FERTILITY AND THE LABOR SUPPLY OF WOMEN

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FOREWORD

In highly industrialized countries population growth is strongly associated with swings in fertility, which create imbalances in the age composition of the population and increase tensions in educational and social security systems. The analysis of fertility behavior, therefore, is an integral element in the planning of such programs.

It has been recognized that fertility behavior depends on the labor supply of women and that the two should be analyzed simultaneously. Increased female labor force participation, especially of married women, has been accompanied by a reduction in fertility to below replacement levels in almost all IIASA countries. Since the decision to join the labor force is likely to be a long-term commitment, fundamental changes in life styles, demand for family care, labor mobility, and family structure may evolve.

Data on fertility and labor force participation for several IIASA countries are analyzed in this paper. Despite cultural and economic differences, certain common trends can be observed, indicating that fertility and labor supply might be governed by similar factors. In the second part of this paper theoretical models aimed at explaining these developments are discussed. Finally, an econometric procedure is employed to test one of these theories.

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ABSTRACT

The relation between fertility and female labor supply has been extensively studied, theoretically as well as empirically, in the literature. But until now no consensus has emerged from these investigations. In this analysis the problem is addressed in an international context.

After a brief introduction which underlines the importance of this question in a macroeconomic framework, data on fertility and labor force participation are discussed for the IIASA countries. For the Western countries increasing consonance both in the trend as well as in the cycles can be observed for the fertility and labor supply behavior. The development of the corresponding data series for the Eastern countries are more heterogenous. This can be interpreted, at least in the Western countries, as fertility and female labor supply being governed by identical factors. Since business cycles have shown an increasing consonance in the 1970s for the Western countries, it could be argued that the women's wage rate is the driving force behind fertility and labor supply development.

CONTENTS

FERTILITY AND THE LABOR SUPPLY OF WOMEN

1. INTRODUCTION

It has long been observed that fertility and the labor supply of women are strongly correlated. But there is still no definite conclusion on how this relationship might be interpreted. Is the fertility behavior a consequence of the labor supply decision, is the labor supply behavior a consequence of the fertility decision, or are both caused by a third factor? Before turning to these questions, the consequences of changes in the development of labor supply and fertility are analyzed within a macroeconomic framework.

In particular the connection to problems of social security and to changing lifestyles will be mentioned. The next two sections are devoted to the description of the development of fertility and the labor force participation of women in IIASA countries. The international perspective has the advantage that through the analysis of different societies with different institutional settings it might be possible to detect which variables are important to explain the correlation of fertility and the labor supply of women. Section 5 will then confront the results of this comparison with theoretical models aimed to explain the relationship. Finally, in the

last section, an econometric test based on the concept of "Granger causality" will be applied to US data. The results will only partly be in line with the theory presented in section 5. Although data from 1947 until 1979 are used, the degrees of freedom are still not very high, so that an extension of this approach to other countries is useful in order to get more reliable results.

2. A NATION-WIDE PERSPECTIVE

In neoclassical growth models the exogenously given growth rate of population and technical progress determines the growth rate of output (Solow 1956).* It can be demonstrated that, if only non-negative growth rates of population are considered, output per head is maximized, independently of population size when the growth rate of population is zero. In this case, per capita output grows with the rate of technical progress.

There is little knowledge about the impacts of population growth on technical progress embodied in new physical capital, on the investment in human capital, on labor force participation, and on labor productivity. It seems therefore that the "neutrality" of technical progress is uncertain. The effect on economic well-being drawn before cannot be taken for granted, since it rests on the assumption of a neutral technical progress.

The transition to a lower growth rate of population makes the analysis of the impact on economic well-being even more complicated, since during this period structural adjustments in the age composition of the labor force and the population will take place. Let us consider a decline in fertility. This will free a large number of women from activities related to child rearing and create the possibility for them to enter the

