbf{inlf_i} = 1$ for ***married women with one or more pre-school aged children*** and (2) the conditional probability that $\mathbf{inlf_i} = 1$ for ***married women with no pre-school aged children***:

$$\Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 1\right) - \Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 0\right) = \Phi\left(x_{1i}^T\beta\right) - \Phi\left(x_{0i}^T\beta\right)$$

where $\Phi(*)$ is the cumulative distribution function (cdf) of the standard normal distribution and

$$x_{1i}^T = \left(1 \;\; \text{nwifeinc}_i \;\; \text{ed}_i \;\; \exp_i \;\; \exp_i^2 \;\; \text{age}_i \;\; 1\right)$$

$$x_{0i}^T = \left(1 \;\; \text{nwifeinc}_i \;\; \text{ed}_i \;\; \exp_i \;\; \exp_i^2 \;\; \text{age}_i \;\; 0\right)$$

$$\beta = \left(\beta_0 \;\; \beta_1 \;\; \beta_2 \;\; \beta_3 \;\; \beta_4 \;\; \beta_5 \;\; \delta_0\right)^T$$

$$x_{1i}^T\beta = \beta_0 + \beta_1\text{nwifeinc}_i + \beta_2\text{ed}_i + \beta_3\exp_i + \beta_4\exp_i^2 + \beta_5\text{age}_i + \delta_0$$

$$x_{0i}^T\beta = \beta_0 + \beta_1\text{nwifeinc}_i + \beta_2\text{ed}_i + \beta_3\exp_i + \beta_4\exp_i^2 + \beta_5\text{age}_i$$

$$\Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 1\right) = \Phi\left(x_{1i}^T\beta\right) = \Phi\left(\beta_0 + \beta_1\text{nwifeinc}_i + \beta_2\text{ed}_i + \beta_3\exp_i + \beta_4\exp_i^2 + \beta_5\text{age}_i + \delta_0\right)$$

$$\Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 0\right) = \Phi\left(x_{0i}^T\beta\right) = \Phi\left(\beta_0 + \beta_1\text{nwifeinc}_i + \beta_2\text{ed}_i + \beta_3\exp_i + \beta_4\exp_i^2 + \beta_5\text{age}_i + \delta_0 0\right)$$

$$= \Phi\left(\beta_0 + \beta_1\text{nwifeinc}_i + \beta_2\text{ed}_i + \beta_3\exp_i + \beta_4\exp_i^2 + \beta_5\text{age}_i\right)$$

Thus, the **marginal *probability* effect of the indicator variable *dkidslt6$_i$*** in **Model 2** is

$$\Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 1\right) - \Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 0\right) = \Phi\left(x_{1i}^T\beta\right) - \Phi\left(x_{0i}^T\beta\right)$$

$$= \Phi\left(\beta_0 + \beta_1\text{nwifeinc}_i + \beta_2\text{ed}_i + \beta_3\exp_i + \beta_4\exp_i^2 + \beta_5\text{age}_i + \delta_0\right)$$

$$- \Phi\left(\beta_0 + \beta_1\text{nwifeinc}_i + \beta_2\text{ed}_i + \beta_3\exp_i + \beta_4\exp_i^2 + \beta_5\text{age}_i\right)$$

<u>Model 3</u> – a full interaction model in the binary variable *dkidslt6_i*

The **probit index function**, or regression function, **for Model 3** is:

$$x_i^T\beta = \beta_0 + \beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i$$
$$+ \delta_0 dkidslt6_i + \delta_1 dkidslt6_i\, nwifeinc_i + \delta_2 dkidslt6_i\, ed_i + \delta_3 dkidslt6_i \exp_i + \delta_4 dkidslt6_i \exp_i^2 + \delta_5 dkidslt6_i\, age_i$$

Remarks: Model 3 is the ***full-interaction*** generalization of Model 2: it interacts the $dkidslt6_i$ indicator variable with all the other regressors in Model 2, and thereby permits all index function coefficients to differ between the two groups of married women distinguished by $dkidslt6_i$.

- In Model 3, the **probit *index* function** for ***married women who currently have no pre-school aged children***, for whom $dkidslt6_i$ = 0, is obtained by setting $dkidslt6_i$ = 0 in the index function for Model 3:

$$\left(x_i^T\beta \,\middle|\, dkidslt6_i = 0\right) = \beta_0 + \beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i$$

- In Model 3, the **probit *index* function** for ***married women who currently have one or more pre-school aged children***, for whom $dkidslt6_i$ = 1, is obtained by setting $dkidslt6_i$ = 1 in the index function for Model 3:

$$\left(x_i^T\beta \,\middle|\, dkidslt6_i = 1\right) = \beta_0 + \beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i$$
$$+ \delta_0 1 + \delta_1 1\cdot nwifeinc_i + \delta_2 1\cdot ed_i + \delta_3 1\cdot \exp_i + \delta_4 1\cdot \exp_i^2 + \delta_5 1\cdot age_i$$
$$= \beta_0 + \beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i + \delta_0 + \delta_1 nwifeinc_i + \delta_2 ed_i + \delta_3 \exp_i + \delta_4 \exp_i^2 + \delta_5 age_i$$
$$= (\beta_0 + \delta_0) + (\beta_1 + \delta_1) nwifeinc_i + (\beta_2 + \delta_2) ed_i + (\beta_3 + \delta_3) \exp_i + (\beta_4 + \delta_4) \exp_i^2 + (\beta_5 + \delta_5) age_i$$

- In Model 3, the **marginal *index* effect** of the **binary indicator variable *dkidslt6*$_i$** is simply the difference between (1) the index function for ***married women who currently have one or more pre-school aged children***, $\left(x_i^T\beta \mid dkidslt6_i = 1\right)$ and (2) the index function for ***married women who currently have no pre-school aged children***, $\left(x_i^T\beta \mid dkidslt6_i = 0\right)$:

$$\left(x_i^T\beta \mid dkidslt6_i = 1\right) - \left(x_i^T\beta \mid dkidslt6_i = 0\right)$$

$$= \beta_0 + \beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i + \delta_0 + \delta_1 nwifeinc_i + \delta_2 ed_i + \delta_3 \exp_i + \delta_4 \exp_i^2 + \delta_5 age_i$$
$$- \left(\beta_0 + \beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i\right)$$

$$= \beta_0 + \beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i + \delta_0 + \delta_1 nwifeinc_i + \delta_2 ed_i + \delta_3 \exp_i + \delta_4 \exp_i^2 + \delta_5 age_i$$
$$- \beta_0 - \beta_1 nwifeinc_i - \beta_2 ed_i - \beta_3 \exp_i - \beta_4 \exp_i^2 - \beta_5 age_i$$

$$= \delta_0 + \delta_1 nwifeinc_i + \delta_2 ed_i + \delta_3 \exp_i + \delta_4 \exp_i^2 + \delta_5 age_i$$

- In Model 3, the **marginal *probability* effect** of the **binary indicator variable *dkidslt6*** $dkidslt6_i$ is the difference between (1) the conditional probability that $\mathbf{inlf_i} = 1$ for ***married women with one or more pre-school aged children*** and (2) the conditional probability that $\mathbf{inlf_i} = 1$ for ***married women with no pre-school aged children***:

$$\Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 1\right) - \Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 0\right) = \Phi\left(x_{1i}^T\beta\right) - \Phi\left(x_{0i}^T\beta\right)$$

where $\Phi(*)$ is the cumulative distribution function (cdf) of the standard normal distribution and

$$x_{1i}^T = \left(1 \;\; \text{nwifeinc}_i \;\; \text{ed}_i \;\; \exp_i \;\; \exp_i^2 \;\; \text{age}_i \;\; 1 \;\; \text{nwifeinc}_i \;\; \text{ed}_i \;\; \exp_i \;\; \exp_i^2 \;\; \text{age}_i\right)$$

$$x_{0i}^T = \left(1 \;\; \text{nwifeinc}_i \;\; \text{ed}_i \;\; \exp_i \;\; \exp_i^2 \;\; \text{age}_i \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0\right)$$

$$\beta = \left(\beta_0 \;\; \beta_1 \;\; \beta_2 \;\; \beta_3 \;\; \beta_4 \;\; \beta_5 \;\; \delta_0 \;\; \delta_1 \;\; \delta_2 \;\; \delta_3 \;\; \delta_4 \;\; \delta_5\right)^T$$

$$\begin{aligned} x_{1i}^T\beta = \; & \beta_0 + \beta_1\text{nwifeinc}_i + \beta_2\text{ed}_i + \beta_3\exp_i + \beta_4\exp_i^2 + \beta_5\text{age}_i \\ & + \delta_0 + \delta_1\text{nwifeinc}_i + \delta_2\text{ed}_i + \delta_3\exp_i + \delta_4\exp_i^2 + \delta_5\text{age}_i \end{aligned}$$

$$x_{0i}^T\beta = \beta_0 + \beta_1\text{nwifeinc}_i + \beta_2\text{ed}_i + \beta_3\exp_i + \beta_4\exp_i^2 + \beta_5\text{age}_i$$

$$\Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 1\right)$$

$$= \Phi\begin{pmatrix} \beta_0 + \beta_1\text{nwifeinc}_i + \beta_2\text{ed}_i + \beta_3\exp_i + \beta_4\exp_i^2 + \beta_5\text{age}_i \\ + \delta_0 + \delta_1\text{nwifeinc}_i + \delta_2\text{ed}_i + \delta_3\exp_i + \delta_4\exp_i^2 + \delta_5\text{age}_i \end{pmatrix}$$

$$= \Phi\begin{pmatrix} (\beta_0 + \delta_0) + (\beta_1 + \delta_1)\text{nwifeinc}_i + (\beta_2 + \delta_2)\text{ed}_i \\ + (\beta_3 + \delta_3)\exp_i + (\beta_4 + \delta_4)\exp_i^2 + (\beta_5 + \delta_5)\text{age}_i \end{pmatrix}$$

$$\Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 0\right)$$

$$= \Phi\begin{pmatrix} \beta_0 + \beta_1\text{nwifeinc}_i + \beta_2\text{ed}_i + \beta_3\exp_i + \beta_4\exp_i^2 + \beta_5\text{age}_i \\ + \delta_0 0 + \delta_1 0 + \delta_2 0 + \delta_3 0 + \delta_4 0 + \delta_5 0 \end{pmatrix}$$

$$= \Phi\left(\beta_0 + \beta_1\text{nwifeinc}_i + \beta_2\text{ed}_i + \beta_3\exp_i + \beta_4\exp_i^2 + \beta_5\text{age}_i\right)$$

Thus, the **marginal *probability* effect of the indicator variable *dkidslt6_i*** in **Model 3** is

$$\Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 1\right) - \Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 0\right) =$$

$$\Phi\begin{pmatrix} \beta_0 + \beta_1\text{nwifeinc}_i + \beta_2\text{ed}_i + \beta_3\exp_i + \beta_4\exp_i^2 + \beta_5\text{age}_i \\ + \delta_0 + \delta_1\text{nwifeinc}_i + \delta_2\text{ed}_i + \delta_3\exp_i + \delta_4\exp_i^2 + \delta_5\text{age}_i \end{pmatrix}$$

$$- \Phi\left(\beta_0 + \beta_1\text{nwifeinc}_i + \beta_2\text{ed}_i + \beta_3\exp_i + \beta_4\exp_i^2 + \beta_5\text{age}_i\right)$$

We are concerned with **three aspects** of the **marginal *probability* effect of the indicator variable** $dkidslt6_i$:

1. the **existence** of the **marginal *probability* effect of the indicator variable** $dkidslt6_i$;

2. the **direction (sign)** of the **marginal *probability* effect of the indicator variable** $dkidslt6_i$;

3. the **magnitude (size)** of the **marginal *probability* effect of the indicator variable** $dkidslt6_i$.

