Demographic transition, economic growth and labor market dynamics
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Chapter 3

Economic Development, Fertility Decline and Female Labor Force Participation

3.1 Introduction

This chapter presents theoretical and empirical work on women’s labor force participation across the process of economic development. Many studies have investigated the relationship between economic development and fertility and the relationship between fertility and female labor force participation, but the relationship between economic development and female labor force participation has received considerably less attention in the literature. Although one might expect that women want more children if income levels rise (Becker, 1960; Hotz et al., 1997, pp. 292-293), the first relationship has generally been found to be negative. The quality-quantity model of fertility is one of the first models that acknowledged that economic progress simultaneously increases the return to human capital, which in turn can lead to a reduction in fertility as families choose smaller family size with increased investments in each child (Hotz et al., 1997, pp. 294-308). Another reason is that the need to have children as a form of old-age security diminishes. In addition, lower mortality reduces the return to large families, representing another additional force toward lower fertility (Falcao and Soares, 2007). Finally, children who are useful from an early age on the farm

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1 This chapter is based on joint work with Paul Elhorst. The authors are thankful to the participants of the European Economic Association conference 2009, Scottish Economic Society Conference 2009 and 4th European workshop on labor economics. The usual disclaimer applies.
in low-income economies become increasingly less useful and more expensive to raise if income levels increase, all the more so as they spend an increasing number of years in school (Jacobsen, 1999).

The second relationship between fertility and female labor force participation has been found to be negative too. The reason is that with fewer children to take care of, women are able to spend an increasingly larger share of their life working for pay, both in terms of participation and in number of hours. Figures 3.1(a)-(d) illustrate that high-income and (lower and upper) middle-income countries show a negative relationship between the fertility rate and female labor force participation over the period 1960-2000. Only in low-income countries does this negative relationship seem not to exist. There may be two reasons for this. First, studies of the behavioral response to changes in fertility are complicated by issues of endogeneity, since the increase in female labor force participation may have a negative feedback effect on the fertility rate. Endogeneity requires instrumental variable methods, such as two-stage least squares (2SLS) to obtain consistent parameter estimates. Second, the income level should be controlled for, an important aspect that often is not adequately modeled as we will show in this paper.

Goldin (1995) and Mammen and Paxson (2000) were among the first to point out that the third relationship between female labor force participation rates and per capita income around the world is U-shaped. In poor, mainly agricultural economies, the number of women who are in the labor force is relatively high. In most cases they are unpaid workers on family farms who combine agricultural work with child care. When income levels rise, often because of an expansion of the manufacturing sector and the introduction of new technologies, women’s labor force participation rates fall. Men move into new blue-collar jobs that increase family income, exerting so-called unearned income effects that reduce women’s participation. Furthermore, as men move out of agriculture and into paid employment, there are fewer family farms on which women can work. In other words, opportunities for women decline in absolute terms due to the separation of market work from household work. At the same time, women may be barred from manufacturing employment by social custom or by employer preference. Those women who are in manufacturing are mostly self-employed or, again, unpaid family workers, for example, in home-based craft production (Schultz, 1990).
Figure 3.1: Fertility rate and female labor force participation by income

Panel 1: Fertility rate and Female Labor Force Participation: High Income Economies

Panel 2: Fertility Rate and Female Labor Force Participation: Upper Middle Income Economies

Panel 3: Fertility Rate and Female Labor Force Participation: Lower Middle Income Economies

Panel 4: Fertility Rate and Female Labor Force Participation: Low Income Economies

Source: Key Indicators of Labor Markets & World Development Indicators
When economic development continues, women move back into the labor force. There are several reasons for this. First, since the educational attainment of women tends to improve in more developed countries, the value of women’s time in the market increases, which strengthens the incentives of women to work outside the home. Second, since employment in the agricultural and in the manufacturing sector tends to fall and employment in the services sector tends to increase in more developed countries, more women tend to enter the labor market because these jobs are experienced as more acceptable forms of employment as far as women are concerned. Bowen and Finegan (1969) were among the first to point out that the sectoral composition of employment might explain structural differences between metropolitan areas in the relative abundance of those jobs commonly held by females. This study however mainly focused on developed countries. In a study on women’s labor force participation from a world perspective, Shultz (1990) found that the shift in the composition of production out of agriculture and into manufacturing and services was associated with an expansion of opportunities for women’s employment relative to men’s, particularly as wage earners. The possibility of doing this kind of work part-time, especially in the services sector, is also of importance since part-time work permits women to combine work outside the household with their domestic activities within the household (Jaumotte, 2003). Third, more women are able to enter the labor market since fertility tends to decline when the economy develops. This is also known as one of the main effects of demographic transition — a change from high to low rates of mortality and fertility. Bloom et al. (2009) found that total labor supply would rise by about 11% due to increased female labor market participation when fertility declines by four births per woman.

Taken as a whole, this story tells us that across the process of economic development women’s labor force participation rates first fall and then start to increase again. Figure 3.2 shows the female labor force participation rate in 2005 for a cross-section of 40

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2 Other effects are changes in per capita income growth, investment in human capital, savings, and age of retirement, etc.

3 The U-shaped behavior of female economic participation with economic development resembles with the inverted-U hypothesis of inequality and growth. Kuznets (1955) suggested that economic progress (measured by income per capita) is initially accompanied by rising inequality but then these disparities disappear as benefits of development spread widely. Similarly, female participation initially decline with economic development but then this decline changes into an increase.
countries, while Table 3.1A in appendix gives an overview of the countries included and the income classes to which they belong. Figure 3.2 illustrates that the female participation rate is indeed relatively high in low-income countries (e.g., Tanzania, Madagascar and Zambia), relatively low in lower middle-income countries (e.g., Egypt and Tunisia), and again relatively high in both upper middle-income countries (e.g., China and Brazil) and high-income countries (e.g., Canada, Italy and the US). However, although Goldin (1995) and Mammen and Paxson (2000) recognized the U-shaped relationship between economic development and female labor force participation from a theoretical viewpoint, it is another issue as to how to model this relationship empirically.

**Figure 3.2: GDP per capita and female labor force participation (2005)**

A textbook overview of the theory behind the U-shaped relationship can be found in Hoffman and Averett (2010), but illustrative of this literature is that empirical approaches to this relationship are sparse. To cover the U-shaped relationship Bloom *et al.* (2009) adopted a linear regression model and controlled for the level of urbanization, that is, the percentage of the total population living in an urban area. The idea was that the time cost of working in an urban setting increases (commuting time is one reason), as a result of which labor supply falls. Although they indeed found a negative and significant effect, it is questionable whether this variable is really able to cover the
supposed U-shaped relationship, since such a nonlinear relationship cannot be covered by adding another explanatory variable to a linear regression model. This is because the same change in economic development is likely to be less influential in high-income countries than in low-income countries.

Another possibility is that economic development affects female labor force participation interactively with other explanatory variables, that is, it modifies the effects that these variables have on female labor force participation (Pampel and Tanaka, 1986). For example, a shift to manufacturing employment in industrializing countries may eliminate work opportunities for women to such a degree that variation in fertility and education may make little difference for female labor force participation. For these two reasons we propose a regression model with interaction effects between the level of income per worker and the three key variables that explain female labor force participation across the process of economic development, namely, fertility, the share of employment in agriculture and the level of education. The square of the level of income per worker will also be considered. This approach offers the opportunity to model the regime shift between female participation rates, which first decline and then increase if the economy develops, as well as the opportunity to compute the turning points of this regime shift for the different explanatory variables in the model, as we will show in this chapter.