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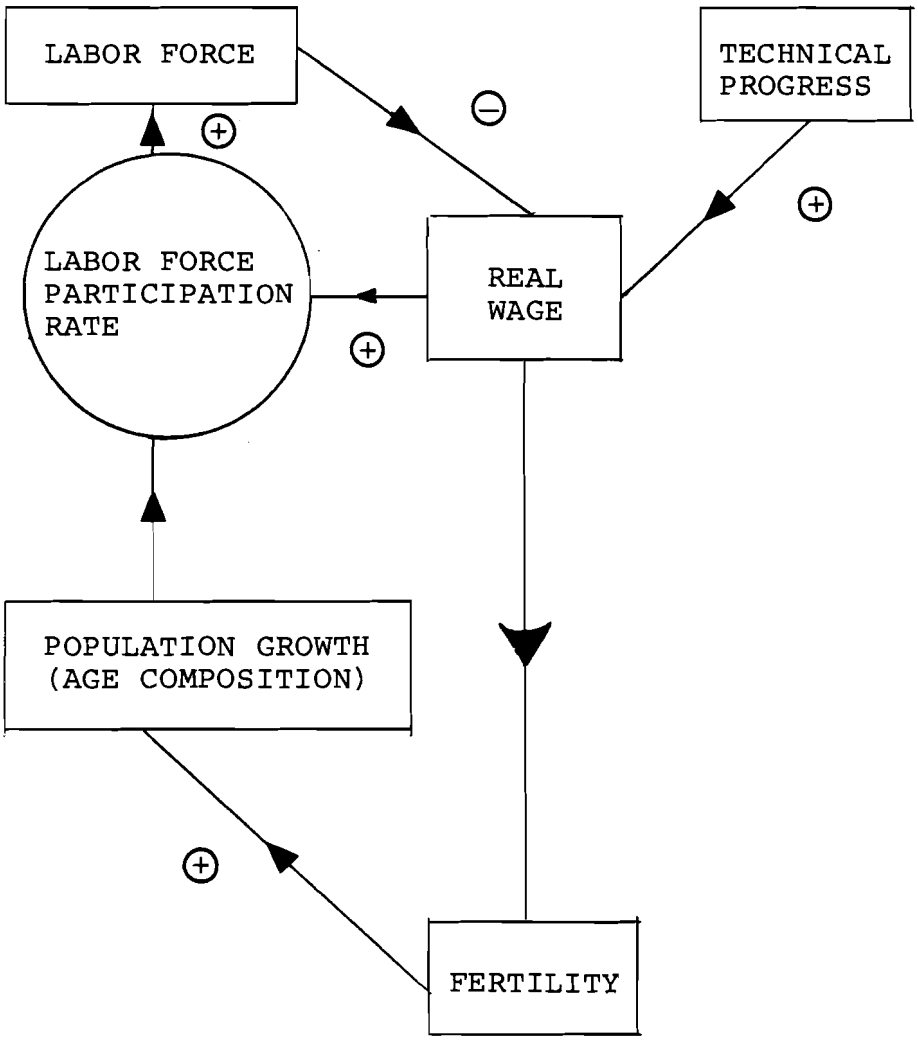
*In Keynesian-type models the "natural" growth rate, which is determined also by the growth rate of population and technical progress, sets an upper limit for the "warranted" rate of growth, which in equilibrium equals the actual rate of growth (Harrod 1939).

labor force. As is shown in different empirical studies, this change in the participation decision is likely to be a long-term commitment and not easily reversible. This means that once a woman has entered the labor force, she is likely to persist in this status (see Clark and Summers 1982:826; Heckman and Willis 1977). This persistence effect can be rationalized on several grounds. There may be high transaction costs. Or, women who are employed longer accumulate more human capital which raises their return on work in the future relative to leisure and children. Labor supply and fertility are not easily substitutable over time, because children represent a long-term commitment and since the possibility of having children is restricted by age.

A slowdown in population growth will also bring about an aging of the population. Since in most social security programs today's beneficiaries are financed by today's workers, such an imbalance in the age structure of the population poses great difficulties for these programs. Another possible consequence of such a development is the reduction of labor mobility—geographically as well as occupationally.

Up to this stage the growth rate of the population has been kept exogenous. However, it is now recognized that fertility does respond to economic well-being (Becker 1981; Easterlin 1978; Schultz 1981). This means that in a complete model, fertility should be treated endogenously. Since in industrialized countries population growth is at least primarily governed by fertility behavior, population growth must be determined endogeously. Furthermore the decision to enter the labor force is primarily based on economic considerations. This implies that the ratio of labor force to population is no longer constant and that the terms "labor force" and "population" cannot be used interchangeably—as is done in the simple growth models.

The interrelations of labor supply, fertility, and economic well-being, here represented by the real wage, are summarized in Figure 1. It is assumed that fertility is the main determinant of a population's growth and age composition. Taking the



Key

⊕ : Positive effect hypothesized
⊖ : Negative effect hypothesized

Figure 1. Schematic representation of the links between fertility and labor supply to economic well-being measured by the real wage.

labor force participation rate as given, a rise in fertility is followed by an increase in the labor force, thereby reducing the real wage. Assuming that a higher labor supply will induce real wages to fall, the labor force participation will also be reduced. In this diagram the impact of the real wage on fertility is ambiguous. In a Malthusian framework this relationship is hypothesized to be positive (see Schultz 1981:31). On the other hand it can be argued that a raise in women's real wage rate will increase the opportunity costs for not working and for having children, and therefore fertility will be reduced.

3. FERTILITY BEHAVIOR

Having analyzed labor supply and fertility decisions in a broader context, I will now turn to the description of actual developments of fertility in the 17 IIASA countries. The net reproduction rate (NRR)* serves as a measure of fertility. The choice of this measure was not motivated by theoretical considerations but rather by the availability of comparable data. An alternative would have been to take the total period fertility ration (TPFR) or the completed fertility (CF) as was done in the survey "Recent Course of Fertility in Western Europe" by G. Calot and C. Blayo (1982). A comparison of the NRR and TPFR for the countries where both measures were available shows that the selection of the NRR is not critical for the interpretations given in this paper.

The range of the maximum and minimum NRRs among the 11 Western** and the 6 Eastern† IIASA countries is shown in Figures 2 and 3, respectively. The striking feature about

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*The NRR indicates to what extent a generation of mothers is replaced by daughters. It is calculated under the assumption that the actual fertility and mortality conditions will prevail in the future. A value of one indicates complete replacement.

**A similar figure of the range of the TPFR among 11 West European countries can be found in Calot and Blayo (1982:354).

†Because of data availability the analysis for the Eastern countries started only in 1960.