❑ **Testing the marginal *probability* effect of the binary explanatory variable *dkidslt6*$_i$ -- *test* and *lincom***

Proposition to be Tested

- Does the ***conditional* probability of labour force participation** for married women depend on the presence in the family of one or more dependent children under 6 years of age?
- Is the probability of labour force participation for married women with given values of nwifeinc_i, ed_i, exp_i, and age_i who currently have one or more pre-school aged children equal to the probability of labour force participation for married women with the same values of nwifeinc_i, ed_i, exp_i, and age_i who currently have no pre-school aged children?
- Is it true that

$$\begin{aligned}&\Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 1,\ \text{nwifeinc}_i,\ \text{ed}_i,\ \text{exp}_i,\ \text{age}_i\right)\\ &= \Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 0,\ \text{nwifeinc}_i,\ \text{ed}_i,\ \text{exp}_i,\ \text{age}_i\right)?\end{aligned}$$

Null and Alternative Hypotheses: General Formulation

The ***null hypothesis*** in general is:

$$H_0: \quad \Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 1,\ \ldots\right) = \Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 0,\ \ldots\right)$$

The ***alternative hypothesis*** in general is:

$$H_1: \quad \Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 1,\ \ldots\right) \neq \Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 0,\ \ldots\right)$$

Testing the <u>Existence</u> of the Marginal Probability Effect of the Indicator Variable *dkidslt6_i*

For testing the ***existence* of a relationship** between any explanatory variable and the probability that the observed dependent variable equals 1, use either of the two *Stata* commands for probit estimation: use ***either*** the **probit** command ***or*** the **dprobit** command.

<u>Null and Alternative Hypotheses: Model 2</u>

The null hypothesis in general is:

$$H_0: \quad \Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 1, \ldots\right) = \Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 0, \ldots\right)$$

For Model 2,

$$\Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 1, \ldots\right) = \Phi\left(x_i^T\beta \middle| \text{dkidslt6}_i = 1\right)$$
$$= \Phi\left(\beta_0 + \beta_1\text{nwifeinc}_i + \beta_2\text{ed}_i + \beta_3\exp_i + \beta_4\exp_i^2 + \beta_5\text{age}_i + \delta_0\right)$$

$$\Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 0, \ldots\right) = \Phi\left(x_i^T\beta \middle| \text{dkidslt6}_i = 0\right)$$
$$= \Phi\left(\beta_0 + \beta_1\text{nwifeinc}_i + \beta_2\text{ed}_i + \beta_3\exp_i + \beta_4\exp_i^2 + \beta_5\text{age}_i\right)$$

These two probabilities are equal if the exclusion restriction $\delta_0 = 0$ is true. In other words, **a *sufficient* condition** for these two probabilities to be equal is the exclusion restriction $\boldsymbol{\delta_0 = 0}$.

The ***null* and *alternative* hypotheses for Model 2** are therefore:

H$_0$: $\delta_0 = 0$
H$_1$: $\delta_0 \neq 0$

Important Point: A test of the null hypothesis that the **marginal *probability* effect** of pre-school aged children is zero **is equivalent to** a test of the null hypothesis that the **marginal *index* effect** of pre-school aged children is zero.

- **Marginal *probability* effect of <u>pre-school aged children</u> equals *zero*** in Model 2 if

$$\Phi\left(x_i^T\beta \,\middle|\, dkidslt6_i = 1\right) = \Phi\left(x_i^T\beta \,\middle|\, dkidslt6_i = 0\right).$$

In Model 2,

$$\Phi\left(x_i^T\beta \,\middle|\, dkidslt6_i = 1\right) = \Phi\left(\beta_0 + \beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i + \delta_0\right)$$

$$\Phi\left(x_i^T\beta \,\middle|\, dkidslt6_i = 0\right) = \Phi\left(\beta_0 + \beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i\right)$$

Question: What coefficient restriction(s) are sufficient to make these two probabilities equal for any given values of $nwifeinc_i$, ed_i, $\exp_i$, and age_i?

Answer: By inspection – i.e., by comparing the function $\Phi\left(x_i^T\beta \,\middle|\, dkidslt6_i = 1\right)$ and the function $\Phi\left(x_i^T\beta \,\middle|\, dkidslt6_i = 0\right)$ – we can see that a sufficient condition for $\Phi\left(x_i^T\beta \,\middle|\, dkidslt6_i = 1\right) = \Phi\left(x_i^T\beta \,\middle|\, dkidslt6_i = 0\right)$ in Model 2 is the single coefficient exclusion restriction $\delta_0 = 0$.

- **Marginal *index* effect of <u>pre-school aged children</u> equals *zero*** if

  $\left(x_i^T\beta \,\middle|\, \text{dkidslt6}_i = 1\right) = \left(x_i^T\beta \,\middle|\, \text{dkidslt6}_i = 0\right)$.

  In Model 2,

  $\left(x_i^T\beta \,\middle|\, \text{dkidslt6}_i = 1\right) = \beta_0 + \beta_1\text{nwifeinc}_i + \beta_2\text{ed}_i + \beta_3\exp_i + \beta_4\exp_i^2 + \beta_5\text{age}_i + \delta_0$

  $\left(x_i^T\beta \,\middle|\, \text{dkidslt6}_i = 0\right) = \beta_0 + \beta_1\text{nwifeinc}_i + \beta_2\text{ed}_i + \beta_3\exp_i + \beta_4\exp_i^2 + \beta_5\text{age}_i$

  Question: What coefficient restriction(s) are sufficient to make these two index functions equal for any given values of nwifeinc_i, ed_i, $\exp_i$, and age_i?

  Answer: By inspection – i.e., by comparing the index function $\left(x_i^T\beta \,\middle|\, \text{dkidslt6}_i = 1\right)$ and the index function $\left(x_i^T\beta \,\middle|\, \text{dkidslt6}_i = 0\right)$ – we can see that a sufficient condition for $\left(x_i^T\beta \,\middle|\, \text{dkidslt6}_i = 1\right) = \left(x_i^T\beta \,\middle|\, \text{dkidslt6}_i = 0\right)$ in Model 2 is the single coefficient exclusion restriction $\delta_0 = 0$.

- ***<u>Result</u>:*** The single coefficient exclusion restriction $\delta_0 = 0$ is sufficient to make the ***both* the marginal *probability* effect *and* the marginal *index* effect** of pre-school aged children equal to zero in Model 2.

❑ How to Perform this Test for Model 2 in *Stata*

- First, compute ML estimates of probit Model 2 and display the full set of saved results. Enter the following commands:

```
probit inlf nwifeinc ed exp expsq age dkidslt6
ereturn list
```

- To calculate a **Wald test** of H_0 against H_1 and the p-value for the calculated W-statistic, enter the following **test**, **return list** and **display** commands:

```
test dkidslt6     or   test dkidslt6 = 0
return list
display sqrt(r(chi2))
```

- To calculate a **two-tail asymptotic t-test** of H_0 against H_1, enter the following **lincom**, **return list** and **display** commands:

```
lincom _b[dkidslt6]
return list
display r(estimate)/r(se)
```

The results of this two-tail t-test are identical with those of the previous Wald test.

Note that this **lincom** command merely replicates the test statistic and p-value that are displayed in the output of the **probit** command for the regressor ***dkidslt6***.

Null and Alternative Hypotheses: Model 3

The null hypothesis in general is:

$$H_0: \quad \Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 1, \ldots\right) = \Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 0, \ldots\right)$$

For Model 3,

$$\begin{aligned}\Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 1\right) &= \Phi\left(x_i^T\beta \middle| \text{dkidslt6}_i = 1\right) \\ &= \Phi\begin{pmatrix}\beta_0 + \beta_1\text{nwifeinc}_i + \beta_2\text{ed}_i + \beta_3\exp_i + \beta_4\exp_i^2 + \beta_5\text{age}_i \\ + \delta_0 + \delta_1\text{nwifeinc}_i + \delta_2\text{ed}_i + \delta_3\exp_i + \delta_4\exp_i^2 + \delta_5\text{age}_i\end{pmatrix}\end{aligned}$$

$$\begin{aligned}\Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 0\right) &= \Phi\left(x_i^T\beta \middle| \text{dkidslt6}_i = 0\right) \\ &= \Phi\left(\beta_0 + \beta_1\text{nwifeinc}_i + \beta_2\text{ed}_i + \beta_3\exp_i + \beta_4\exp_i^2 + \beta_5\text{age}_i\right)\end{aligned}$$

These two probabilities are equal if the six exclusion restrictions $\delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$ are true. In other words, a sufficient condition for these two probabilities to be equal is the set of six coefficient exclusion restrictions $\delta_j = 0$ for all j = 0, 1, …, 5.

The ***null* and *alternative* hypotheses for Model 3** are therefore:

H_0: $\delta_j = 0 \quad \forall \; j = 0, 1, 2, 3, 4, 5$

$\Rightarrow \quad \delta_0 = 0 \textit{ and } \delta_1 = 0 \textit{ and } \delta_2 = 0 \textit{ and } \delta_3 = 0 \textit{ and } \delta_4 = 0 \textit{ and } \delta_5 = 0$

H_1: $\delta_j \neq 0 \qquad j = 0, 1, 2, 3, 4, 5$

$\Rightarrow \quad \delta_0 \neq 0 \textit{ and/or } \delta_1 \neq 0 \textit{ and/or } \delta_2 \neq 0 \textit{ and/or } \delta_3 \neq 0 \textit{ and/or } \delta_4 \neq 0 \textit{ and/or } \delta_5 \neq 0$

Important Point: A test of the null hypothesis that the **marginal *probability* effect** of pre-school aged children is zero **is equivalent to** a test of the null hypothesis that the **marginal *index* effect** of pre-school aged children is zero.