The previous studies by Pampel and Tanaka (1986), Tansel (2002) and Fatima and Sultana (2009) already considered the square of the level of income per worker.4 In all three of these studies the coefficient of the level of income per worker was found to be negative and significant, and that of its square to be positive and significant. However, since we find that the coefficients of other interaction terms are significant too, we must conclude that just one interaction term is not sufficient to cover the supposed U-shaped relationship. In addition, to investigate the existence of a U-shaped curve, the latter two studies only used data from a single country, whereas we will be using time-series cross-section data from different countries around the world. The time-series component of the data is utilized to investigate whether countries move along this curve if the economy

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4 Pampel and Tanaka (1986) considered the square of energy use per capita, a variable they used as a proxy for economic development.
develops, while the cross-sectional component is utilized to cover every part of the U-shaped relationship. If the analysis would be limited to one country or to a set of developing or developed countries only, then the sample might not be representative for the relationship we would like to examine. In this respect, Pampel and Tanaka (1986) pointed out that if the effects of development are linear, examination of a sample dominated by nations at one level of development would not greatly bias the results — the linear effect would be the same at different levels of development. However, if the effects are not linear, a restricted sample might misspecify the true relationship.

This chapter is structured as follows. In Section 3.2, we postulate a microeconomic framework for the labor force decision and its causal factors. This framework will then be aggregated across individuals to make it suitable for analyzing the labor force participation rate at the country level. In addition, we will show that aggregation across individuals or across groups of people is not allowed if their marginal reactions are significantly different from each other. In addition, we will present a framework to test this hypothesis. Section 3.3 describes the data and the empirical implementation of the data into the model. In Section 3.4, we present and discuss the results of our empirical analysis. This will also include the turning points of the explanatory variables for different female age groups, that is, the income level at which the impact of the explanatory variables changes sign. These turning points throw more light on the question of whether the relationship between women’s labor force participation and economic development is really U-shaped. The last section of the paper summarizes the empirical results and discusses their policy implications.

3.2 The theoretical framework

Simple textbooks models of labor supply specify that the labor force participation rate may be derived from a model of choice between consumption and working time. At micro level, the decision to participate in the labor market can be considered as a dichotomous random variable that takes the value of 1 if the decision is positive and 0 if it is negative. If we start from data observed at country level instead of individual data, the observed variable consists of a proportion $L_j$ of a group of women belonging to the female working age population in country $c$ ($c=1,\ldots,C$) who decide to participate. In
Section 2.1 we will present a theoretical framework to identify the key determinants of the individual labor force decision. In Section 2.2 we will explain the transition from the micro level to the country level.

The decision at the micro level

A woman is assumed to participate in the labor market if the utility level $U$ associated with participation exceeds the utility level associated with being inactive. These utility levels depend on whether this woman is already employed or not.

First, suppose a woman is already employed. If she is able to keep her job, she receives an hourly wage ($w_f$) for the number of hours being supplied ($h_f$). Women who work on a family farm do not receive an hourly wage rate, but their wage rate may be approached by the shadow wage rate from the production part of a household production model (Elhorst, 1994). The probability ($P_d$) that a woman will lose her job depends on labor market conditions ($l$), with a high value of $l$ assumed to refer to favorable conditions. If labor market conditions are unfavorable (e.g., loss of employment in agriculture), this implies a decrease in $l$ and an increase in $P_d(l)$. When a woman loses her job involuntarily in higher-income countries, she may receive unemployment benefits, but in lower-income countries this is generally not the case. In addition to this, the woman’s utility level depends on the number of children she gives birth to (fertility) and the quality per child ($q$). Although having more children may increase the woman’s utility level in principle, the counteracting effect is that the time available for work will be reduced due to childcare responsibilities. This implies that working time is a function of fertility, $h_f=h_f(\tau)$, where the first derivative of $h_f$ with respect to $\tau$ is negative, $\frac{\partial h_f}{\partial \tau}<0$. A decline in fertility may be offset by increasing the expense per child associated with desiring a higher quality of life. The possibilities of doing so depend on the wage levels of both man and wife within the household, $q=q(w_m,w_f)$. Finally, the woman’s utility depends on the income earned by her husband. Improvements in men’s

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5 Although unemployed people may also be said to participate in the labor market, being unemployed in developing countries is often comparable to being inactive.

6 Hill (1983) treats the decision to enter the labor force as an employee as being distinct from the choice to enter the labor market as a family worker. Although this is another way to model different regimes, it is only applicable when having individual data and when it is observed which women do paid work and which women do family work. At the aggregated level, this information is not available.
wages due to an expansion of the manufacturing sector without corresponding improvements in women’s wages reduce the labor force participation of women, since a rise in unearned income (i.e., the income of a woman independent of hours worked) leads unambiguously to a reduction in hours worked. In lower-income countries this may have the effect that a woman will quit working altogether. In sum, a woman already employed will remain active as long as

\[
U\{ (1-P_d(l))w_f(h_f(\tau), \tau, q(w_m, w_f), w_m) \} > U\{ 0, \tau, q(w_m,0), w_m \}. \tag{3.1}
\]

Second, suppose a woman is not yet participating in the labor market. If she is able to find a job, she will obtain the benefits of being active \((w_f h_f)\), as well as face the disadvantage of having less time available for childcare. In addition, a woman seeking a job incurs search costs \((s)\), or relatively more so than a woman who already has a job and might be looking for another one. The probability of finding a job depends again on labor market conditions \((l)\). If labor market conditions are unfavorable (e.g., relatively few jobs in the services sector), this probability \((P_f(l))\) decreases. In sum, a woman will become active if

\[
U\{ P_f(l)w_f(h_f(\tau), \tau, q(w_m, w_f), w_m) \} > U\{ 0, \tau, q(w_m,0), w_m \}. \tag{3.2}
\]

From this theoretical framework it follows that the participation decision is positively related to the female wage rate \((w_f)\) and favorable labor market conditions \((l)\), and negatively related to the male wage rate \((w_m)\), fertility and search costs.