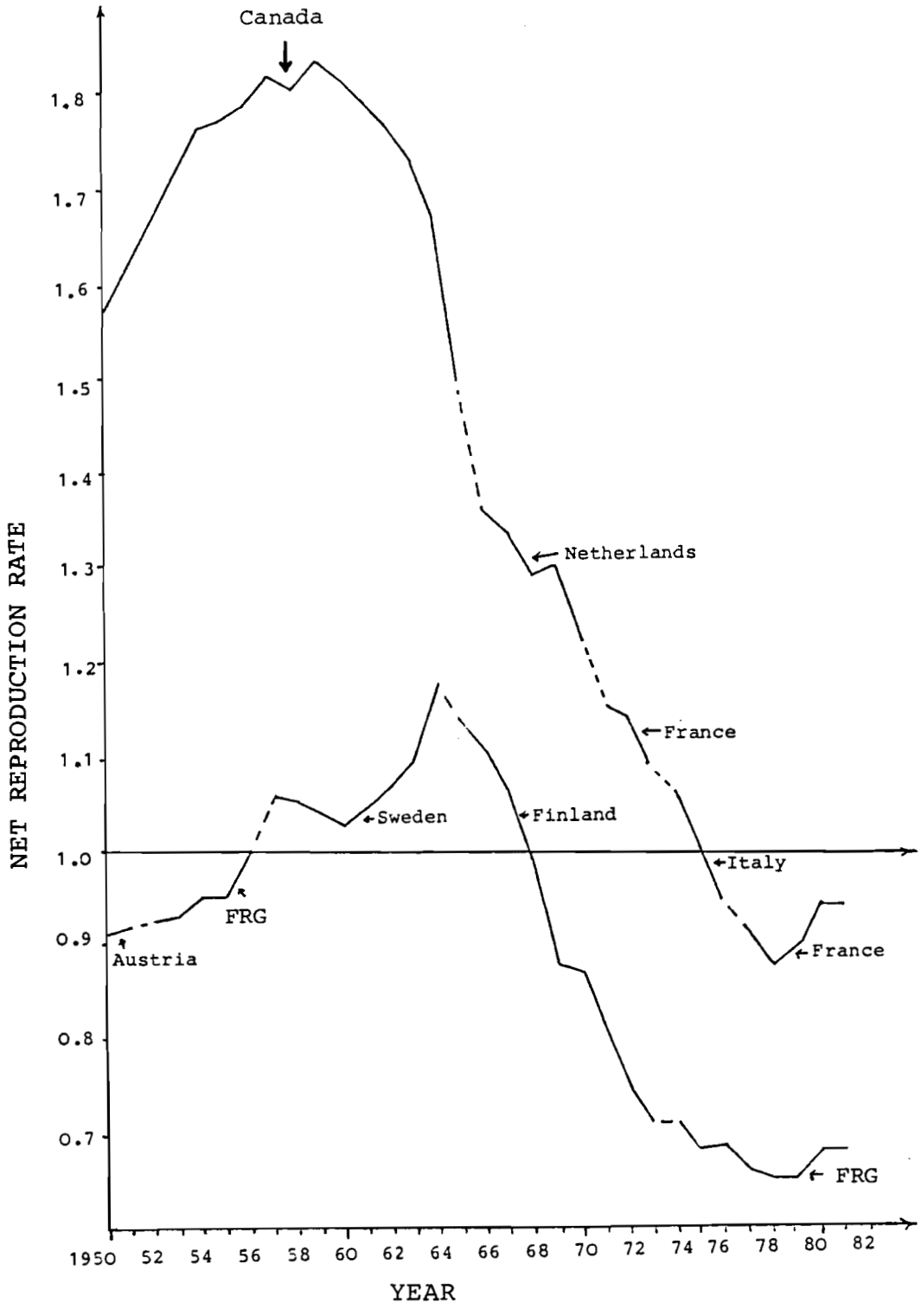


Figure 2. Range of the maximum and minimum NRRs among the 11 Western IIASA countries.

Source: Demographic Yearbook (Historical Supplement 1979 and other selected years).