- **<u>Marginal *probability* effect</u> of pre-school aged children equals *zero*** if

$$\Phi\left(x_i^T\beta \,\middle|\, \text{dkidslt6}_i = 1\right) = \Phi\left(x_i^T\beta \,\middle|\, \text{dkidslt6}_i = 0\right).$$

In Model 3,

$$\Phi\left(x_i^T\beta \,\middle|\, \text{dkidslt6}_i = 1\right)$$
$$= \Phi\begin{pmatrix} \beta_0 + \beta_1\text{nwifeinc}_i + \beta_2\text{ed}_i + \beta_3\exp_i + \beta_4\exp_i^2 + \beta_5\text{age}_i \\ +\delta_0 + \delta_1\text{nwifeinc}_i + \delta_2\text{ed}_i + \delta_3\exp_i + \delta_4\exp_i^2 + \delta_5\text{age}_i \end{pmatrix}$$

$$\Phi\left(x_i^T\beta \,\middle|\, \text{dkidslt6}_i = 0\right)$$
$$= \Phi\left(\beta_0 + \beta_1\text{nwifeinc}_i + \beta_2\text{ed}_i + \beta_3\exp_i + \beta_4\exp_i^2 + \beta_5\text{age}_i\right)$$

Question: What coefficient restriction(s) are sufficient to make these two probabilities equal for any given values of nwifeinc_i, ed_i, $\exp_i$, and age_i?

Answer: By inspection – i.e., by comparing the function $\Phi\left(x_i^T\beta \,\middle|\, \text{dkidslt6}_i = 1\right)$ and the function $\Phi\left(x_i^T\beta \,\middle|\, \text{dkidslt6}_i = 0\right)$ – we can see that a sufficient condition for $\Phi\left(x_i^T\beta \,\middle|\, \text{dkidslt6}_i = 1\right) = \Phi\left(x_i^T\beta \,\middle|\, \text{dkidslt6}_i = 0\right)$ in Model 3 is the set of six coefficient exclusion restrictions $\delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$.

- **<u>Marginal *index* effect</u> of pre-school aged children equals *zero*** if

$$\left(x_i^T\beta \mid dkidslt6_i = 1\right) = \left(x_i^T\beta \mid dkidslt6_i = 0\right).$$

In Model 3,

$$\left(x_i^T\beta \mid dkidslt6_i = 1\right) = \beta_0 + \beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i$$
$$+ \delta_0 + \delta_1 nwifeinc_i + \delta_2 ed_i + \delta_3 \exp_i + \delta_4 \exp_i^2 + \delta_5 age_i$$

$$\left(x_i^T\beta \mid dkidslt6_i = 0\right) = \beta_0 + \beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i$$

Question: What coefficient restriction(s) are sufficient to make these two index functions equal for any given values of $nwifeinc_i$, ed_i, $\exp_i$, and age_i?

Answer: By inspection – i.e., by comparing the index function $\left(x_i^T\beta \mid dkidslt6_i = 1\right)$ and the index function $\left(x_i^T\beta \mid dkidslt6_i = 0\right)$ – we can see that a sufficient condition for $\left(x_i^T\beta \mid dkidslt6_i = 1\right) = \left(x_i^T\beta \mid dkidslt6_i = 0\right)$ in Model 3 is the set of six coefficient exclusion restrictions $\delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$.

- ***<u>Result</u>:*** The six coefficient exclusion restrictions $\delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$ are sufficient to make the ***both*** **the marginal *probability* effect *and* the marginal *index* effect** of pre-school aged children **equal to *zero*** in Model 3.

❑ **How to Perform this Test for Model 3 in *Stata***

H_0: $\delta_j = 0 \quad \forall\ j = 0, 1, 2, 3, 4, 5 \quad \Rightarrow \quad \delta_0 = 0$ *and* $\delta_1 = 0$ *and* $\delta_2 = 0$ *and* $\delta_3 = 0$ *and* $\delta_4 = 0$ *and* $\delta_5 = 0$

H_1: $\delta_j \neq 0 \quad j = 0, 1, 2, 3, 4, 5 \quad \Rightarrow \quad \delta_0 \neq 0$ *and/or* $\delta_1 \neq 0$ *and/or* $\delta_2 \neq 0$ *and/or* $\delta_3 \neq 0$ *and/or* $\delta_4 \neq 0$ *and/or* $\delta_5 \neq 0$

- Before estimating Model 3, it is necessary to create the ***dkidslt6**$_i$* **interaction variables**. Enter the following **generate** commands:

```
generate d6nwinc = dkidslt6*nwifeinc
generate d6ed = dkidslt6*ed
generate d6exp = dkidslt6*exp
generate d6expsq = dkidslt6*expsq
generate d6age = dkidslt6*age
```

- Next, compute ML estimates of probit Model 3 and display the full set of saved results. Enter the following commands:

```
probit inlf nwifeinc ed exp expsq age dkidslt6 d6nwinc d6ed d6exp d6expsq d6age
ereturn list
```

- To calculate a **Wald test** of H_0 against H_1 and the p-value for the calculated W-statistic, enter the following **test** and **return list** commands:

```
test dkidslt6 d6nwinc d6ed d6exp d6expsq d6age
return list
```

- A second hypothesis test you should perform on Model 3 is a test of the null hypothesis that ***all slope* coefficient differences** between married women who have one or more pre-school aged children and married women who have no pre-school aged children **equal zero**. The null and alternative hypotheses are:

  H_0: $\delta_j = 0 \quad \forall \; j = 1, 2, 3, 4, 5 \;\Rightarrow\; \delta_1 = 0 \textit{ and } \delta_2 = 0 \textit{ and } \delta_3 = 0 \textit{ and } \delta_4 = 0 \textit{ and } \delta_5 = 0$

  H_1: $\delta_j \neq 0 \quad j = 1, 2, 3, 4, 5 \;\Rightarrow\; \delta_1 \neq 0 \textit{ and/or } \delta_2 \neq 0 \textit{ and/or } \delta_3 \neq 0 \textit{ and/or } \delta_4 \neq 0 \textit{ and/or } \delta_5 \neq 0$

  Note that the null hypothesis H_0 implies Model 2, whereas the alternative hypothesis H_1 implies Model 3. Enter the **test** command:

  ```
  test d6nwinc d6ed d6exp d6expsq d6age
  ```

```
. probit inlf nwifeinc ed exp expsq age dkidslt6 d6nwinc d6ed d6exp d6expsq d6age

Iteration 0:   log likelihood =  -514.8732
Iteration 1:   log likelihood = -406.48086
Iteration 2:   log likelihood = -402.63328
Iteration 3:   log likelihood = -402.61111
Iteration 4:   log likelihood = -402.61111

Probit estimates                                  Number of obs   =        753
                                                  LR chi2(11)     =     224.52
                                                  Prob > chi2     =     0.0000
Log likelihood = -402.61111                       Pseudo R2       =     0.2180

------------------------------------------------------------------------------
        inlf |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    nwifeinc |  -.0109103   .0056007    -1.95   0.051    -.0218874    .0000668
          ed |   .1215786   .0280427     4.34   0.000     .0666159    .1765413
         exp |    .137317   .0208939     6.57   0.000     .0963657    .1782682
       expsq |  -.0022349   .0006495    -3.44   0.001     -.003508   -.0009619
         age |  -.0593504   .0085496    -6.94   0.000    -.0761072   -.0425935
    dkidslt6 |  -2.527031   1.267708    -1.99   0.046    -5.011694   -.0423684
     d6nwinc |  -.0059201   .0109624    -0.54   0.589    -.0274059    .0155658
        d6ed |   .0327202   .0623143     0.53   0.600    -.0894135     .154854
       d6exp |  -.1128835   .0663563    -1.70   0.089    -.2429394    .0171724
     d6expsq |   .0030026   .0033465     0.90   0.370    -.0035564    .0095616
       d6age |   .0503914   .0260813     1.93   0.053    -.0007271    .1015099
       _cons |   .6084091   .4961565     1.23   0.220    -.3640398    1.580858
------------------------------------------------------------------------------
```

```
. ereturn list

scalars:
                  e(N) =  753
               e(ll_0) =  -514.8732045671461
                 e(ll) =  -402.6111063731551
               e(df_m) =  11
               e(chi2) =  224.5241963879821
               e(r2_p) =  .2180383387563736

macros:
             e(depvar) : "inlf"
                e(cmd) : "probit"
           e(crittype) : "log likelihood"
            e(predict) : "probit_p"
           e(chi2type) : "LR"

matrices:
                  e(b) :  1 x 12
                  e(V) :  12 x 12

functions:
             e(sample)
```

```
. * Test 1:
. test dkidslt6 d6nwinc d6ed d6exp d6expsq d6age

 ( 1)  dkidslt6 = 0
 ( 2)  d6nwinc = 0
 ( 3)  d6ed = 0
 ( 4)  d6exp = 0
 ( 5)  d6expsq = 0
 ( 6)  d6age = 0

           chi2(  6) =   58.11
         Prob > chi2 =    0.0000

. return list

scalars:
              r(drop) =  0
              r(chi2) =  58.11036668348744
                r(df) =  6
                 r(p) =  1.08838734793e-10
```

```
. * Test 2:
. test d6nwinc d6ed d6exp d6expsq d6age

 ( 1)  d6nwinc = 0
 ( 2)  d6ed = 0
 ( 3)  d6exp = 0
 ( 4)  d6expsq = 0
 ( 5)  d6age = 0

           chi2(  5) =    9.03
         Prob > chi2 =    0.1078

. return list

scalars:
              r(drop) =  0
              r(chi2) =  9.031191992371875
                r(df) =  5
                 r(p) =  .1078264635420236
```

```
. dprobit inlf nwifeinc ed exp expsq age dkidslt6 d6nwinc d6ed d6exp d6expsq d6age

Iteration 0:   log likelihood =  -514.8732
Iteration 1:   log likelihood = -406.48086
Iteration 2:   log likelihood = -402.63328
Iteration 3:   log likelihood = -402.61111
Iteration 4:   log likelihood = -402.61111

Probit estimates                                       Number of obs =    753
                                                       LR chi2(11)   = 224.52
                                                       Prob > chi2   = 0.0000
Log likelihood = -402.61111                            Pseudo R2     = 0.2180

------------------------------------------------------------------------------
    inlf |      dF/dx   Std. Err.      z    P>|z|     x-bar  [    95% C.I.   ]
---------+--------------------------------------------------------------------
nwifeinc |  -.0042484   .0021794    -1.95   0.051    20.129   -.00852  .000023
      ed |   .0473425   .0108958     4.34   0.000   12.2869   .025987  .068698
     exp |    .053471   .0081365     6.57   0.000   10.6308   .037524  .069418
   expsq |  -.0008703   .0002531    -3.44   0.001   178.039  -.001366 -.000374
     age |  -.0231109   .0033213    -6.94   0.000   42.5378  -.029621 -.016601
dkidslt6*|  -.7273305   .1555487    -1.99   0.046   .195219   -1.0322 -.422461
 d6nwinc |  -.0023053     .00427    -0.54   0.589   4.04408  -.010674  .006064
    d6ed |   .0127412   .0242742     0.53   0.600   2.47809  -.034835  .060318
   d6exp |  -.0439567   .0258347    -1.70   0.089   1.37317  -.094592  .006678
 d6expsq |   .0011692   .0013032     0.90   0.370    15.012  -.001385  .003723
   d6age |   .0196223   .0101508     1.93   0.053   6.87251  -.000273  .039518
---------+--------------------------------------------------------------------
  obs. P |   .5683931
 pred. P |   .5870885  (at x-bar)
------------------------------------------------------------------------------
(*) dF/dx is for discrete change of dummy variable from 0 to 1
    z and P>|z| are the test of the underlying coefficient being 0
```

```
. ereturn list

scalars:
                  e(N) =  753
               e(ll_0) =  -514.8732045671461
                 e(ll) =  -402.6111063731551
               e(df_m) =  11
               e(chi2) =  224.5241963879821
               e(r2_p) =  .2180383387563736
               e(pbar) =  .5683930942895087
               e(xbar) =  .220061785738521
             e(offbar) =  0

macros:
                e(cmd) : "dprobit"
              e(dummy) : " 0 0 0 0 0 1 0 0 0 0 0"
             e(depvar) : "inlf"
           e(crittype) : "log likelihood"
            e(predict) : "probit_p"
           e(chi2type) : "LR"

matrices:
                  e(b) :  1 x 12
                  e(V) :  12 x 12
            e(se_dfdx) :  1 x 11
               e(dfdx) :  1 x 11

functions:
             e(sample)
```

```
. * Test 1:
. test dkidslt6 d6nwinc d6ed d6exp d6expsq d6age

 ( 1)  dkidslt6 = 0
 ( 2)  d6nwinc = 0
 ( 3)  d6ed = 0
 ( 4)  d6exp = 0
 ( 5)  d6expsq = 0
 ( 6)  d6age = 0

           chi2(  6) =   58.11
         Prob > chi2 =    0.0000

. return list

scalars:
              r(drop) =  0
              r(chi2) =  58.11036668348744
                r(df) =  6
                 r(p) =  1.08838734793e-10
```

```
. * Test 2:
. test d6nwinc d6ed d6exp d6expsq d6age

 ( 1)  d6nwinc = 0
 ( 2)  d6ed = 0
 ( 3)  d6exp = 0
 ( 4)  d6expsq = 0
 ( 5)  d6age = 0

           chi2(  5) =    9.03
         Prob > chi2 =    0.1078

. return list

scalars:
              r(drop) =  0
              r(chi2) =  9.031191992371875
                r(df) =  5
                 r(p) =  .1078264635420236
```