There are more variables that have been found or have been argued to affect the labor force participation rate of women. Overviews have been provided by Elhorst (1996), Jacobsen (1999), Lim (2001), Jaumotte (2003), and Hoffman and Averett (2010). In this paper, however, we will focus on the key variables across the process of economic development.
The participation rate at the country level

The transition from the micro level to the macro level for homogeneous groups is discussed in Pencavel (1986), while Elhorst and Zeilstra (2007) extended this study by addressing the problem of heterogeneous population groups. Pencavel used the concept of reservation wage, the individual’s implicit value of time when on the margin between participating in the labor market and not participating. This reservation wage, \( w^* \), depends on observable explanatory variables \((X)\) and unobservable explanatory variables \((\varepsilon)\). Suppose women of a particular age group \((g)\) have identical observable explanatory variables \(X_g\), but different unobserved explanatory variables \(\varepsilon\). Wages \((w)\) may vary between age groups and between countries, but (like \(X_g\)) they do not vary within age groups within countries, that is, \(w=w_g\). Consequently, differences in reservation wages are caused by different values of the unobserved explanatory variables \(\varepsilon\) only. Let \(f_g(w_g^*)\) be the density function describing the distribution of reservation wages across women of group \(g\) and \(F_g(w_g^*)\) the cumulative distribution function corresponding to the density function. This cumulative distribution function \(F_g(w)\) is interpreted as giving for any value of \(w_g\) the probability of the event \(w_g^* \leq w_g\), that is, the proportion of women who offer positive hours of work to the labor market since the market wage rate exceeds their reservation wage. Then the labor force participation rate \(L_g\) of age group \(g\) is the cumulative distribution of \(w_g^*\) evaluated at \(w_g^* = w_g\), given \(X_g\) and a set of fixed but unknown parameters \(\beta_g\),

\[
L_g(w_g, X_g, \beta_g) = F_g(w_g | X_g, \beta_g),
\]

where the dependence of the labor participation rate of age group \(g\) has been made explicit on \(w_g\) and \(X_g\).

Since different age groups within each country may have different observable explanatory variables \(w_g\) and \(X_g\), the total labor force participation rate is determined by the sum of the group-specific cumulative density functions \(F_g(w_g | X_g, \beta_g)\) \((g=1,\ldots,G)\), weighted by the share of each age group in the total female population of working age \((a_g)\). In mathematical terms

\[
L_{total} = \sum_{g=1}^{G} a_g F_g(w_g | X_g, \beta_g).
\]

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From this equation it follows that there are two ways to deal with the problem of heterogeneous groups. One way is to consider a limited number of regression equations for broad population groups and to correct for the composition effect of groups having different observable explanatory variables \( X \). This approach was followed by Pampel and Tanaka (1986), Tansel (2002), Jaumotte (2003), Elhorst and Zeilstra (2007) and Fatima and Sultana (2009). The other, more prevalent, way is to consider as many population groups as necessary to obtain within-group homogeneity and then to estimate a separate regression equation for each age group. This approach was followed by Bloom et al. (2009), but only for women whose age was below 45. Women aged 45 and over were excluded with the argument that fertility beyond age 45 is very low. However, it would have been interesting to test whether fertility indeed has no effect on the participation rate of older women. Older women may still have to care for children who have not yet left home or they may not be able to re-enter the labor market even if they want to.

Generally, the extent to which the participation rate may be aggregated or must be disaggregated can be considered as offering two competing models to choose from. Supposing that the participation rate of two female age groups can be explained, say A and B, or their joint participation rate can be explained, then the first model consists of two participation rate equations

\[
L_A = \frac{n_A}{N_A} = X_A \beta_A + \epsilon_A, \quad L_B = \frac{n_B}{N_B} = X_B \beta_B + \epsilon_B, \quad (3.5)
\]

where \( n \) is the female labor force, \( N \) is the female working age population, and \( w \) is assumed to be part of \( X \). The second model consists of one participation rate equation

\[
L_{A+B} = \frac{n_A + n_B}{N_A + N_B} = X_{A+B} \beta_{A+B} + \epsilon_{A+B}, \quad (3.6)
\]

where \( L_{A+B} = W_A L_A + W_B L_B \) with \( W_A = N_A/(N_A + N_B) \) and \( W_B = N_B/(N_A + N_B) \). \( \epsilon_A \) and \( \epsilon_B \) in (5), and \( \epsilon_{A+B} \) in (6), are independently and identically normally distributed error terms for all women with zero mean and variance \( \sigma^2_A \), \( \sigma^2_B \) and \( \sigma^2_{A+B} \), respectively.

Starting from two participation rate equations of two different age groups and from \( X_A = X_B \), it is possible to investigate whether the marginal reactions of two age groups are...
the same by testing the hypothesis $H_0 : \beta_A = \beta_B$ against the alternative hypothesis $H_1 : \beta_A \neq \beta_B$. Note that the participation rate of every age group is taken to depend on the same set of explanatory variables. If one equation is to contain an explanatory variable that is lacking in the other and its coefficient estimate is statistically different from zero, $H_0$ would have to be rejected in advance.

The so-called Chow test can be used to test the equality of sets of coefficients in two regressions, but this test is only valid under the assumption that the error variances of both equations equalize, $\sigma_A^2 = \sigma_B^2$. The empirical analysis to be discussed later in this paper reveals that this assumption is rather implausible; if the parameter vector $\beta$ differs between two age groups, the error variance is different as well. Therefore, the Wald test is adopted here. Let $\beta_A$ and $\beta_B$ denote two vectors of $k$ parameters, one for group A and one for group B, with covariance matrices $V_A$ and $V_B$, then the Wald statistic
\begin{equation}
(\hat{\beta}_A - \hat{\beta}_B)(V_A + V_B)^{-1}(\hat{\beta}_A - \hat{\beta}_B),
\end{equation}
has a chi-squared distribution with $k$ degrees of freedom under the null hypothesis that the estimates of $\beta_A$ and $\beta_B$ have the same expected value.

### 3.3 Empirical analysis: Implementation

The data we use for the empirical analysis comprises 40 countries over the period 1960-2000. We selected observations over five-year intervals (1960, 1965, …, 2000). Since the data set is not complete, the total number of observations is 326. The countries included belong to different income classes, so as to cover every part of the supposed U-shaped relationship between the female labor force participation rate and economic development.

The variable to be explained is the female labor force participation rate of ten five-year age groups (15-19, 20-24, …, 60-64). According to the International Labor Organization (ILO), the organization from which the data were extracted, a woman is economically active if she is employed or actively seeking work.\(^7\) The female labor force participation rate is defined as the number of economically active women belonging to a particular age group divided by the total female population in that age group.

\(^7\) The data from 1960-1980 and 1980-2005 were taken from different data sets (ILO 1997, 2007).
Chapter 3

The theoretical framework set out in Section 2 invites the use of regression analysis to evaluate the empirical reliability of the female wage rate \( w_f \), the male wage rate \( w_m \), labor market conditions \( l \), fertility \( \tau \) and search costs \( s \). However, further explanation of how these variables have been implemented and the functional form of the relationship to be estimated would seem appropriate.