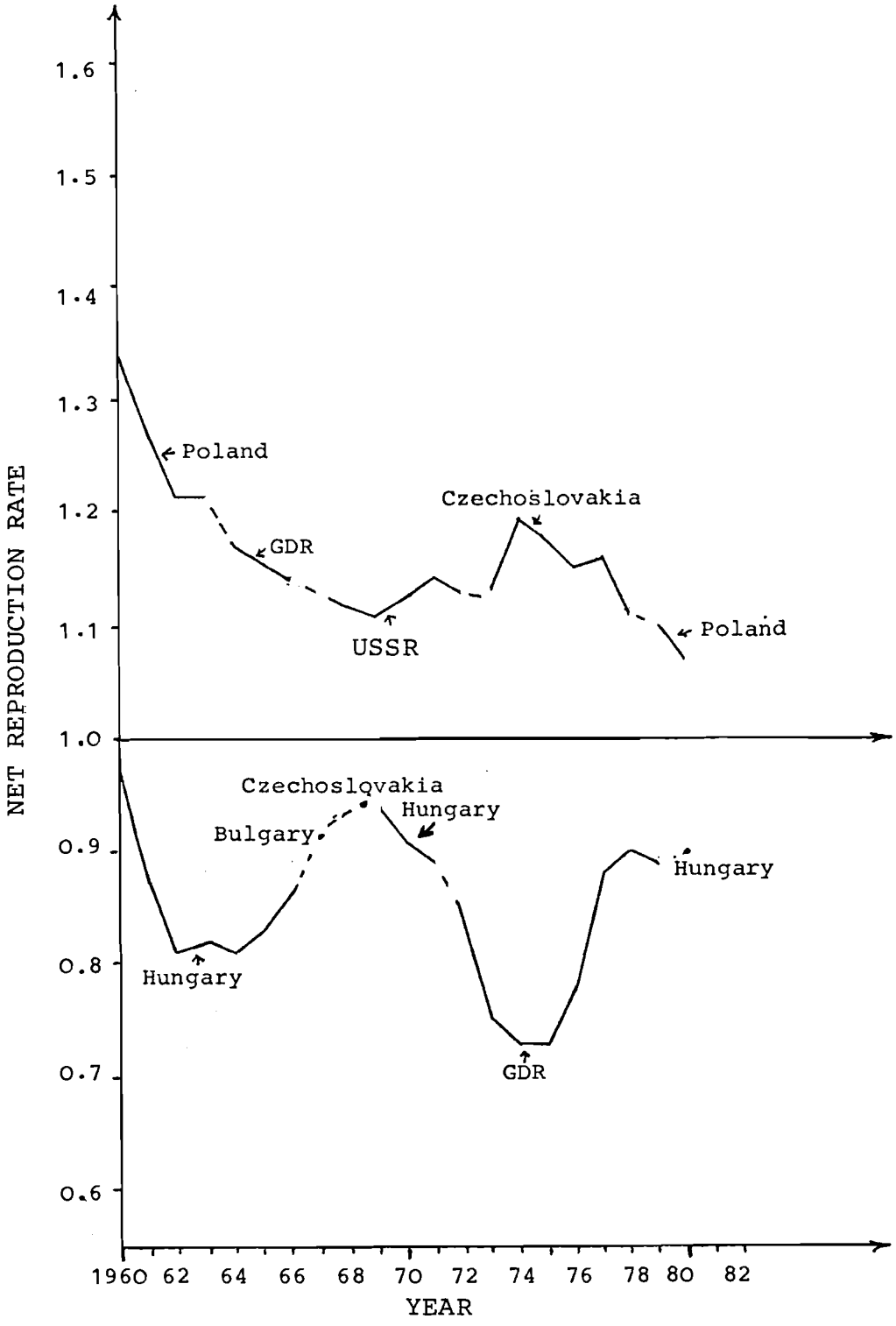


Figure 3. Range of the maximum and minimum NRRs among the 6 Eastern IIASA countries.

Source: Demographic Yearbook (Historical Supplement 1979, and other selected years).

Figure 2 is the increasing similarity in fertility behavior among the Western countries. Whereas the spread of the NRR was about .8 in the 1950s, it narrowed considerably to about .2 in the 1980s. This narrowing of the range was accompanied also by an increasing consonance of the cycles. Whereas the American countries reached their peak in the late 1950s, the European countries had their peak 5 years later. But beginning in the mid-1960s all countries experienced a decline in fertility until the late 1970s where fertility started for most countries to increase again. All this suggests that the fertility pattern in the Western IIASA countries is governed by identical factors.

The figure for the Eastern IIASA countries does not show the similarity present in the Western countries. Instead large cyclical fluctuations dominate. The GDR, for example, reached its peak in 1964 and its trough only 11 years later. At nearly the same time, from 1968 to 1974, Czechoslovakia moved from its trough to its peak. Excluding the mid-1970s it is possible to perceive a downward trend also for the Eastern IIASA countries during the last two decades.

4. LABOR SUPPLY

Assuming that the labor market is always in equilibrium, that is labor supplied equals labor demand, the employment ratio (proportion of the population who are employed) can be taken as a measure of labor supply. But, since there are good reasons to believe that this is not always the case, a measure of labor supply should not only include people actually employed but also those who are not able to find employment at the prevailing wage. Therefore a more appropriate labor supply measure is provided by the labor force participation rate (LFPR). It is defined as the proportion of the population looking for work or working.* Since the scope of this study lies in the relation between

*For a more detailed discussion of these issues see Clark and Summers (1982:833).

fertility and female labor supply, it seems reasonable to concentrate on those age groups which mainly bear the responsibility of reproduction. This means that we analyze the LFPR of women ages 20-30 years. In contrast to demographic statistics it is difficult to construct comparable time series on LFPR. The subsequent discussion relates therefore only to a few countries.

As will be made clear in the following discussion, it is reasonable to disaggregate the LFPR into the age groups of 20-24 years and 25-30 years. Figures 4 and 5 show the development of the LFPR for four selected Western IIASA countries. The most striking feature is the difference between the United States and the other countries. The LFPR for women aged 20-24 increased in the last 20 years from about 45 percent to nearly 70 percent. The corresponding numbers for the age group 25-34 are 35 and 65 percent. This dramatic increase began just after the peak in the NRR had been reached. In the 1950s the LFPR fluctuated around 45 and 35 percent.