❑ Interpreting the coefficient estimates in full-interaction Model 3

Full-interaction Model 3 estimates ***two* distinct sets of probit coefficients**: (1) the probit coefficients for married women who have no pre-school aged children (for whom $dkidslt6_i = 0$); and (2) the probit coefficients for married women who have one or more pre-school aged children (for whom $dkidslt6_i = 1$).

- Recall that the **probit *index* function for Model 3** is:

$$
\begin{aligned}
x_i^T\beta \;=\; & \beta_0 + \beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i \\
& + \delta_0 dkidslt6_i + \delta_1 dkidslt6_i\, nwifeinc_i + \delta_2 dkidslt6_i\, ed_i \\
& + \delta_3 dkidslt6_i \exp_i + \delta_4 dkidslt6_i \exp_i^2 + \delta_5 dkidslt6_i\, age_i
\end{aligned}
$$

- The **probit index function for married women who have no pre-school aged children** (for whom $dkidslt6_i = 0$) is obtained by **setting the indicator variable $dkidslt6_i = 0$** in the probit index function for Model 3:

$$\left(x_i^T\beta \,\middle|\, dkidslt6_i = 0 \right) = \beta_0 + \beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i$$

Implication: The probit coefficient estimates for married women who have no pre-school aged children (for whom $dkidslt6_i = 0$) are given directly by the coefficient estimates of the first six terms in the above index function.

The probit coefficient estimates for **married women who have *no* pre-school aged children** are:

β_0 = the intercept coefficient for women for whom $dkidslt6_i = 0$
β_1 = the slope coefficient of $nwifeinc_i$ for women for whom $dkidslt6_i = 0$
β_2 = the slope coefficient of ed_i for women for whom $dkidslt6_i = 0$
β_3 = the slope coefficient of exp_i for women for whom $dkidslt6_i = 0$
β_4 = the slope coefficient of exp_i^2 for women for whom $dkidslt6_i = 0$
β_5 = the slope coefficient of age_i for women for whom $dkidslt6_i = 0$.

- The **probit index function for married women who currently have one or more pre-school aged children** (for whom $\text{dkidslt6}_i = 1$) is obtained by setting the indicator variable $\text{dkidslt6}_i = 1$ in the probit index function for Model 3:

$$\left(x_i^T\beta \,\middle|\, \text{dkidslt6}_i = 1\right) = \beta_0 + \beta_1\text{nwifeinc}_i + \beta_2\text{ed}_i + \beta_3\exp_i + \beta_4\exp_i^2 + \beta_5\text{age}_i$$
$$+ \delta_0 + \delta_1\text{nwifeinc}_i + \delta_2\text{ed}_i + \delta_3\exp_i + \delta_4\exp_i^2 + \delta_5\text{age}_i$$

Implication: The probit coefficient estimates for married women who have one or more pre-school aged children (for whom $\text{dkidslt6}_i = 1$) are obtained from Model 3 by summing pairs of coefficient estimates. In particular, **for married women who have one or more pre-school aged children**:

$\beta_0 + \delta_0$ = the intercept coefficient for women for whom $\text{dkidslt6}_i = 1$
$\beta_1 + \delta_1$ = the slope coefficient of nwifeinc_i for women for whom $\text{dkidslt6}_i = 1$
$\beta_2 + \delta_2$ = the slope coefficient of ed_i for women for whom $\text{dkidslt6}_i = 1$
$\beta_3 + \delta_3$ = the slope coefficient of $\exp_i$ for women for whom $\text{dkidslt6}_i = 1$
$\beta_4 + \delta_4$ = the slope coefficient of $\exp_i^2$ for women for whom $\text{dkidslt6}_i = 1$
$\beta_5 + \delta_5$ = the slope coefficient of age_i for women for whom $\text{dkidslt6}_i = 1$.

- Compute from Model 3 the probit coefficient estimates, t-ratios and p-values for those **married women who have one or more pre-school aged children (for whom $\text{dkidslt6}_i = 1$)**. Enter the **lincom** commands:

```
lincom _b[_cons] + _b[dkidslt6]
lincom _b[nwifeinc] + _b[d6nwinc]
lincom _b[ed] + _b[d6ed]
lincom _b[exp] + _b[d6exp]
lincom _b[expsq] + _b[d6expsq]
lincom _b[age] + _b[d6age]
```

```
. * Model 3 probit coefficients for women for whom dkidslt6 = 1
. lincom _b[_cons] + _b[dkidslt6]

 ( 1)  dkidslt6 + _cons = 0

------------------------------------------------------------------------------
        inlf |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         (1) |  -1.918622   1.166582    -1.64   0.100    -4.205081    .3678365
------------------------------------------------------------------------------

. lincom _b[nwifeinc] + _b[d6nwinc]

 ( 1)  nwifeinc + d6nwinc = 0

------------------------------------------------------------------------------
        inlf |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         (1) |  -.0168304   .0094237    -1.79   0.074    -.0353004    .0016397
------------------------------------------------------------------------------

. lincom _b[ed] + _b[d6ed]

 ( 1)  ed + d6ed = 0

------------------------------------------------------------------------------
        inlf |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         (1) |   .1542988   .0556478     2.77   0.006     .0452311    .2633665
------------------------------------------------------------------------------
```

```
. lincom _b[exp] + _b[d6exp]

 ( 1)  exp + d6exp = 0

------------------------------------------------------------------------------
        inlf |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         (1) |   .0244335    .062981     0.39   0.698    -.0990069    .1478739
------------------------------------------------------------------------------

. lincom _b[expsq] + _b[d6expsq]

 ( 1)  expsq + d6expsq = 0

------------------------------------------------------------------------------
        inlf |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         (1) |   .0007676   .0032829     0.23   0.815    -.0056666    .0072019
------------------------------------------------------------------------------

. lincom _b[age] + _b[d6age]

 ( 1)  age + d6age = 0

------------------------------------------------------------------------------
        inlf |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         (1) |  -.0089589   .0246402    -0.36   0.716    -.0572529     .039335
------------------------------------------------------------------------------
```

❑ Marginal *probability* effects of *binary* explanatory variable *dkidslt6* in Model 2 – *dprobit* with *at(vecname)* option

- Use the **dprobit** command *without* the **at(*vecname*)** option to compute the marginal probability effects in Model 2 at the **sample *mean* values of the regressors**, i.e., at $x_i^T = \bar{x}^T$. Enter the following command:

```
dprobit inlf nwifeinc ed exp expsq age dkidslt6
```

- The next series of *Stata* commands will demonstrate how to use the **dprobit** command with the **at(*vecname*)** option to compute the **marginal *probability* effect of the dummy variable *dkidslt6$_i$* in Model 2** for married women whose non-wife family income is $20,000 per year ($nwifeinc_i$ = 20), who have 14 years of formal education (ed_i = 14) and 10 years of actual work experience (exp_i = 10, $expsq_i$ = 100), and who are 40 years of age (age_i = 40):

$$\Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 1\right) - \Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 0\right)$$

$$= \Phi\left(x_{1i}^T\beta\right) - \Phi\left(x_{0i}^T\beta\right)$$

$$= \Phi\left(\beta_0 + \beta_1\text{nwifeinc}_i + \beta_2\text{ed}_i + \beta_3\exp_i + \beta_4\exp_i^2 + \beta_5\text{age}_i + \delta_0\right) - \Phi\left(\beta_0 + \beta_1\text{nwifeinc}_i + \beta_2\text{ed}_2 + \beta_3\exp_i + \beta_4\exp_i^2 + \beta_5\text{age}_i\right)$$

$$= \Phi\left(\beta_0 + \beta_1 20 + \beta_2 14 + \beta_3 10 + \beta_4 100 + \beta_5 40 + \delta_0\right) - \Phi\left(\beta_0 + \beta_1 20 + \beta_2 14 + \beta_3 10 + \beta_4 100 + \beta_5 40\right)$$

<u>A Three Step Procedure</u>: The procedure for this computation consists of three steps.

<u>Step 1</u>: Compute an estimate of the probability of labour force participation for married women with the specified characteristics **who have *one or more* dependent children under 6 years of age, for whom $\mathbf{dkidslt6_i = 1}$**: i.e., compute an estimate of

$$\Phi\left(x_{1i}^T\beta\right) = \Phi\left(\beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i + \delta_0 + \beta_0\right)$$

$$= \Phi\left(\beta_1 20 + \beta_2 14 + \beta_3 10 + \beta_4 100 + \beta_5 40 + \delta_0 1 + \beta_0 1\right) \qquad \text{in } \textit{Stata} \text{ format}$$

where $x_{1i}^T = \left(nwifeinc_i \;\; ed_i \;\; \exp_i \;\; \exp_i^2 \;\; age_i \;\; 1 \;\; 1\right) = \left(20 \;\; 14 \;\; 10 \;\; 100 \;\; 40 \;\; 1 \;\; 1\right)$.