One difficulty that immediately emerges empirically is that we do not have comparable international data on male and female wage levels. To address this problem, Bloom et al. (2009) assumed a simple Cobb-Douglas function where output \( Y \) depends on capital \( K \) and aggregate labor \( L \) and men and women are paid according to their marginal products. In mathematical terms

\[
Y = K^\alpha [L_m h_m + L_f h_f]^{1-\alpha}, \tag{3.8}
\]

where effective labor \( L \) is the sum of the male and female forces, \( L_m \) and \( L_f \), weighted by their education levels, \( h_m \) and \( h_f \), respectively, and \( 0<\alpha<1 \). Consequently,

\[
w_f = (1-\alpha)(\frac{K}{L})^\alpha h_f \quad \text{and} \quad w_m = (1-\alpha)(\frac{K}{L})^\alpha h_m. \tag{3.9}
\]

Put into words, female wages rise with female education, male wages with male education, and both female and male wages rise with the capital-labor ratio. As an alternative to male and female wages, one may therefore also use the capital-labor ratio and the educational levels of males and females. This alternative approach, however, raises two complications. Formally, the capital-labor ratio cannot be treated as an exogenous explanatory variable. This is because the size of the labor force, the denominator of this ratio, depends on the number of women who decide to participate. Following Bloom et al. (2009), we therefore proxy the capital-labor ratio by \( K/W \), where \( W \) represents the total male and female population of working age (15-64). Second, the correlation coefficient between the educational levels of men and of women is high (0.94). Including highly correlated variables in a regression may cause the coefficients to have the wrong sign or implausible magnitudes and to have high standard errors and low significance levels even if they are jointly significant and the \( R^2 \) for the regression is high (Greene, 2008, p. 59). To avoid that the regression results are undermined by multicollinearity issues, we will only consider the
educational level of women. This variable is proxied by the average years of schooling of the female population aged 15 and over, and taken from Barro and Lee (2000). To measure the numerator of the capital-labor ratio, we took data from Penn World Tables 6.2 with respect to the physical capital stock (Heston et al., 2006).

In addition to the wage level, the better educated women, compared with the less educated, (1) possess skills that are in demand more often by an economy that pursues continued technological progress, (2) are likely to conduct more efficient searches, and (3) are less prone to layoffs and exhibit more stable patterns of employment. In this respect, the educational level of women can also be said to cover search costs.

The labor market conditions of a country are measured by employment in agriculture, that is, the percentage share of employed people in agriculture. This is because we have seen that the number of women who are in the labor force is relatively high in poor, mainly agricultural economies, and that this number diminishes if employment in agriculture falls.

Fertility is defined as the total number of children a woman will have by the end of her fertile period based on prevailing age-specific fertility rates. Data on the total fertility rate were taken from World Development Indicators (World Bank 2007). The fertility rate is treated as an endogenous explanatory variable. As instrumental variables we use the birth rate, the number of childbirths per 1,000 of the population (but then lagged five years in time), the infant mortality rate (up to one year of age) and the mortality rate under five years of age. Data on the birth rate were extracted from World Population Prospects (United Nations 2005) and data on infant mortality rates from World Development Indicators (World Bank 2007). Other instrumental variables were considered too, but rejected because they did not pass the (mis)specification tests to be discussed in the next section.

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8 Since our data set is comparable to the data set used in Bloom et al. (2009), we suspect that these problems may have affected the empirical results reported in that study as well.
Summary statistics of all the variables by different income groups are presented in Table 3.2A in the appendix. This table demonstrates that the female participation rate of every age group shows a U-shaped relationship if we move from low-income economies to high-income economies. The participation rates of females aged between 15 and 19 on up to between 50 and 54 are the lowest for lower middle-income economies, while the participation rates of females aged between 55 and 59 and 60 and 64 are the lowest for the upper middle-income economies. In addition, an inverse U-shaped relationship is apparent between the number of women in the labor force and their ages. The female participation rate is low in the 15-19 age category; it increases sharply in the 20-24 age category and then remains constant or gradually increases up to the 40-44 age category. In the 45-54 age category the female participation rate starts to decline and in the 60-64 age category it falls off dramatically.

All other variables increase or decrease if we move from low-income economies to high-income economies. The average years of schooling and the capital-labor ratio increase if incomes rise, while the total fertility rate, employment in agriculture, the birth rate, infant mortality rate and mortality rate under 5 years of age fall if incomes rise.

We pose the following empirical model for every age group

\[
L_{it} = f(\tau_{it}, K_{it}, A_{it}, h_{fit}) + \mu_i + \lambda_t + \epsilon_{it},
\]

where \(L_{it}\) denotes the female participation rate of a particular age group of country \(i\) at time \(t\). \(\tau\) is the fertility rate, \(K/W\) is the capital-labor ratio (the denominator measured by the total population of working age), \(A\) is the share of employment in agriculture and \(h_f\) is the educational level of females. All these variables refer to country \(i\) at time \(t\). \(\epsilon_{it}\) are independently and identically normally distributed error terms for all \(i\) and \(t\) with zero mean and variance \(\sigma^2\), \(\mu_i\) denotes a country fixed effect, and \(\lambda_t\) indicates a time-period fixed effect. Country fixed effects control for all country-specific, time-invariant

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9 Economies are divided according to 2006 GNI per capita, calculated using the World Bank Atlas method. The groups are: low income, $935 or less; lower middle income $936 - $3,705; upper middle income $3,706 - $11,455; and high income $11,456 or more.
variables whose omission could bias the estimates in a typical cross-sectional study\textsuperscript{10}; the justification for adding time-period fixed effects notes that they control for all time-specific, country-invariant variables whose omission could bias the estimates in a typical time-series study (Baltagi, 2005).

It is clear from both the introductory section of this paper and the data description in Table 2 that a linear functional form in equation (3.10) will not be able to capture the posited U-shaped relationship between economic development and female labor force participation. To model the regime shift between falling and rising female participation rates across the process of economic development, there should be a nonlinear relationship in one of the explanatory variables reflecting the income position of an economy. In (3.11) we propose a quadratic functional form in the capital-labor ratio, since this variable is used as a proxy for the wage level and therefore best reflects the transition of economies from low income levels to middle and high income levels

\[
L_t = \beta_1 t_{it} + \beta_2 x_{it} + \beta_3 \frac{K}{W_{it}} + \beta_4 \left( \frac{K}{W_{it}} \right)^2 + \beta_5 A_{it} + \beta_6 A_{it} \frac{K}{W_{it}} + \beta_7 h_{it} + \beta_8 h_{it} + \mu_t + \lambda_i + \epsilon_{it} 
\]

This quadratic functional form is a generalization of the linear functional form in that it also contains product terms between the different explanatory variables and the capital-labor ratio. To test whether this functional form better describes the data than the linear function form, we will test the null hypothesis $H_0: \beta_2 = \beta_4 = \beta_6 = \beta_8 = 0$.

Starting with (3.11) we can also calculate the turning points of the explanatory variables, that is, the point at which the positive impact of a certain variable changes into a negative impact or vice versa. For example, in a low-income economy the share of employment in agriculture is expected to have a positive effect on female labor force participation and in higher-income economies to have a negative effect (see section 3.1).