In the other countries, especially in the FRG, a downward trend in the LFPR took place during the phase of high fertility rates—the years from 1960 to 1969. In the following decade, a reversal of the trend can be observed. Although the pattern of the LFPR of the two age groups is similar—decreasing in the 1960s, increasing in the 1970s—the slope of the trend is different. In particular the decrease in the LFPR during the 1960s is much more pronounced for the younger age group; whereas the increase in the 1970s is much higher for the older age group. This can be attributed to the increased investment in higher education, which not only has the effect of reducing the LFPR for women aged 20-24, but also induces a higher LFPR in the future in order to get the return on the investment in human capital. This is illustrated by the development of the female enrollment ratio for third level education (see Table 1).

This tendency is reinforced by the reduction in the number of children, which increases the time between the completion of fertility and the age of retirement and makes it therefore profitable to invest more in human capital and to join the labor

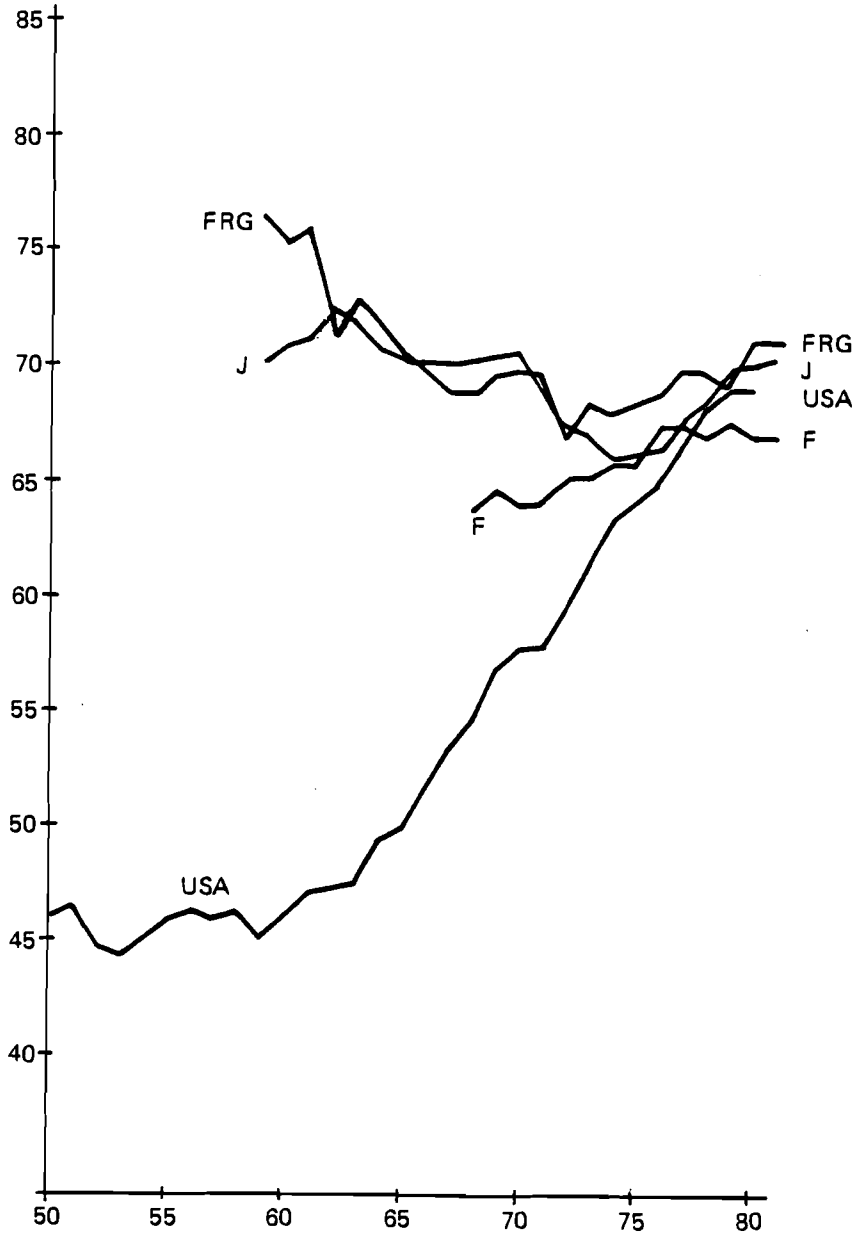


Figure 4. LFPR for women aged 20-24.

Source: Handbook of Labor Statistics; Wirtschaft und Statistik; Annuaire Statistique de la France; Japan Statistical Yearbook.