<u>Step 2</u>: Compute an estimate of the probability of labour force participation for married women with the specified characteristics **who have *no* dependent children under 6 years of age, for whom $\mathbf{dkidslt6_i = 0}$**: i.e., compute an estimate of

$$\Phi\left(x_{0i}^T\beta\right) = \Phi\left(\beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i + \delta_0 + \beta_0\right)$$

$$= \Phi\left(\beta_1 20 + \beta_2 14 + \beta_3 10 + \beta_4 100 + \beta_5 40 + \delta_0 0 + \beta_0 1\right) \qquad \text{in } \textit{Stata} \text{ format}$$

where $x_{0i}^T = \left(nwifeinc_i \;\; ed_i \;\; \exp_i \;\; \exp_i^2 \;\; age_i \;\; 0 \;\; 1\right) = \left(20 \;\; 14 \;\; 10 \;\; 100 \;\; 40 \;\; 0 \;\; 1\right)$

<u>Step 3</u>: Compute an estimate of the difference $\Phi\left(x_{1i}^T\beta\right) - \Phi\left(x_{0i}^T\beta\right)$, which is the **marginal *probability* effect of having one or more dependent children under 6 years of age** for married women who have the specified characteristics.

- **<u>Step 1</u>:** Use the **dprobit** command *with* the **at(*vecname*)** option to compute the marginal probability effects in Model 2 for married women whose non-wife family income is $20,000 per year ($nwifeinc_i = 20$), who have 14 years of formal education ($ed_i = 14$) and 10 years of actual work experience ($exp_i = 10$, $expsq_i = 100$), who are 40 years of age ($age_i = 40$), and **who have *one or more* dependent children under 6 years of age (dkidslt6 = 1)**. You will first have to create a vector containing the specified values of the regressors for Model 2, since the **dprobit** command does not permit number lists in the **at( )** option. Note that in *Stata* format, the vector x_{1i}^T with the dummy variable ***dkidslt6$_i$* = 1** is written as:

$$x_{1i}^T = \left(nwifeinc_i \;\; ed_i \;\; exp_i \;\; exp_i^2 \;\; age_i \;\; 1 \;\; 1\right) = \left(20 \;\; 14 \;\; 10 \;\; 100 \;\; 40 \;\; 1 \;\; 1\right).$$

Enter the following commands:

```
matrix x1vec = (20, 14, 10, 100, 40, 1, 1)
matrix list x1vec
dprobit inlf nwifeinc ed exp expsq age dkidslt6, at(x1vec)
ereturn list
```

Display and save the value of $\Phi\left(x_{1i}^T\hat{\beta}\right)$ generated by the above **dprobit** command, where $\Phi\left(x_{1i}^T\hat{\beta}\right)$ is an estimate of $\Pr\left(inlf_i = 1 \middle| dkidslt6_i = 1\right)$. Enter the commands:

```
display e(at)
scalar PHIx1vec = e(at)
scalar list PHIx1vec
```

```
. display e(at)
.41935631

. scalar PHIx1vec = e(at)

. scalar list PHIx1vec
  PHIx1vec = .41935631
```

- **<u>Step 2</u>:** Now use the **dprobit** command *with* the **at(*vecname*)** option to compute the marginal probability effects in Model 2 for married women whose non-wife family income is $20,000 per year ($nwifeinc_i = 20$), who have 14 years of formal education ($ed_i = 14$) and 10 years of actual work experience ($exp_i = 10$, $expsq_i = 100$), who are 40 years of age ($age_i = 40$), and **who have *no* dependent children under 6 years of age (dkidslt6 = 0)**. First, you will have to create a vector containing the specified values of the regressors for Model 2; the **dprobit** command does not permit number lists in the **at( )** option. Note that in *Stata* format, the vector x_{0i}^T with the dummy variable ***dkidslt6$_i$* = 0** is written as:

$$x_{0i}^T = \left(nwifeinc_i \;\; ed_i \;\; exp_i \;\; exp_i^2 \;\; age_i \;\; 0 \;\; 1\right) = \left(20 \;\; 14 \;\; 10 \;\; 100 \;\; 40 \;\; 0 \;\; 1\right)$$

Enter the following commands:

```
matrix x0vec = (20, 14, 10, 100, 40, 0, 1)
matrix list x0vec
dprobit inlf nwifeinc ed exp expsq age dkidslt6, at(x0vec)
ereturn list
```

Display and save the value of $\Phi\left(x_{0i}^T\hat{\beta}\right)$ generated by the above **dprobit** command, where $\Phi\left(x_{0i}^T\hat{\beta}\right)$ is an estimate of $\Pr\left(inlf_i = 1 \middle| dkidslt6_i = 0\right)$. Enter the commands:

```
display e(at)
scalar PHIx0vec = e(at)
scalar list PHIx0vec
```

```
. display e(at)
.79350221

. scalar PHIx0vec = e(at)

. scalar list PHIx0vec
  PHIx0vec = .79350221
```

- **Step 3:** Finally, compute the estimate of the difference $\Phi\left(x_{1i}^{T}\beta\right) - \Phi\left(x_{0i}^{T}\beta\right)$, which is the marginal probability effect of having one or more dependent children under 6 years of age for married women who have the specified characteristics. Enter the commands:

```
scalar diffPHI = PHIx1vec - PHIx0vec
scalar list PHIx1vec PHIx0vec diffPHI

. scalar list PHIx1vec PHIx0vec diffPHI
  PHIx1vec = .41935631
  PHIx0vec = .79350221
   diffPHI = -.3741459
```

- Carefully compare the results of this three-step procedure with the output of the two **dprobit** commands you have estimated. Enter the following commands:

```
* Model 2 at x0vec: dprobit
dprobit inlf nwifeinc ed exp expsq age dkidslt6, at (x0vec)
* Model 2 at x1vec: dprobit
dprobit inlf nwifeinc ed exp expsq age dkidslt6, at (x1vec)
```

The *Stata* output listing produced by these commands is reproduced on the following page. Note in particular the highlighted results in the output listing for these two **dprobit** commands.

```
. * Model 2 at x0vec: dprobit
. dprobit inlf nwifeinc ed exp expsq age dkidslt6, at (x0vec)

Iteration 0:   log likelihood =  -514.8732
Iteration 1:   log likelihood = -410.52123
Iteration 2:   log likelihood = -407.00272
Iteration 3:   log likelihood = -406.98832

Probit regression, reporting marginal effects           Number of obs =    753
                                                        LR chi2(6)    = 215.77
                                                        Prob > chi2   = 0.0000
Log likelihood = -406.98832                             Pseudo R2     = 0.2095

------------------------------------------------------------------------------
    inlf |      dF/dx   Std. Err.      z    P>|z|        x  [    95% C.I.   ]
---------+--------------------------------------------------------------------
nwifeinc |  -.0032397   .0013341    -2.39   0.017       20  -.005854 -.000625
      ed |   .0347428   .0061286     4.92   0.000       14   .022731  .046755
     exp |   .0334919   .0050403     6.32   0.000       10   .023613  .043371
   expsq |  -.0005032   .0001622    -2.94   0.003      100  -.000821 -.000185
     age |  -.0152501   .0021914    -6.73   0.000       40  -.019545 -.010955
dkidslt6*|  -.3741459   .0527655    -7.04   0.000        0  -.477564 -.270728
---------+--------------------------------------------------------------------
  obs. P |   .5683931
 pred. P |    .583103  (at x-bar)
 pred. P |   .7935022  (at x)
------------------------------------------------------------------------------
(*) dF/dx is for discrete change of dummy variable from 0 to 1
    z and P>|z| correspond to the test of the underlying coefficient being 0
```

```
. * Model 2 at x1vec: dprobit
. dprobit inlf nwifeinc ed exp expsq age dkidslt6, at (x1vec)

Iteration 0:   log likelihood =  -514.8732
(output omitted)
Iteration 3:   log likelihood = -406.98832

Probit regression, reporting marginal effects           Number of obs =    753
                                                        LR chi2(6)    = 215.77
                                                        Prob > chi2   = 0.0000
Log likelihood = -406.98832                             Pseudo R2     = 0.2095

------------------------------------------------------------------------------
    inlf |      dF/dx   Std. Err.      z    P>|z|         x  [    95% C.I.   ]
---------+--------------------------------------------------------------------
nwifeinc |  -.0044364   .0018708    -2.39   0.017        20  -.008103  -.00077
      ed |   .0475765   .0100112     4.92   0.000        14   .027955  .067198
     exp |   .0458635   .0076519     6.32   0.000        10   .030866  .060861
   expsq |  -.0006891   .0002397    -2.94   0.003       100  -.001159 -.000219
     age |  -.0208833   .0029759    -6.73   0.000        40  -.026716 -.015051
dkidslt6*|  -.3741459   .0527655    -7.04   0.000         1  -.477564 -.270728
---------+--------------------------------------------------------------------
  obs. P |   .5683931
 pred. P |    .583103  (at x-bar)
 pred. P |   .4193563  (at x)
------------------------------------------------------------------------------
(*) dF/dx is for discrete change of dummy variable from 0 to 1
    z and P>|z| correspond to the test of the underlying coefficient being 0
```

❑ Computing marginal *probability* effect of the *binary* explanatory variable *dkidslt6* in Model 2 – using the *margins* command after *probit*

In Model 2, the explanatory variable $\boldsymbol{dkidslt6_i}$ is a ***binary*** explanatory variable that distinguishes between married women who have one or more pre-school aged children under 6 years of age (for whom $\boldsymbol{dkidslt6_i}$ = 1), and married women who have no pre-school aged children under 6 years of age (for whom $\boldsymbol{dkidslt6_i}$ = 0). This section demonstrates how to use the **margins** command to easily estimate the **marginal probability effect** of the ***binary*** **explanatory variable** $\boldsymbol{dkidslt6_i}$ at ***user-specified*** **values** of the ***continuous*** **explanatory variables in Model 2**, i.e., $\boldsymbol{nwifeinc_i}$, $\boldsymbol{ed_i}$, $\boldsymbol{exp_i}$, and $\boldsymbol{age_i}$.