\textsuperscript{10} There are many other social, cultural and institutional factors that may affect the female labor force participation rate. Social traditions are very important in determining the roles played by men and women in society. Women are generally considered as homemaker and care provider and men as bread earner. Antecol (2000) finds that women are more likely to participate in the labor market if their male partners exhibit greater cultural acceptance of such behavior. Since we control for country specific fixed effects, such cultural and social differences across countries are accounted for.
Its turning point depends on the income level, in the quadratic equation approached by the capital-labor ratio. The turning point of an explanatory variable can be obtained by differentiating the quadratic functional form by that particular variable, which for all explanatory variables in the model gives

\[
\frac{\partial L}{\partial \tau} = \beta_1 + \beta_2 \frac{K}{W}, \quad \frac{\partial L}{\partial A} = \beta_5 + \beta_6 \frac{K}{W}, \quad \frac{\partial L}{\partial h_f} = \beta_7 + \beta_8 \frac{K}{W} \quad \text{and} \\
\frac{\partial L}{\partial \frac{K}{W}} = \beta_3 + \beta_2 \tau + 2\beta_4 \frac{K}{W} + \beta_6 A + \beta_8 h_f,  
\]  

(3.12)

where the subscripts i and t have been left aside, because the turning points will be determined at the sample mean. The first derivative with respect to the variable A shows that the marginal effect of the share of employment in agriculture will be negative if the capital-labor ratio is smaller than \(-\beta_5/\beta_6\) and positive if it is greater than \(-\beta_5/\beta_6\) (note: if both \(\beta_5\)s are positive or negative, then the marginal effect can only be positive). The marginal effect of the capital-labor ratio itself not only depends on the capital-labor ratio, but also on the fertility rate, the share of employment in agriculture and the educational level of females. However, by substituting the first derivatives of these variables into the first derivative of the capital-labor ratio and by rearranging terms, we obtain following equation which only depends on the capital-labor ratio.

\[
\frac{\partial L}{\partial \frac{K}{W}} = \beta_3 + \beta_2 \tau + \beta_5 A + \beta_8 h_f + (2\beta_4 + \beta_5^2 + \beta_6^2 + \beta_8^2) \frac{K}{W},  
\]  

(3.13)

This equation shows that the marginal effect of the capital-labor ratio can also be negative or positive, depending on the turning point that in this particular case can be calculated by

\[
\beta_3 + \beta_1 \beta_2 + \beta_6 \beta_8 + \beta_2 \beta_8 \\
2\beta_4 + \beta_5^2 + \beta_6^2 + \beta_8^2 .  
\]  

(3.14)
3.4 Empirical analysis: Results

The first panel of Table 3.1 reports the estimation results of the nonlinear regression model (3.11) for the ten age groups that have been considered. Although country fixed and time-period fixed effects have been included too, their coefficient estimates are not reported for reasons of space. Since the share of employment in agriculture is measured in percentages, its coefficient presents the shift in the participation rate measured on the interval 0-100% when this variable rises by one percentage point. The coefficient of the fertility rate shows the shift in the participation rate when this variable increases by one child, of education when this variable changes by one year of schooling, and of the capital-labor ratio when this ratio increases by US$1,000 (in the remainder of this paper we use $).

The fertility rate and the product term between the fertility rate and the capital-labor ratio have been treated as two separate endogenous explanatory variables. The results are reported in the second panel of Table 3.1. Note that the alternative approach of using fitted values for the fertility rate only and calculating the product term between the fertility rate and the capital-labor ratio based on the fitted values of the fertility rate is inconsistent (Kelejian, 1971; Greene, 2008, p.380). We also estimated the model, ignoring the endogeneity of the fertility rate, but we have not reported the results of this exercise. Instead, we will explain the main differences.

The results from the first-stage regressions show that the capital-labor ratio, employment in agriculture, and education have a negative effect on the fertility rate, and that the birth rate and the two mortality rates have a positive effect. Many of these results are in line with previous papers (see Anna and Marco 2005). Both for the fertility rate and the product term between the fertility rate and the capital-labor ratio, the R-squared is relatively high, indicating that the instruments together with the exogenous regressors do have predictive power with respect to the fertility rate. This is also illustrated by the F-tests of the first-stage regressions.
Chapter 3

Diagnostics

The third panel of Table 3.1 reports the results of several diagnostics to test whether the model is correctly specified. To test the hypothesis that instrumental variables techniques are required, we ran the Davidson and MacKinnon (1993) test of exogeneity for a regression equation with fixed effects. The null hypothesis states that an ordinary least squares estimator of the same equation will yield consistent estimates: that is, any endogeneity among the regressors should not have deleterious effects on OLS estimates. Under the null, the test statistic is distributed $F(M, N-K)$, where $M$ is the number of regressors specified as endogenous in the original instrumental variables regression, $N$ is the total number of observations and $K$ is the number of regressors. A rejection indicates that the instrumental variables fixed effects estimator should be employed. Since the five-percent critical value of this density function is 3.04, the null must be rejected for every age group. Table 3.1 reports the results for the instrumental variables we use, the birth rate, the number of childbirths per 1,000 of the population (but then lagged five years in time), the infant mortality rate (up to one year of age) and the mortality rate under five years of age. Similar test results have also been computed for alternative sets of instrumental variables (see Table 3.3A in the appendix). However, these alternative sets did not pass all the (mis)specification tests.

To test the joint hypothesis that instruments are valid and that the model is correctly specified, we applied the Sargan-Hansen test of over identifying restrictions. The joint null hypothesis is that the instruments are valid instruments, that is, uncorrelated with the error terms, and that the excluded instruments are correctly excluded from the estimated equation. Under the null, the test statistic is distributed as chi-squared in the number of $(L-K)$ over identifying restrictions, where $L$ is the total number of instruments. A rejection casts doubt about the validity of instruments. For all population groups except females aged between 60 and 64, we find that the joint hypothesis cannot be rejected.

Finally, we have tested whether the instruments are redundant, irrelevant or weak. First, excluded instruments are redundant if the asymptotic efficiency of the estimation is not improved by using them. The test statistic computes the rank of the matrix cross-
product between the endogenous regressors and the possibly redundant instruments after both have all other instruments partialled out. Under the null that the specified instruments are redundant, the statistic is distributed as chi-squared with degrees of freedom equal to the number of endogenous regressors (M) times the number of instruments being tested (L). Second, excluded instruments are relevant if they are correlated with the endogenous regressors. The test statistic computes the rank of the matrix of reduced form coefficients on the excluded instruments. Under the null that the instruments are irrelevant, the statistic is distributed as chi-squared with degrees of freedom equal to L1-M+1, where L1 is the number of excluded instruments. Third, excluded instruments are weak if their correlation with the endogenous regressors is weak. The critical value of the F version of the corresponding Cragg-Donald Wald statistic within our empirical setting is approximately 8.18. The results of these three tests reported in the last panel of Table 3 indicate that our instruments are neither redundant, nor irrelevant, nor weak. It should be stressed, however, that this positive result was achieved after a severe selection procedure in which several possible instrumental variables had to be dropped, among which women’s life expectancy, male education, the child dependency ratio, the level of urbanization and the capital-labor ratio lagged in time. Furthermore, just as Falcao and Soarás (2007), we found that child mortality does not appear to be a particularly important determinant of female labor force participation, but that its effect on fertility is important.

We have tested whether it is necessary to adopt a quadratic functional form in the capital-labor ratio. If the coefficients of the interaction effects are not jointly significant, then a linear functional form would suffice. The test results are reported in the last line of the first panel in Table 3.1. They indicate that the linear functional form should be strongly rejected in favor of the proposed quadratic functional form for all age groups. The R-squared ranges from 0.07 percent for females aged 60-64 to 0.57 for females aged 25-29.

To investigate the hypothesis that the country fixed effects are not jointly significant, we performed an F-test. The results indicate that we should reject this hypothesis for all age groups. To test whether random effects can replace these fixed
effects, we performed Hasuman’s specification test (Baltagi, 2005). The results reject the random effects model in favor of the fixed effects model for all age groups.