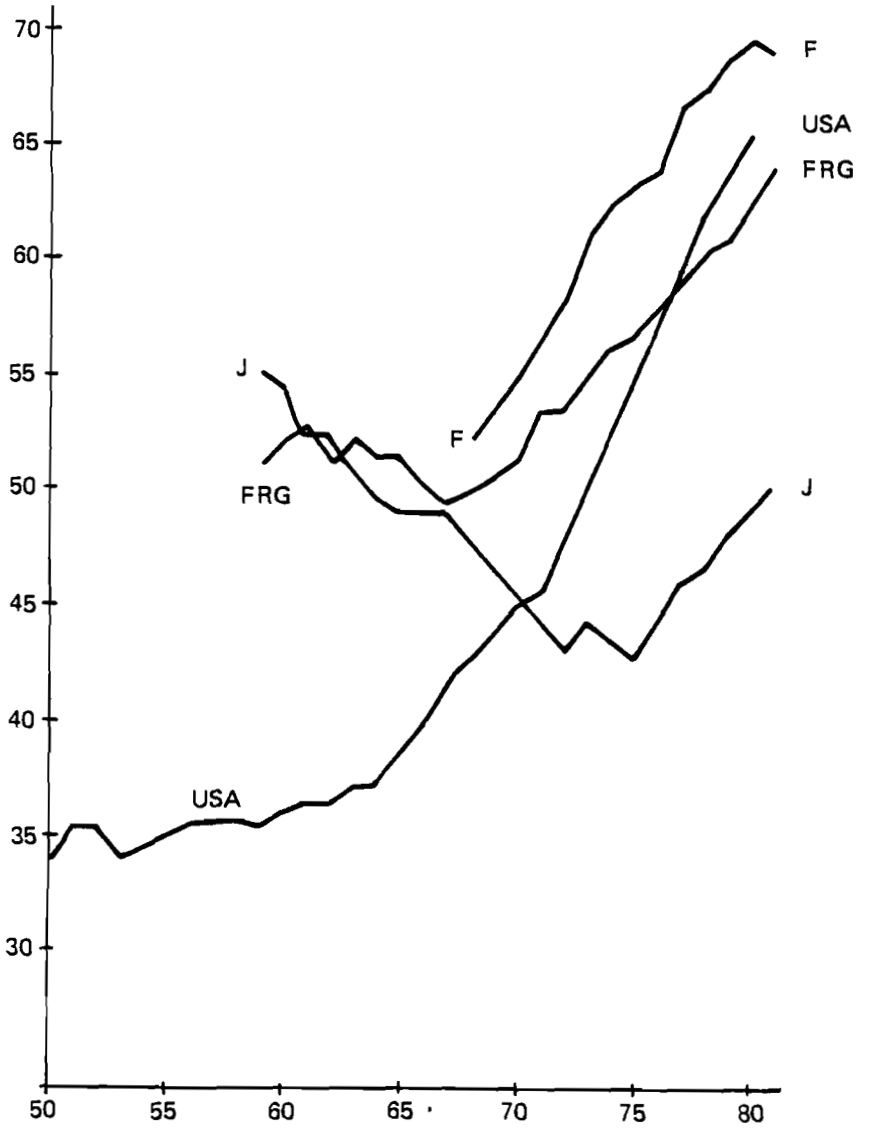


Figure 5. LFPR for women aged 25-29.

Source: Handbook of Labor Statistics; Wirtschaft und Statistik; Annuaire Statistique de la France; Japan Statistical Yearbook.

force for a longer time span. The development of these arguments on a theoretical level can be found in Weiss and Gronau (1981).

Since the women from the United States have reached the level of the European LFPR only in the mid-1970s, it is difficult to foresee if the future development will coincide as has been the case for the NRR. Nevertheless, it seems likely that the LFPR in different countries will show an increasing consonance, implying that they are governed by identical factors. Since in the 1970s business cycles in the Western countries moved more closely together, real wage rates should also have had this tendency. Admitting that wage rates are important factors in explaining fertility and labor supply, it is possible to explain the increasing consonance.

Table 1. Female enrollment ratio for third-level equation in the FRG.

1960	1965	1970	1975	1979
2.9	4.3	7.4	19.0	22.1

SOURCE: Statistical yearbooks of UNESCO (selected years).

Another interesting disaggregation of women's LFPR is by marital status. The corresponding figures for USA, FRG, and Austria are listed in Table 2. From there it is clear that the decline of the LFPR for women aged 20-24 during the 1960s in the FRG is due to the decline of LFPR of single women, which declined from 91.4(!) percent in 1960 to around 75 percent in 1975 and remained at that level from then on. In the meantime rising LFPRs for married women are observed. A similar pattern can be found for Austria. Since the decline of LFPRs for single women was only moderate in the United States, the strong increase for married women has dominated and has been responsible for the sharp rise in the LFPR over the last 20 years.

Table 2. Labor force participation rates for women aged 20-25.

Country	Year 1960	1965	1970	1975	1980
USA					
total	46.2	50.0	57.8	64.1	69.0
married	31.7	37.1	47.9	57.0	61.4
single	77.2	72.9	73.0	72.5	75.2
FRG					
total	75.3	70.4	69.4	68.4	71.1
married	50.4	51.7	55.2	62.1	63.3
single	91.4	86.5	84.2	75.3	76.9
AUSTRIA					
total	75.2[a]		68.7[b]	68.3	70.3[c]
married	54.1[a]		54.7[b]	53.2	58.6[c]
not married	90.0[a]		84.3[b]	77.1	75.5[c]

[a] value for 1961
[b] value for 1971
[c] value for 1981. Data derived form Mikrozensus 1981.

SOURCES: Handbook of Labor Statistics, Wirtschaft und Statistik [Economy and Statistics]; Österreichische Statistische Zentralamt [Austrian Statistical Bureau].

The development of the LFPR for women aged 20-24 and 25-44 in the six Eastern IIASA countries is shown in Figures 6 and 7. Although the pattern in the different countries is quite heterogeneous, a positive trend—with the exception of Bulgaria—can be observed. The largest increases take place in Hungary and Czechoslovakia. The USSR and Poland also show sizable increases. After 1975 only observations for the CSSR, Poland, and Hungary were available. Whereas in Czechoslovakia the LFPR continued to rise from 80.1 to 83.4 percent, the other two countries experienced a decline of 5.2 and 8.3 percentage points, respectively. In constrast to the Western countries no increasing consonance for this age group can be observed.