- To begin, re-estimate Model 2 by Maximum Likelihood using the **probit** command with all regressors entered in factor-variable notation. Enter the **probit** command:

```
probit inlf c.nwifeinc c.ed c.exp c.exp#c.exp c.age i.dkidslt6
```

Stata output on next page

```
. probit inlf c.nwifeinc c.ed c.exp c.exp#c.exp c.age i.dkidslt6

Iteration 0:   log likelihood =  -514.8732
Iteration 1:   log likelihood = -407.89693
Iteration 2:   log likelihood = -406.98942
Iteration 3:   log likelihood = -406.98832
Iteration 4:   log likelihood = -406.98832

Probit regression                                 Number of obs   =        753
                                                  LR chi2(6)      =     215.77
                                                  Prob > chi2     =     0.0000
Log likelihood = -406.98832                       Pseudo R2       =     0.2095

------------------------------------------------------------------------------
        inlf |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    nwifeinc |  -.0113531   .0047493    -2.39   0.017    -.0206616   -.0020446
          ed |   .1217526   .0247401     4.92   0.000     .0732629    .1702423
         exp |   .1173689    .018582     6.32   0.000     .0809488     .153789
             |
 c.exp#c.exp |  -.0017634   .0005991    -2.94   0.003    -.0029376   -.0005892
             |
         age |  -.0534423   .0079365    -6.73   0.000    -.0689976    -.037887
  1.dkidslt6 |  -1.022174    .145213    -7.04   0.000    -1.306786   -.7375618
       _cons |   .4815005   .4547181     1.06   0.290    -.4097307    1.372732
------------------------------------------------------------------------------
```

- **<u>First</u>**, estimate the ***conditional probability*** **of labour force participation** in Model 2 for both married women with pre-school aged children (for whom $\boldsymbol{dkidslt6_i}$ = 1) and married women without pre-school aged children (for whom $\boldsymbol{dkidslt6_i}$ = 0), where both categories of women have non-wife family income of $20,000 per year, have 14 years of formal education and 10 years of actual work experience, and are 40 years of age. In other words, estimate the ***conditional probability*** **of labour force participation** in Model 2 at the following selected values of the four continuous explanatory variables: $nwifeinc_i = 20$, $ed_i = 14$, $exp_i = 10$, $age_i = 40$. Enter *on one line* the following **margins** command:

```
margins i.dkidslt6, at(nwifeinc = (20) ed = (14) exp = (10) age = (40))
```

Stata output

```
. * Marginal probability effect of BINARY explanatory variable 'dkidslt6' in Model 2
. margins i.dkidslt6, at(nwifeinc = (20) ed = (14) exp = (10) age = (40))

Adjusted predictions                                   Number of obs   =        753
Model VCE    : OIM

Expression   : Pr(inlf), predict()
at           : nwifeinc        =          20
               ed              =          14
               exp             =          10
               age             =          40

------------------------------------------------------------------------------
             |            Delta-method
             |     Margin   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    dkidslt6 |
          0  |   .7935022   .0246955    32.13   0.000        .7451    .8419045
          1  |   .4193563   .0493966     8.49   0.000     .3225407     .516172
------------------------------------------------------------------------------
```

Note that the estimated ***conditional probability* of labour force participation** for married women with the specified characteristics who have no pre-school aged children, for whom $\boldsymbol{dkidslt6_i}$ = 0, is 0.7935, while the estimated ***conditional probability* of labour force participation** for married women with the same specified characteristics who have one or more pre-school aged children, for whom $\boldsymbol{dkidslt6_i}$ = 1, is 0.4194. The difference between these two conditional probabilities is by definition the **marginal *probability* effect** of the ***binary* explanatory variable** $\boldsymbol{dkidslt6_i}$ in Model 2 for married women with the user-specified characteristics.

- **<u>Second</u>**, estimate the **marginal *probability* effect** of the ***binary*** **explanatory variable** $\boldsymbol{dkidslt6_i}$ in Model 2 for married women whose non-wife family income is $20,000 per year, who have 14 years of formal education and 10 years of actual work experience, and who are 40 years of age. In other words, estimate the **marginal *probability* effect** of $\boldsymbol{dkidslt6_i}$ at the following selected values of the four continuous explanatory variables: $nwifeinc_i = 20$, $ed_i = 14$, $exp_i = 10$, $age_i = 40$. Enter *on one line* the following **margins** command:

```
margins r.dkidslt6, at(nwifeinc = (20) ed = (14) exp = (10) age = (40))
```

Stata output

```
. margins r.dkidslt6, at(nwifeinc = (20) ed = (14) exp = (10) age = (40))

Contrasts of adjusted predictions
Model VCE    : OIM

Expression   : Pr(inlf), predict()
at           : nwifeinc        =          20
               ed              =          14
               exp             =          10
               age             =          40

------------------------------------------------
             |         df        chi2     P>chi2
-------------+----------------------------------
    dkidslt6 |          1       50.28     0.0000
------------------------------------------------

--------------------------------------------------------------
             |            Delta-method
             |   Contrast   Std. Err.     [95% Conf. Interval]
-------------+------------------------------------------------
    dkidslt6 |
   (1 vs 0)  |  -.3741459   .0527658      -.477565   -.2707268
--------------------------------------------------------------
```

Alternatively, enter *on one line* the following **margins** command:

```
margins r.dkidslt6, at(nwifeinc = (20) ed = (14) exp = (10) age = (40))
contrast(nowald effects)
```

Stata output

```
. margins r.dkidslt6, at(nwifeinc = (20) ed = (14) exp = (10) age = (40))
contrast(nowald effects)

Contrasts of adjusted predictions
Model VCE    : OIM

Expression   : Pr(inlf), predict()
at           : nwifeinc        =          20
               ed              =          14
               exp             =          10
               age             =          40

------------------------------------------------------------------------------
             |            Delta-method
             |   Contrast   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    dkidslt6 |
   (1 vs 0)  |  -.3741459   .0527658    -7.09   0.000     -.477565   -.2707268
------------------------------------------------------------------------------
```

Compare the results of these two alternative **margins** commands.

The first **margins** command performs a **Wald test** of the null hypothesis that the marginal probability effect of $\boldsymbol{dkidslt6_i}$ equals zero; the sample value of the Wald test statistic is labeled **`chi2`**.

The second **margins** command performs a **large sample t-test** of the null hypothesis that the marginal probability effect of $\boldsymbol{dkidslt6_i}$ equals zero; the sample value of the test statistic is labeled **`z`**.

Otherwise, these two **margins** commands yield identical results, i.e., identical point estimates of the marginal probability effect of $\boldsymbol{dkidslt6_i}$ and its standard error, identical 95 percent confidence limits, and identical p-values of the calculated test statistics for the null hypothesis that the marginal probability effect of $\boldsymbol{dkidslt6_i}$ equals zero.

❑ Computing the marginal *probability* effect of the binary explanatory variable *dkidslt6ᵢ* in Model 3 – *dprobit* with *at(vecname)* option

This section demonstrates how to use the **dprobit** command with the **at(*vecname*)** option to compute the **marginal *probability* effect of the dummy variable *dkidslt6ᵢ* in Model 3** for married women who have the **sample *median* values** of the explanatory variables $nwifeinc_i$, ed_i, exp_i, and age_i.

Here we are concerned with obtaining an estimate of the **direction and magnitude** of the **marginal *probability* effect of the dummy variable *dkidslt6ᵢ* in Model 3**.

Recall that the **marginal *probability* effect of the dummy variable *dkidslt6ᵢ* in Model 3** is given by:

$$\Pr\left(inlf_i = 1 \middle| dkidslt6_i = 1\right) - \Pr\left(inlf_i = 1 \middle| dkidslt6_i = 0\right) = \Phi\left(x_{1i}^T\beta\right) - \Phi\left(x_{0i}^T\beta\right)$$

$$\Phi\begin{pmatrix}\beta_0 + \beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i \\ + \delta_0 + \delta_1 nwifeinc_i + \delta_2 ed_i + \delta_3 \exp_i + \delta_4 \exp_i^2 + \delta_5 age_i\end{pmatrix}$$

$$- \ \Phi\left(\beta_0 + \beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i\right)$$

In *Stata* format, the **marginal *probability* effect of the dummy variable *dkidslt6ᵢ* in Model 3** is written with the ***intercept* coefficient β_0 as the *last***, not the first, **term** in the probit index function:

$$\Phi\left(x_{1i}^T\beta\right) - \Phi\left(x_{0i}^T\beta\right) = \Phi\begin{pmatrix}\beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i \\ + \delta_0 + \delta_1 nwifeinc_i + \delta_2 ed_i + \delta_3 \exp_i + \delta_4 \exp_i^2 + \delta_5 age_i + \beta_0\end{pmatrix}$$

$$- \ \Phi\left(\beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i + \beta_0\right)$$

We can be more specific about the *Stata* format for the regressor vectors x_{1i}^T and x_{0i}^T and the probit coefficient vector β for full-interaction Model 3.

- Recall that in *Stata* format the **probit *index* function for Model 3** is written as:

$$x_i^T\beta = \beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i + \delta_0 dkidslt6_i$$
$$+ \delta_1 dkidslt6_i\, nwifeinc_i + \delta_2 dkidslt6_i\, ed_i + \delta_3 dkidslt6_i \exp_i + \delta_4 dkidslt6_i \exp_i^2 + \delta_5 dkidslt6_i\, age_i + \beta_0$$

- The **probit coefficient vector β for Model 3 in *Stata* format** is the **12×1 column vector**:

$$\beta = \left(\beta_1 \;\; \beta_2 \;\; \beta_3 \;\; \beta_4 \;\; \beta_5 \;\; \delta_0 \;\; \delta_1 \;\; \delta_2 \;\; \delta_3 \;\; \delta_4 \;\; \delta_5 \;\; \beta_0\right)^T$$

- The **probit index function for married women who currently have one or more pre-school aged children** (for whom $dkidslt6_i = 1$) is obtained by setting the indicator variable **$dkidslt6_i = 1$** everywhere it appears in the probit index function for Model 3:

$$x_{1i}^T\beta = \left(x_i^T\beta \,\middle|\, dkidslt6_i = 1\right) = \beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i$$
$$+ \delta_0 + \delta_1 nwifeinc_i + \delta_2 ed_i + \delta_3 \exp_i + \delta_4 \exp_i^2 + \delta_5 age_i + \beta_0$$

In *Stata* format, the regressor vector x_{1i}^T is therefore the 1×12 row vector:

$$x_{1i}^T = \left(nwifeinc_i \;\; ed_i \;\; \exp_i \;\; \exp_i^2 \;\; age_i \;\; 1 \;\; nwifeinc_i \;\; ed_i \;\; \exp_i \;\; \exp_i^2 \;\; age_i \;\; 1\right)$$

- Again, in *Stata* format the **probit *index* function for Model 3** is written as:

$$x_i^T\beta = \beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i + \delta_0 dkidslt6_i$$
$$+ \delta_1 dkidslt6_i\, nwifeinc_i + \delta_2 dkidslt6_i\, ed_i + \delta_3 dkidslt6_i \exp_i + \delta_4 dkidslt6_i \exp_i^2 + \delta_5 dkidslt6_i\, age_i + \beta_0$$

- The **probit index function for married women who have no pre-school aged children** (for whom $dkidslt6_i = 0$) is obtained by setting the indicator variable $\mathbf{dkidslt6_i = 0}$ everywhere it appears in the probit index function for Model 3:

$$x_{0i}^T\beta = \left(x_i^T\beta \,\middle|\, dkidslt6_i = 0\right)$$
$$= \beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i + \delta_0 0 + \delta_1 0 + \delta_2 0 + \delta_3 0 + \delta_4 0 + \delta_5 0 + \beta_0$$

In *Stata* format, the regressor vector x_{0i}^T is therefore the 1×12 row vector:

$$x_{0i}^T = \left(nwifeinc_i \;\; ed_i \;\; \exp_i \;\; \exp_i^2 \;\; age_i \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 1\right)$$

Three-step procedure for computing the marginal *probability* effect of the dummy variable *dkidslt6$_i$* in Model 3

<u>Step 1</u>: Compute an estimate of the probability of labour force participation for married women with the specified characteristics **who currently have *one or more* dependent children under 6 years of age, for whom dkidslt6$_i$ = 1**: i.e., compute an estimate of

$$\Phi\left(x_{1i}^T\beta\right) = \Phi\begin{pmatrix}\beta_0 + \beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i \\ + \delta_0 + \delta_1 nwifeinc_i + \delta_2 ed_i + \delta_3 \exp_i + \delta_4 \exp_i^2 + \delta_5 age_i\end{pmatrix}$$

<u>Step 2</u>: Compute an estimate of the probability of labour force participation for married women with the specified characteristics **who currently have *no* dependent children under 6 years of age, for whom dkidslt6$_i$ = 0**: i.e., compute an estimate of

$$\Phi\left(x_{0i}^T\beta\right) = \Phi\left(\beta_0 + \beta_1 nwifeinc_i + \beta_2 ed_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \beta_5 age_i\right)$$

<u>Step 3</u>: Compute an estimate of the difference $\Phi\left(x_{1i}^T\beta\right) - \Phi\left(x_{0i}^T\beta\right)$, which is the marginal probability effect of having one or more pre-school aged children for married women who have the specified characteristics.