Finally, we have tested the equality of the coefficients of the eight explanatory variables reported in Table 3.1 for all crosswise combinations of population groups (including the total female working age population), a total of 55 pairs. Since the square root of the error variance ranges from 2.31 for females aged 60-64 to 2.74 for females aged 35-39 (see $\sigma$ in Table 3.1), we used the Wald statistic specified in (3.7). The results indicate that the null hypothesis has to be rejected in 46 cases. Only female labor force behavior in the successive age groups of 24-29 on up to 40-44 shows any resemblance to each other. In other words, the marginal reaction of the different population groups being identical is the exception rather than the rule. It follows from this finding that age-targeted policies to enhance the female labor force participation rate may be more successful than one uniform policy.

**Interpretation of coefficient estimates**

Fertility appears to have a large negative and significant effect on the participation rate of females in every age group, whereas the interaction effect between fertility and the capital-labor ratio appears to have a positive effect. This positive effect\(^{11}\), however, is only significant for females aged between 15 and 19, and 20 through 24. The fact that the coefficient of the fertility variable is negative and that the coefficient of the product term with the capital-labor ratio is positive indicates that fertility has a negative effect on the female labor force participation rate in lower-income economies and a positive effect in higher-income economies. The turning point for the total female working age population, which is illustrated in Panel 1 of Figure 3.3, amounts to $69,410. In other words, in countries located in Africa, South Asia, the Middle East, North Africa and South America, fertility affects participation negatively, while in countries located in Europe, North America and Oceania, fertility affects participation positively.

\(^{11}\) The finding of a positive effect of fertility on labor supply for women below 25 in developed countries may be an education effect - early childbearing may take women out of education and into the labor market.
Table 3.1: Female labor force participation, fixed effects estimation

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Fertility × capital-labor ratio</td>
<td>0.307***</td>
<td>0.211*</td>
<td>0.191</td>
<td>0.140</td>
<td>0.130</td>
<td>0.125</td>
<td>0.139</td>
<td>0.134</td>
<td>0.193*</td>
<td>0.153</td>
<td>0.140</td>
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<td>(0.101)</td>
<td>(0.124)</td>
<td>(0.123)</td>
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<td>(0.129)</td>
<td>(0.124)</td>
<td>(0.115)</td>
<td>(0.107)</td>
<td>(0.111)</td>
<td>(0.115)</td>
<td>(0.091)</td>
<td></td>
</tr>
<tr>
<td>Capital-labor ratio</td>
<td>-1.056***</td>
<td>-0.050</td>
<td>0.035</td>
<td>0.102</td>
<td>0.010</td>
<td>0.019</td>
<td>0.152</td>
<td>-0.244</td>
<td>-0.394*</td>
<td>-0.274</td>
<td>-0.222</td>
</tr>
<tr>
<td>(0.28)</td>
<td>(0.298)</td>
<td>(0.291)</td>
<td>(0.289)</td>
<td>(0.294)</td>
<td>(0.276)</td>
<td>(0.248)</td>
<td>(0.219)</td>
<td>(0.222)</td>
<td>(0.215)</td>
<td>(0.191)</td>
<td></td>
</tr>
<tr>
<td>Capital-labor ratio × capital-labor ratio</td>
<td>-0.005</td>
<td>-3.28***</td>
<td>-2.548***</td>
<td>-2.601***</td>
<td>-2.331***</td>
<td>-2.462***</td>
<td>-2.186***</td>
<td>-1.836***</td>
<td>-2.022***</td>
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<td>(0.001)</td>
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<td>(0.001)</td>
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<td>(0.001)</td>
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<tr>
<td>Agriculture</td>
<td>0.324*</td>
<td>0.314</td>
<td>0.399*</td>
<td>0.432**</td>
<td>0.355*</td>
<td>0.403*</td>
<td>0.296</td>
<td>0.204</td>
<td>0.227</td>
<td>0.141</td>
<td>0.221</td>
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<td>(0.171)</td>
<td>(0.208)</td>
<td>(0.206)</td>
<td>(0.196)</td>
<td>(0.207)</td>
<td>(0.206)</td>
<td>(0.199)</td>
<td>(0.189)</td>
<td>(0.20)</td>
<td>(0.216)</td>
<td>(0.151)</td>
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<tr>
<td>Agriculture × capital-labor ratio</td>
<td>-0.029***</td>
<td>-0.032***</td>
<td>-0.035***</td>
<td>-0.036***</td>
<td>-0.035***</td>
<td>-0.034***</td>
<td>-0.029***</td>
<td>-0.025**</td>
<td>-0.026**</td>
<td>-0.018*</td>
<td>-0.024***</td>
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<td>(0.01)</td>
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<td>(0.01)</td>
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<td>(0.01)</td>
<td>(0.008)</td>
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<td>(1.294)</td>
<td>(1.576)</td>
<td>(1.594)</td>
<td>(1.704)</td>
<td>(1.809)</td>
<td>(1.751)</td>
<td>(1.697)</td>
<td>(1.577)</td>
<td>(1.464)</td>
<td>(1.487)</td>
<td>(1.217)</td>
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<tr>
<td>Education × capital-labor ratio</td>
<td>0.079***</td>
<td>0.072***</td>
<td>0.071***</td>
<td>0.065***</td>
<td>0.071***</td>
<td>0.072***</td>
<td>0.076***</td>
<td>0.086***</td>
<td>0.063***</td>
<td>0.065***</td>
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<tr>
<td>(0.021)</td>
<td>(0.023)</td>
<td>(0.022)</td>
<td>(0.023)</td>
<td>(0.023)</td>
<td>(0.022)</td>
<td>(0.021)</td>
<td>(0.019)</td>
<td>(0.019)</td>
<td>(0.019)</td>
<td>(0.016)</td>
<td></td>
</tr>
</tbody>
</table>

| Significance of country fixed effects     |         |         |         |         |         |         |         |         |         |         |         |
| Dependent variable: Fertility            |         |         |         |         |         |         |         |         |         |         |         |
| R²                                       | 0.27    | 0.18    | 0.57    | 0.56    | 0.52    | 0.56    | 0.52    | 0.46    | 0.15    | 0.07    | 0.34    |
| σ                                        | 2.47    | 2.70    | 2.64    | 2.69    | 2.74    | 2.67    | 2.59    | 2.40    | 2.42    | 2.31    | 2.24    |

| Hausman test (FE vs. RE)                  |         |         |         |         |         |         |         |         |         |         |         |
| Chi-sq(8)                                 | 31.21   | 44.31   | 50.64   | 40.69   | 34.35   | 31.07   | 40.74   | 74.25   | 50.48   | 79.23   | 58.83   |
| p-value                                   | <0.01   | <0.01   | <0.01   | <0.01   | <0.01   | <0.01   | <0.01   | <0.01   | <0.01   | <0.01   | <0.01   |

| Nonlinearity Test                         |         |         |         |         |         |         |         |         |         |         |         |
| Dependent variable: Fertility × capital-labor ratio | 2.569*** | (0.369) |         |         |         |         |         |         |         |         |         |
| Lagged birth rate                         | 0.076*** | (0.010) |         |         |         |         |         |         |         |         |         |