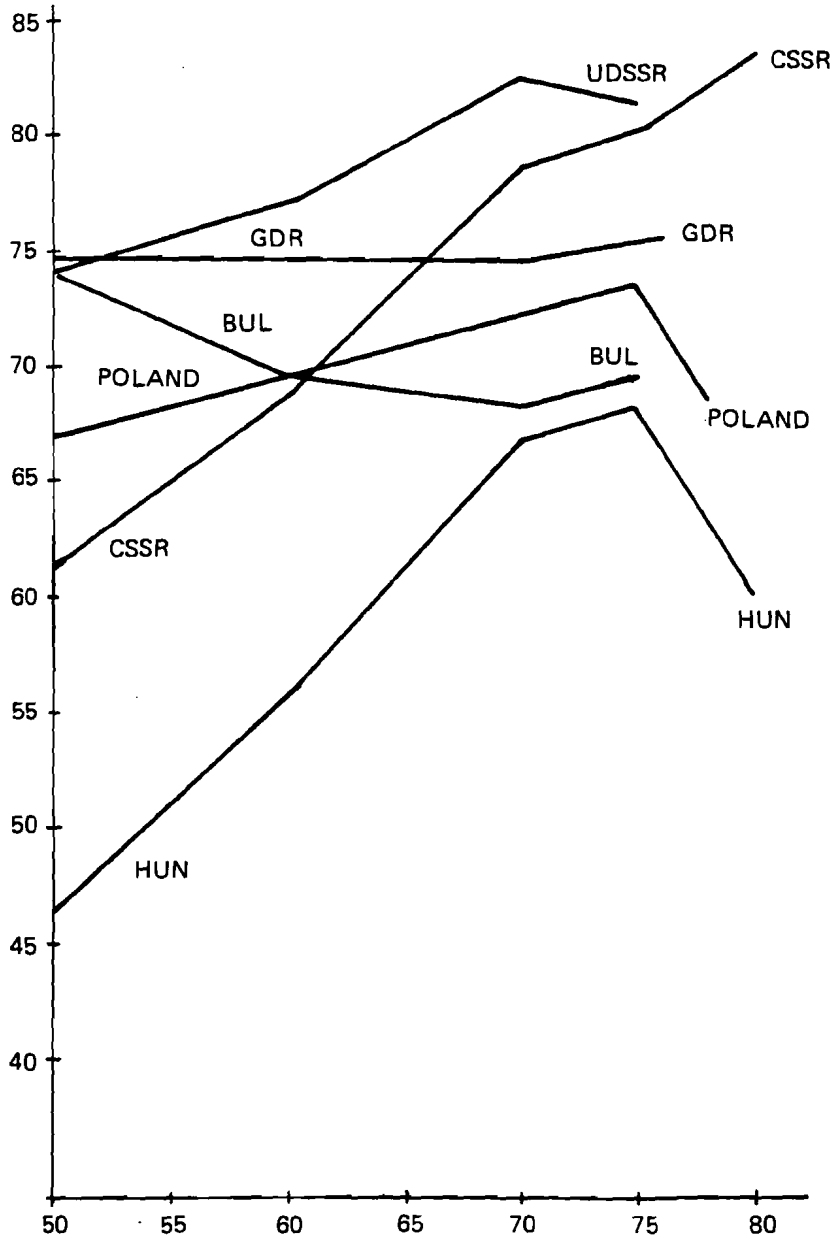


Figure 6. LFPR for women aged 20-24.

Source: ILO.