- Compute (or select) the values of the explanatory variables at which you wish to compute the marginal probability effect of the binary variable $dkidslt6_i$. For this purpose, we will use the **pooled sample *medians*** of the explanatory variables $nwifeinc_i$, ed_i, exp_i, and age_i. Enter the following commands:

```
summarize nwifeinc, detail
return list
scalar nwinc50p = r(p50)
summarize ed, detail
scalar ed50p = r(p50)
summarize exp, detail
scalar exp50p = r(p50)
scalar exp50psq = exp50p^2
summarize age, detail
scalar age50p = r(p50)
scalar list nwinc50p ed50p exp50p exp50psq age50p
```

The sample median values of the explanatory variables computed by these commands are as follows:

```
nwinc50p =  17.700001
   ed50p =         12
  exp50p =          9
exp50psq =         81
  age50p =         43
```

- **<u>Step 1</u>:** Use the **dprobit** command *with* the **at(*vecname*)** option to compute the marginal probability effects in Model 3 for median married women whose non-wife family income is $17,700 per year ($nwifeinc_i = 17.700$), who have 12 years of formal education ($ed_i = 12$) and 9 years of actual work experience ($exp_i = 9$, $expsq_i = 81$), who are 43 years of age ($age_i = 43$), and **who have *one or more* dependent children under 6 years of age (dkidslt6 = 1)**. You will first have to create the vector x_{1i}^T containing the median values of the regressors in Model 3 when $dkidslt6_i = 1$, since the **dprobit** command does not permit number lists in the **at( )** option.

  Remember that *Stata* places the equation intercept coefficient β_0 in the *last*, not the first, element of the probit coefficient vector β, so that the coefficient vector β for Model 3 is written in *Stata* format as:

$$\beta = \left(\beta_1 \;\; \beta_2 \;\; \beta_3 \;\; \beta_4 \;\; \beta_5 \;\; \delta_0 \;\; \delta_1 \;\; \delta_2 \;\; \delta_3 \;\; \delta_4 \;\; \delta_5 \;\; \beta_0\right)^T$$

  In *Stata* format, the vector x_{1i}^T for Model 3 thus takes the form:

$$x_{1i}^T = \left(nwifeinc_i \;\; ed_i \;\; exp_i \;\; exp_i^2 \;\; age_i \;\; 1 \;\; nwifeinc_i \;\; ed_i \;\; exp_i \;\; exp_i^2 \;\; age_i \;\; 1\right)$$

$$= \begin{pmatrix} \text{nwinc50p ed50p exp50p exp50psq age50p 1} \\ \text{nwinc50p ed50p exp50p exp50psq age50p 1} \end{pmatrix}$$

Step 1 *Stata* commands are:

```
matrix x1median = (nwinc50p, ed50p, exp50p, expsq50p, age50p, 1, nwinc50p, ed50p,
exp50p, expsq50p, age50p, 1)

matrix list x1median

dprobit inlf nwifeinc ed exp expsq age dkidslt6 d6nwinc d6ed d6exp d6expsq d6age,
at(x1median)

ereturn list
```

Display and save the value of $\Phi\left(x_{1i}^{T}\hat{\beta}\right)$ generated by the above **dprobit** command, where $\Phi\left(x_{1i}^{T}\hat{\beta}\right)$ is an estimate of $\Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 1\right)$. The value of $\Phi\left(x_{1i}^{T}\hat{\beta}\right)$ is temporarily stored as the scalar **e(at)** following execution of the above **dprobit** command. Enter the commands:

```
display e(at)
scalar PHIx1med = e(at)
scalar list PHIx1med
```

These commands save the value of $\Phi\left(x_{1i}^{T}\hat{\beta}\right)$ as the scalar **`PHIx1med`**.

- **Step 2:** Now use the **dprobit** command *with* the **at(*vecname*)** option to compute the marginal probability effects in Model 3 for median married women whose non-wife family income is $17,700 per year ($nwifeinc_i$ = 17.700), who have 12 years of formal education ($ed_i = 12$) and 9 years of actual work experience ($exp_i = 9$, $expsq_i = 81$), who are 43 years of age ($age_i = 43$), and **who have *no* dependent children under 6 years of age (dkidslt6 = 0)**. Again, you will first have to create the vector x_{0i}^T containing the median values of the regressors in Model 3 when $dkidslt6_i = 0$.

  In *Stata* format, the vector x_{0i}^T for Model 3 takes the form:

$$x_{0i}^T = \left(\text{nwifeinc}_i \;\; \text{ed}_i \;\; \text{exp}_i \;\; \text{exp}_i^2 \;\; \text{age}_i \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 1\right)$$

$$= \left(\text{nwinc50p} \;\; \text{ed50p} \;\; \text{exp50p} \;\; \text{exp50psq} \;\; \text{age50p} \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 1\right)$$

Step 2 *Stata* commands are:

```
matrix x0median = (nwinc50p, ed50p, exp50p, exp50psq, age50p, 0, 0, 0, 0, 0, 0, 1)
matrix list x0median
dprobit inlf nwifeinc ed exp expsq age dkidslt6 d6nwinc d6ed d6exp d6expsq d6age,
at(x0median)
ereturn list
```

Display and save the value of $\Phi\left(x_{0i}^{T}\hat{\beta}\right)$ generated by the above **dprobit** command, where $\Phi\left(x_{0i}^{T}\hat{\beta}\right)$ is an estimate of $\Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 0\right)$. The value of $\Phi\left(x_{0i}^{T}\hat{\beta}\right)$ is temporarily stored as the scalar **e(at)** following execution of the above **dprobit** command. Enter the commands:

```
display e(at)
scalar PHIx0med = e(at)
scalar list PHIx0med
```

These commands save the value of $\Phi\left(x_{0i}^{T}\hat{\beta}\right)$ as the scalar **`PHIx0med`**.

- **<u>Step 3</u>:** Finally, compute the estimate of the difference $\Phi\left(x_{1i}^{T}\beta\right) - \Phi\left(x_{0i}^{T}\beta\right)$, which is the marginal probability effect having one or more dependent children under 6 years of age for married women who have the specified characteristics. **Step 3 *Stata* commands** are:

```
scalar diffPHImed = PHIx1med - PHIx0med
scalar list PHIx1med PHIx0med diffPHImed
```

The value of the scalar **`diffPHImed`** is **the estimate for Model 3** of

$$\Pr\left(\text{inlf}_i = 1 \,\middle|\, \text{dkidslt6}_i = 1\right) - \Pr\left(\text{inlf}_i = 1 \,\middle|\, \text{dkidslt6}_i = 0\right) = \Phi\left(x_{1i}^{T}\beta\right) - \Phi\left(x_{0i}^{T}\beta\right)$$

i.e., of the **marginal *probability* effect of having one or more dependent children under 6 years of age** for married women who have the median characteristics of women in the full sample.

$$\textbf{diffPHImed} = \hat{\Pr}\left(\text{inlf}_i = 1 \,\middle|\, \text{dkidslt6}_i = 1\right) - \hat{\Pr}\left(\text{inlf}_i = 1 \,\middle|\, \text{dkidslt6}_i = 0\right) = \Phi\left(x_{1i}^{T}\hat{\beta}\right) - \Phi\left(x_{0i}^{T}\hat{\beta}\right)$$

Output of Step 1 *Stata* Commands

```
. dprobit inlf nwifeinc ed exp expsq age dkidslt6 d6nwinc d6ed d6exp d6expsq d6age, at(x1median)

Iteration 0:   log likelihood = -514.8732
Iteration 1:   log likelihood = -406.48086
Iteration 2:   log likelihood = -402.63328
Iteration 3:   log likelihood = -402.61111
Iteration 4:   log likelihood = -402.61111

Probit estimates                                        Number of obs =    753
                                                        LR chi2(11)   = 224.52
                                                        Prob > chi2   = 0.0000
Log likelihood = -402.61111                             Pseudo R2     = 0.2180

------------------------------------------------------------------------------
    inlf |      dF/dx   Std. Err.      z    P>|z|        x  [    95% C.I.   ]
---------+--------------------------------------------------------------------
nwifeinc |  -.0039009   .0020603    -1.95   0.051      17.7  -.007939  .000137
      ed |   .0434699   .0113882     4.34   0.000        12   .021149   .06579
     exp |   .0490971    .009644     6.57   0.000         9   .030195  .067999
   expsq |  -.0007991   .0002526    -3.44   0.001        81  -.001294 -.000304
     age |  -.0212205   .0040365    -6.94   0.000        43  -.029132 -.013309
dkidslt6*|  -.6603895   .0730752    -1.99   0.046         1  -.803614 -.517165
 d6nwinc |  -.0021167   .0039297    -0.54   0.589      17.7  -.009819  .005585
    d6ed |    .011699   .0221757     0.53   0.600        12  -.031765  .055162
   d6exp |   -.040361   .0215344    -1.70   0.089         9  -.082568  .001846
 d6expsq |   .0010736   .0011221     0.90   0.370        81  -.001126  .003273
   d6age |   .0180172   .0111044     1.93   0.053        43  -.003747  .039781
---------+--------------------------------------------------------------------
  obs. P |   .5683931
 pred. P |   .5870885  (at x-bar)
 pred. P |   .3198606  (at x)
------------------------------------------------------------------------------
(*) dF/dx is for discrete change of dummy variable from 0 to 1
    z and P>|z| are the test of the underlying coefficient being 0
```

```
. ereturn list

scalars:
                  e(N) =  753
               e(ll_0) =  -514.8732045671461
                 e(ll) =  -402.6111063731551
               e(df_m) =  11
               e(chi2) =  224.5241963879821
               e(r2_p) =  .2180383387563736
               e(pbar) =  .5683930942895087
               e(xbar) =  .220061785738521
             e(offbar) =  0
                 e(at) =  .3198606279066483
```

[*output omitted*]

```
. display e(at)
.31986063

. scalar PHIx1med = e(at)

. scalar list PHIx1med
  PHIx1med =  .31986063
```