Dependent variable: Fertility
### Chapter 3

<table>
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<tr>
<th>Linear</th>
<th>Capital-labor ratio</th>
<th>-0.012</th>
<th>1.836***</th>
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<td>(0.008)</td>
<td></td>
<td>(0.398)</td>
</tr>
<tr>
<td>×</td>
<td>Capital-labor ratio</td>
<td>0.001</td>
<td>-0.0002</td>
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<tr>
<td></td>
<td>(0.008)</td>
<td></td>
<td>(0.001)</td>
</tr>
<tr>
<td>Education</td>
<td>-0.003</td>
<td>0.005</td>
<td>-1.028***</td>
</tr>
<tr>
<td></td>
<td>(0.0001)</td>
<td></td>
<td>(0.021)</td>
</tr>
<tr>
<td>× Capital-labor ratio</td>
<td>0.001***</td>
<td>-0.0002***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0001)</td>
<td></td>
<td>(0.001)</td>
</tr>
<tr>
<td>Agriculture</td>
<td>-0.003</td>
<td>0.005</td>
<td>0.062***</td>
</tr>
<tr>
<td></td>
<td>(0.0001)</td>
<td></td>
<td>(0.006)</td>
</tr>
<tr>
<td>× Capital-labor ratio</td>
<td>0.062***</td>
<td>-0.067***</td>
<td></td>
</tr>
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<td></td>
<td>(0.0005)</td>
<td></td>
<td>(0.001)</td>
</tr>
<tr>
<td>Education</td>
<td>-0.38***</td>
<td>-2.23</td>
<td>1.557***</td>
</tr>
<tr>
<td></td>
<td>(0.058)</td>
<td></td>
<td>(0.253)</td>
</tr>
<tr>
<td>× Capital-labor ratio</td>
<td>-0.007</td>
<td>0.005</td>
<td>-0.883***</td>
</tr>
<tr>
<td></td>
<td>(0.0005)</td>
<td></td>
<td>(0.161)</td>
</tr>
<tr>
<td>Infant mortality rate</td>
<td>0.005</td>
<td>0.005</td>
<td>27.36</td>
</tr>
<tr>
<td></td>
<td>(0.005)</td>
<td></td>
<td>0.79</td>
</tr>
<tr>
<td>Mortality rate below 5 years of age</td>
<td>0.005</td>
<td>0.005</td>
<td>27.36</td>
</tr>
<tr>
<td></td>
<td>(0.005)</td>
<td></td>
<td>0.79</td>
</tr>
<tr>
<td>R²</td>
<td>0.91</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First stage F-test</td>
<td>28.26</td>
<td>0.79</td>
<td></td>
</tr>
</tbody>
</table>

**Davidson-Mackinnon Test of Exogeneity**

| p-value   | <0.01 | <0.01 | <0.01 | <0.01| <0.01| <0.01| <0.01| <0.01| <0.01| <0.01| <0.01|

**Over identification test**

| Sargan-Hansen test, chi-sq(1) | 0.55 | 0.59 | 0.66 | 0.38 | 0.13 | 1.19 | 2.29 | 2.92 | 1.9 | 6.53 | 0.73 |
| p-value | 0.45 | 0.44 | 0.42 | 0.53 | 0.71 | 0.27 | 0.13 | 0.09 | 0.17 | 0.03 | 0.39 |

**IV Redundancy Test**

| Lagged birth rate | 55.08 | 0.00 |
| Infant mortality rate | 28.47 | 0.00 |
| Mortality rate below 5 years of age | 31.18 | 0.00 |

**Under identification test**

| Chi-sq(2) | 27.81 | 0.00 |
| p-value   | 0.00  |      |

**Weak identification test**

| Cragg-Donald Wald Statistic | 10.1 |

**Notes:**

- All regressions are based on the sample of 326 observations and include country and time-period fixed effects.
- Coefficient of squared capital labor ratio is multiplied by 1000 to make results presentable.
- Robust standard errors in parentheses. * Significant at 10%, ** significant at 5 %, *** significant at 1 %.
The explanation is that these countries not only provide more childcare facilities but also provide more financial support to families with young children, among which are paid parental leave and childcare subsidies (Jaumotte, 2003). First, paid parental leaves help mothers of young children reconcile work and family life, and may strengthen labor market attainment through a job guarantee. Second, childcare subsidies reduce the relative price of childcare, thereby increasing the return of market work relative to home production (in addition to increasing effective income). Figure 3.4 shows the turning points for different age groups based on the estimation results reported in Table 3.1. An inverse U-shaped relationship is apparent between these turning points and the age of women. The turning points for females in the prime age groups are greater than those for the younger and older age groups. This implies that teenagers and elderly women are the first who will enter the labor market as a result of fertility decline when income levels rise, even though the impact of fertility decline is weaker for these age groups (see below). The second group will be women in the younger age groups 20-24 and 25-29 and, finally, women in the age groups 30-34, 35-39 and 40-44.

If the endogeneity of the fertility is not accounted for, the coefficients of the fertility variable remain negative and significant, but they decrease substantially in magnitude. Furthermore, for five age groups (20-24, 25-29, 30-34, 35-39 and 40-44) the sign of the interaction variable changes sign. Consequently, fertility would always have a positive effect on the female participation rate in these apparently younger age groups, which is rather implausible and clearly not in line with previous studies. These findings corroborate the hypothesis that fertility should be treated as an endogenous explanatory variable.

On the basis of our regression results we can also compute the demographic transition effect, that is, the increase in female labor force participation due to the change from high to low rates of fertility when an economy develops. Table 3.2A in appendix shows that the fertility rate declines from 6.03 births per woman in low-income economies to 2.14 in high-income economies. Taking into account that the positive effect of fertility decline diminishes the higher the capital-labor ratio, we find that the total female labor force participation rate will rise by about 19% as a result of such a decline in
fertility when using the estimation results for the total female labor force (last column of Table 3.1). Figure 3.5 graphs the results that are obtained when using the estimation results for the different age groups. This figure shows that the impact of fertility decline for the prime age groups is stronger than for teenagers and elderly women. If these impacts are weighted with the share of each age group in the total female population of working age, the total effect becomes 22%. Bloom et al. (2009) found 11%, but they pointed out that this percentage may underestimate the total effect since they only considered female labor supply of those females aged below 45 (according to our estimation result these age groups explain approximately five percentage points of the total increase). Furthermore, they estimate a linear instead of a quadratic functional form as in this study\textsuperscript{12} and therefore cannot account for regime switch effects. For emerging economies like India and Pakistan our model predicts an increase in the female labor force participation rate by about 10 and 20 percentage points over the period 2010-2050, respectively, based on the decline in fertility over that period projected by the United Nations (2006).\textsuperscript{13}

The share of employment in agriculture has a positive effect on the female participation rate of every group, while the interaction effect between the share of employment in agriculture and the capital-labor ratio has a negative effect. The former effect is significant for five age groups and the latter effect for all age groups. The positive sign of the agricultural variable itself can be explained by the fact that women can combine farm work with family responsibilities in low-income and developing economies. The explanation for the negative sign of the interaction term is twofold. First, a rising capital-labor ratio represents a structural shift from employment in agriculture to industry and services.