Output of Step 2 *Stata* Commands

```
. dprobit inlf nwifeinc ed exp expsq age dkidslt6 d6nwinc d6ed d6exp d6expsq d6age, at(x0median);

Iteration 0:   log likelihood = -514.8732
Iteration 1:   log likelihood = -406.48086
Iteration 2:   log likelihood = -402.63328
Iteration 3:   log likelihood = -402.61111
Iteration 4:   log likelihood = -402.61111

Probit estimates                                        Number of obs =    753
                                                        LR chi2(11)   = 224.52
                                                        Prob > chi2   = 0.0000
Log likelihood = -402.61111                             Pseudo R2     = 0.2180

------------------------------------------------------------------------------
    inlf |      dF/dx   Std. Err.      z    P>|z|         x  [    95% C.I.   ]
---------+--------------------------------------------------------------------
nwifeinc |   -.004054   .0020554    -1.95   0.051      17.7  -.008083 -.000025
      ed |   .0451757   .0104184     4.34   0.000        12   .024756  .065595
     exp |   .0510237   .0074085     6.57   0.000         9   .036503  .065544
   expsq |  -.0008305   .0002325    -3.44   0.001        81  -.001286 -.000375
     age |  -.0220532    .003204    -6.94   0.000        43  -.028333 -.015773
dkidslt6*|  -.6311359   .0559456    -1.99   0.046         0  -.740787 -.521485
 d6nwinc |  -.0021998   .0040816    -0.54   0.589         0  -.010199    .0058
    d6ed |    .012158   .0231649     0.53   0.600         0  -.033244   .05756
   d6exp |  -.0419448   .0245612    -1.70   0.089         0  -.090084  .006194
 d6expsq |   .0011157   .0012413     0.90   0.370         0  -.001317  .003549
   d6age |   .0187242   .0096966     1.93   0.053         0  -.000281  .037729
---------+--------------------------------------------------------------------
  obs. P |   .5683931
 pred. P |   .5870885  (at x-bar)
 pred. P |   .6469122  (at x)
------------------------------------------------------------------------------
(*) dF/dx is for discrete change of dummy variable from 0 to 1
    z and P>|z| are the test of the underlying coefficient being 0
```

```
. ereturn list

scalars:
                  e(N) =  753
               e(ll_0) =  -514.8732045671461
                 e(ll) =  -402.6111063731551
               e(df_m) =  11
               e(chi2) =  224.5241963879821
               e(r2_p) =  .2180383387563736
               e(pbar) =  .5683930942895087
               e(xbar) =  .220061785738521
             e(offbar) =  0
                 e(at) =  .6469121653332525

[output omitted]

. display e(at)
.64691217

. scalar PHIx0med = e(at)

. scalar list PHIx0med
  PHIx0med =  .64691217
```

Output of Step 3 *Stata* Commands

```
.
. * Model 3: compute marginal probability effect of dkidslt6
. scalar diffPHImed = PHIx1med - PHIx0med

. scalar list PHIx1med PHIx0med diffPHImed
  PHIx1med =  .31986063
  PHIx0med =  .64691217
diffPHImed = -.32705154
```

The value of the scalar **`diffPHImed`** is **the estimate for Model 3** of

$$\Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 1\right) - \Pr\left(\text{inlf}_i = 1 \middle| \text{dkidslt6}_i = 0\right) = \Phi\left(x_{1i}^T\beta\right) - \Phi\left(x_{0i}^T\beta\right)$$

In Model 3, the estimated **marginal *probability* effect of having one or more dependent children under 6 years of age** for married women who have the median characteristics of women in the full sample is:

$$\Phi\left(x_{1i}^T\hat{\beta}\right) - \Phi\left(x_{0i}^T\hat{\beta}\right) = \mathbf{-0.32705154} = \mathbf{-0.3271}$$

❑ Computing the marginal *probability* effect of the binary explanatory variable *dkidslt6*$_i$ in Model 3 – *probit* command followed by *margins* command

You have previously computed an estimate of the marginal probability effect of the **binary explanatory variable *dkidslt6*$_i$** in Model 3 at the sample median values of the continuous explanatory variables; however, that procedure, while completely correct, was somewhat laborious.

This section demonstrates a much shorter and easier procedure that uses the **margins** command after Maximum Likelihood estimation of Model 3 with a **probit** command for computing the **marginal *probability* effect of the dummy variable *dkidslt6*$_i$ in Model 3** for married women who have the sample median values of the explanatory variables nwifeinc_i, ed_i, exp_i, and age_i.

- **<u>First</u>**, use the **probit** command to re-estimate Model 3, with all regressors entered in factor-variable notation to distinguish between ***continuous* and *categorical* explanatory variables**. Model 3 contains four *continuous* explanatory variables, specifically nwifeinc_i, ed_i, exp_i, and age_i, and one *binary categorical* explanatory variable, **dkidslt6$_i$**. Enter *on one line* the following command:

```
probit inlf c.nwifeinc c.ed c.exp c.exp#c.exp c.age i.dkidslt6 i.dkidslt6#(c.nwifeinc
c.ed c.exp c.exp#c.exp c.age)
```

The following slide shows you the results of this **probit** estimation command.

```
. probit inlf c.nwifeinc c.ed c.exp c.exp#c.exp c.age i.dkidslt6
 i.dkidslt6#(c.nwifeinc c.ed c.exp c.exp#c.exp c.age) ;

Iteration 0:   log likelihood =  -514.8732
```

(output omitted)

```
Iteration 4:   log likelihood = -402.61111

Probit regression                                 Number of obs   =        753
                                                  LR chi2(11)     =     224.52
                                                  Prob > chi2     =     0.0000
Log likelihood = -402.61111                       Pseudo R2       =     0.2180

------------------------------------------------------------------------------------
                inlf |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------------+--------------------------------------------------------------
            nwifeinc |  -.0109103   .0056007    -1.95   0.051    -.0218874    .0000668
                  ed |   .1215786   .0280427     4.34   0.000     .0666159    .1765413
                 exp |    .137317   .0208939     6.57   0.000     .0963657    .1782682
                     |
         c.exp#c.exp |  -.0022349   .0006495    -3.44   0.001     -.003508   -.0009619
                     |
                 age |  -.0593504   .0085496    -6.94   0.000    -.0761072   -.0425935
          1.dkidslt6 |  -2.527031   1.267708    -1.99   0.046    -5.011694   -.0423684
                     |
 dkidslt6#c.nwifeinc |
                  1  |  -.0059201   .0109624    -0.54   0.589    -.0274059    .0155658
                     |
       dkidslt6#c.ed |
                  1  |   .0327202   .0623143     0.53   0.600    -.0894135     .154854
                     |
      dkidslt6#c.exp |
                  1  |  -.1128835   .0663563    -1.70   0.089    -.2429394    .0171724
                     |
dkidslt6#c.exp#c.exp |
                  1  |   .0030026   .0033465     0.90   0.370    -.0035564    .0095616
                     |
      dkidslt6#c.age |
                  1  |   .0503914   .0260813     1.93   0.053    -.0007271    .1015099
                     |
               _cons |   .6084091   .4961565     1.23   0.220    -.3640398    1.580858
------------------------------------------------------------------------------------
```

- **<u>Second</u>**, use a **margins** command with the **at( )** option to compute estimates of the ***conditional*** **probability of labour force participation** for (1) **married women with *no pre-school aged children***, for whom **dkidslt6$_i$ = 0**, and (2) **married women with *one or more pre-school aged children***, for whom **dkidslt6$_i$ = 1**. Note that the **at( )** option is used tell *Stata* that these conditional probabilities of labour force participation are to be computed at the **sample *median* values** of the four continuous explanatory variables nwifeinc_i, ed_i, exp_i, and age_i. Enter the following **margins** command:

```
margins i.dkidslt6, at((median) nwifeinc ed exp age)
```

Output from this **margins** command:

```
. * Marginal probability effect of 'dkidslt6' at sample medians of continuous covariates
. margins i.dkidslt6, at((median) nwifeinc ed exp age)

Adjusted predictions                              Number of obs   =        753
Model VCE    : OIM

Expression   : Pr(inlf), predict()
at           : nwifeinc        =        17.7 (median)
               ed              =          12 (median)
               exp             =           9 (median)
               age             =          43 (median)

------------------------------------------------------------------------------
             |            Delta-method
             |     Margin   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    dkidslt6 |
          0  |   .6469122   .0256601    25.21   0.000     .5966194    .6972049
          1  |   .3198606   .0948877     3.37   0.001     .1338842     .505837
------------------------------------------------------------------------------
```

- **<u>Third</u>**, use a second **margins** command with the **at( )** option to compute an estimate of the ***marginal* probability effect of dkidslt6$_i$,** which by definition is the difference in the conditional probability of labour force participation between married women with pre-school aged children (for whom **dkidslt6$_i$ = 1**) and married women with no pre-school aged children (for whom **dkidslt6$_i$ = 0**). Enter the following **margins** command:

```
margins r.dkidslt6, at((median) nwifeinc ed exp age)
```

Output from this **margins** command:

```
. margins r.dkidslt6, at((median) nwifeinc ed exp age)

Contrasts of adjusted predictions
Model VCE    : OIM

Expression   : Pr(inlf), predict()
at           : nwifeinc        =        17.7 (median)
               ed              =          12 (median)
               exp             =           9 (median)
               age             =          43 (median)

------------------------------------------------
             |         df        chi2     P>chi2
-------------+----------------------------------
    dkidslt6 |          1       11.07     0.0009
------------------------------------------------

--------------------------------------------------------------
             |            Delta-method
             |   Contrast   Std. Err.     [95% Conf. Interval]
-------------+------------------------------------------------
    dkidslt6 |
   (1 vs 0)  |  -.3270515    .098296     -.5197082   -.1343949
--------------------------------------------------------------
```

- An alternative to the above *Stata* margins command uses the option **contrast(nowald effects)**. Enter the following **margins** command:

```
margins r.dkidslt6, at((median) nwifeinc ed exp age) contrast(nowald effects)
```

Output from this **margins** command:

```
. margins r.dkidslt6, at((median) nwifeinc ed exp age) contrast(nowald effects)

Contrasts of adjusted predictions
Model VCE    : OIM

Expression   : Pr(inlf), predict()
at           : nwifeinc        =        17.7 (median)
               ed              =          12 (median)
               exp             =           9 (median)
               age             =          43 (median)

------------------------------------------------------------------------------
             |            Delta-method
             |   Contrast   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    dkidslt6 |
   (1 vs 0)  |  -.3270515    .098296    -3.33   0.001    -.5197082   -.1343949
------------------------------------------------------------------------------
```

Note that the first of the above **margins** commands reports a **Wald test** of the null hypothesis that the ***marginal* probability effect of dkidslt6$_i$** at sample median values of nwifeinc_i, ed_i, exp_i, and age_i is equal to zero, whereas the second **margins** command reports an equivalent **large-sample t-test** of the same null hypothesis. Otherwise, the results produced by these two **margins** commands are identical.