\textsuperscript{12} Although they do take into account the fact that capital increases in line with the rise in labor supply.

\textsuperscript{13} According to the medium variant, total fertility will decline from 2.76 in 2010 to 1.85 in India and from 4.00 to 2.16 in Pakistan.
Figure 3.3: Marginal effects, confidence intervals and turning points
Figure 3.4: Marginal effects and turning points for different age groups
Consequently, the agricultural sector can employ fewer females. Furthermore, they cannot immediately move to other sectors due to lack of skills and knowledge. Second, when an economy develops, mechanization of farm activities increases labor productivity, as a result of which fewer people are needed in the agricultural sector. In this respect, Boserup (1970, 1990) argued that industrialization marginalized women in the sense of hindering their participation in wage work. In sum, our results corroborate the hypothesis that agricultural employment has a positive effect in lower-income countries and a negative effect in higher-income countries. The turning point for the total female working age population, as illustrated in Panel 2 of Figure 3.3, amounts to $9,210. In addition to this, Panel 2 of Figure 3.4 shows that there are hardly any differences with respect to different age groups. The turning point ranges from $11,170 for females aged 15-19 to $7,830 for females aged 60-64 years. These results reflect the actual situation prevailing in the world. In countries located in Africa and South Asia, the capital-labor ratio is lower than the level at which the marginal effect of the share of employment in agriculture changes sign; these are two regions of the world that also happen to have the highest rate of females employed in the agricultural sector, namely 69 percent and 61 percent in 2007, respectively. Schultz (1990) found that changes in the sectoral composition of the labor force traced out the U-shaped relationship between female labor force participation rate and economic development. Our results confirm this finding.

Education has a negative and significant effect on the female participation rate of every age group, while the interaction effect between education and the capital-labor ratio has a positive and significant effect. These coefficient estimates indicate that education does not have a positive effect on women’s labor force participation in lower-income countries, but only in higher-income countries. The turning point for the total female working age population, as illustrated in Panel 3 of Figure 3.3, amounts to $53,215. In other words, education only has a positive effect for countries located in Europe, North America and Oceania. A similar result was found by Smith and Ward (1985) for the US in 1900 and by Kottis (1990) for Greece over the period 1971-1981 in that the impact of education depended on a country’s stage of development. The explanation is that most women in low-income countries are unpaid workers on family farms and that more schooling does not help to improve their position on the labor market under these
circumstances. Furthermore, women may be barred from manufacturing employment by social custom or employer preference as soon as the economy starts to develop. The results are also in line with the OECD (1994, p.127), which has pointed out that there is little evidence to support an across-the-board increase in educational attainment in developed countries, because there seems to be a dividing line at upper secondary education below which labor market opportunities are worse than above it. Empirical evidence in favor of this proposition was also found by Elhorst and Zeilstra (2007). On the other hand, Panel 3 of Figure 3.4 shows that females in the lowest age groups (15-19 and 20-24) are the first who will benefit from more education when the economy develops. For these age groups we find turning points of $39,430 and $45,361, respectively, which is below the value of $53,215 found for the total female working age population.

**Figure 3.5: The impact of fertility decline on female labor force participation for different age groups**

Since every regression equation of a particular age groups contains five explanatory variables that depend on the capital-labor ratio (note that in most equations three of these variables appear to be significant), it is difficult to draw any conclusion as to whether the capital-labor ratio affects the female participation rate positively or negatively. Therefore, we have calculated the marginal effect of the capital-labor ratio
using (13). Panel 4 of Figure 3.3 graphs this relationship for the total female working age population. It shows that the capital-labor ratio has a negative effect on the female labor force participation rate in countries with capital-labor ratio’s below $86,445 and a positive effect above it. The explanation for this is that improvements in men’s wages due to an expansion of the manufacturing sector in developing countries without corresponding improvements in women’s wages exert (unearned) income effects that reduce women’s participation. Only when the value of women’s time considerably increases, do women move back into the labor force.

3.5 Conclusions

A few studies have argued that women’s participation in the labor force first declines and then rises with economic development, but they were unable to model this relationship empirically. Since such a U-shaped relationship cannot be covered by a linear regression model, we adopted a quadratic functional form with interaction effects between the capital-labor ratio (as indicator of the income level in a particular country) and three variables that are seen as the key explanatory variables of the female labor force participation rate across the process of economic development, namely, fertility, the share of employment in agriculture and the level of education. In addition, the square of the capital-labor ratio was considered. Previous studies by Pampel and Tanaka (1986), Tansel (2002) and Fatima and Sultana (2009) already considered the square of the level of income per worker. However, since the coefficients of the other interaction terms have been found in this paper to be significant too, we must conclude that only one interaction term is not sufficient to model the posited U-shaped relationship. Since female labor force participation may have a negative feedback effect on the fertility rate, we also tested for exogeneity of the fertility rate. Since this hypothesis had to be rejected, instrumental variables were then used to obtain consistent parameter estimates. After a severe selection procedure, three valid instrumental variables were found, namely, the birth rate five years lagged in time, the infant mortality rate (up to one year of age) and the mortality rate under five years of age.

We also investigated the extent to which the labor force behavior of females in different age groups may be lumped together for the purpose of a common treatment.
Previous studies by Pampel and Tanaka (1996), Tansel (2002), Jaumotte (2003), Elhorst and Zeilstra (2007) and Fatima and Sultana (2009) have ignored population distribution effects, relying instead on the representative-agent paradigm. In order for representative-agent models to accurately describe aggregate behavior, all marginal reactions of individuals to changes in aggregate variables must be identical. We have found strong empirical evidence against this condition being applied to females across different age groups.

For every age group and for every explanatory variable in the model we found a particular point where the regime of falling participation rates changes into a regime of rising participation rates. Fertility has a negative effect in countries if the capital-labor ratio is below $69,410 and a positive effect above it. The same applies to the level of women’s education and the capital-labor itself, although the turning points are different, $53,215 and $86,445, respectively. Conversely, the share of employment in agriculture has a positive effect in countries if the capital-labor ratio is below $9,210 and a positive effect above it. Each of these findings corroborates the hypothesis that the relationship between female labor force participation rates and per capita income around the world is U-shaped.

Since women’s labor force status relative to that of men is an important benchmark of their status in society, their integration into the economy is a desirable goal for both equity and efficiency considerations. The existence of a U-shaped relationship between female labor force participation rates and per capita income around the world shows that it is possible to narrow the gap between men and women. The more an economy develops, (1) the lower will be the fertility rate which can free up time from childcare and the more childcare facilities will become available; (2) the more the industry mix will shift into the direction of employment in services which is experienced as a more acceptable form of employment for women, and which, since this kind of work can often be done part-time, permits women to combine work outside the household with their domestic activities; (3) the better women will be educated, as a result of which the value of women’s time in the market will increase, which strengthens the incentives of women to work away from home; and (4) the higher the female wage rate will be, as a result of which the probability will be less that the unearned income effect (the income of
a woman independent of hours worked, i.e., the income of her husband) will have the effect that a woman will quit working altogether. Concurrently, it should be pointed out that, just because the relationship between female labor force participation rates and per capita income is U-shaped, low-income countries will first have to go through a trough and even then they will have a long way to go before the gap eventually disappears.