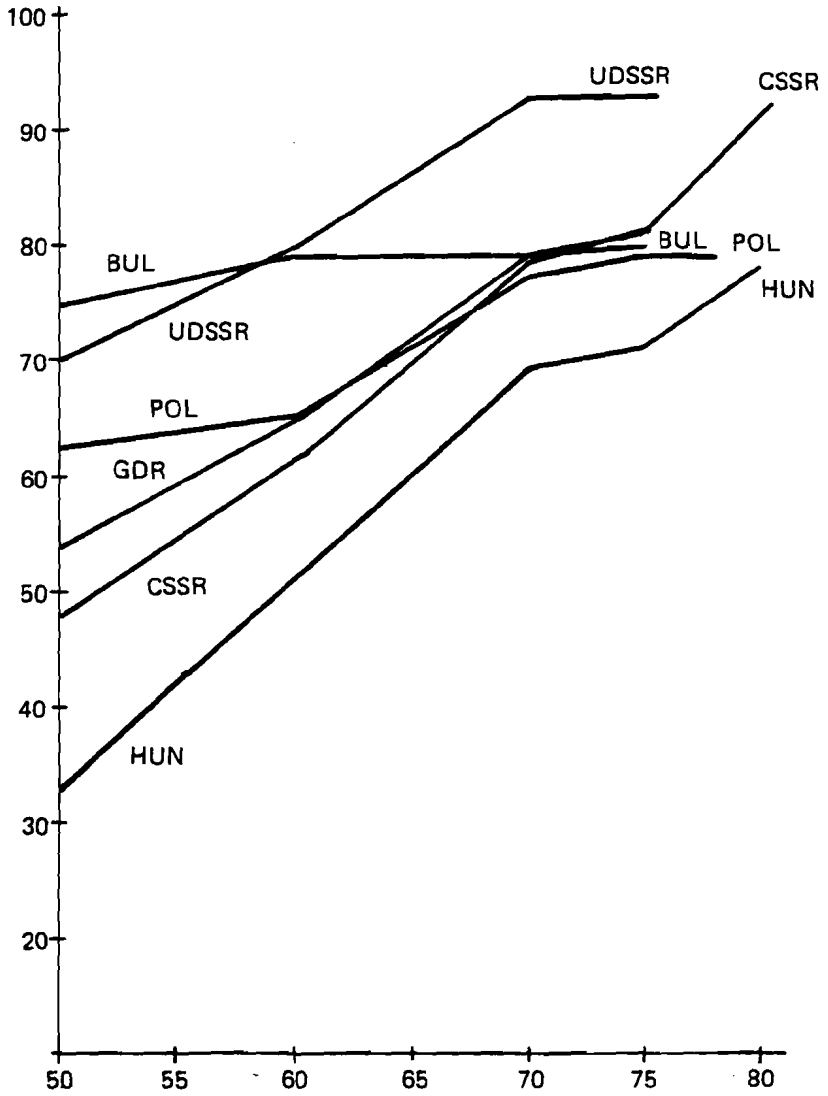


Figure 7. LFPR for women aged 25-44.

Source: ILO.

Looking at the older age group (see Figure 7) a different picture emerges. For all countries one can observe sharply increasing LFPR over the last three decades. This development was accompanied by a diminishing dispersion. Whereas the difference between the maximum and the minimum was 41.1 percentage points in 1950, it was only 22 percentage points 25 years later. As for the Western countries, it seems interesting to analyze the LFPR by marital status. Unfortunately, data were only available for Bulgaria and Hungary. The data for Bulgaria are puzzling because the LFPR is higher for married than for single women (see Table 3). The corresponding data for Hungary show the usual pattern.

Table 3. Labor force participation rates by marital status.

	Age group	
Country	20-24	25-44
Bulgaria (1975)		
total	73.3	93.0
married	83.3	93.1
single	62.6	82.2
not married[a]	64.4	88.2
Hungary (1970)		
total	66.2	68.6
married	58.7	66.8
single	84.3	81.9
not married[a]	83.5	85.3

[a]The not married category includes single, divorced, or widowed women.

SOURCE: Demographic Yearbook (1973, 1979).

5. THE INTERRELATIONSHIP BETWEEN FERTILITY AND LABOR SUPPLY

At a first glance a negative correlation between the NRR and the LFPR can be observed—especially for the Western countries. In the following, two well-known economic interpretations

of this phenomenon will be discussed. Let me first present Easterlin's view also known as the "relative income hypothesis" (Easterlin 1978). He assumes that the labor force consists of four different groups, the first two being young and old males. Young males generally have a low skill and experience level; they engage in a considerable amount of job search causing high job turnover; and their unemployment rates are usually high. The older males are experienced, skilled, and occupy the higher-level career jobs. They have a relatively low job turnover, and their unemployment rates are usually low. Easterlin assumes that the two groups are not substitutes for each other in production and that their labor force participation rates are generally high and insensitive to labor market conditions.

The remaining two labor-force groups consist of young and old women. The assumption here is that young and old women are close substitutes for each other in production. Since they typically hold "non-career" jobs, they are not substitutable for men. Furthermore men are considered as the primary "breadwinners", and their attachment to the labor force is permanent, whereas a woman's labor-force attachment is less permanent. Their primary responsibility is considered to be childbearing, child raising, and taking care of the home.

The "relative income hypothesis" is then stated by Easterlin (1978:403) as follows:

> ... marriage and childbearing vary directly with the income of younger relative to older men ... The reasoning is that the relative income of younger men may be taken as a rough index of the primary breadwinner's ability to support a young household's material aspirations. These aspirations are formed by the material environment that the spouses experienced as they grew up, which depends, in turn, largely on their parent's income. Hence, when young males' income is high relative to older males', it means that they may more easily support the aspirations that they and their potential spouses formed in their families origin. Young people will then feel freer to marry and have children.

By this mechanism, which is based on an "added worker effect" for young women, countercurrent cycles of fertility and labor force participation are generated.

Easterlin's hypothesis challenged that of Becker and his school—the "human capital" approach. This approach views households as utility maximizers, where market goods, leisure time, and "child services" enter the household's utility function. The analysis is then put forward in the usual way using the same framework as the derivation of consumer demand for durable goods [for the formal derivation see Willis (1973)]. As Sanderson (1976) has pointed out, the view rests on two assumptions: (1) the representative household behaves rationally on the basis of unchanging tastes, and (2) the prices of commodities desired by the representative household are unaffected by that household's consumptions decisions. Easterlin rejected the first postulate and replaced it by a mechanism through which tastes (aspirations) change systematically according to one's upbringing. In the course of the debate Becker abandoned assumption (2) and maintained that the relative prices of children and the relative price of goods consumed per child are not independent of households decisions. He reasoned that the family cares about its average level of expenditures per child, but not about its expenditures on each child separately. As parent's income increase they are assumed to spend more, both on themselves and on each of their children.

Both Easterlin and Becker schools assume that, when enough factors are left constant, the underlying relation between fertility and income is positive, but they proceed to show that when income changes, something else is likely to change that has an offsetting effect on fertility. The major source of these different offsetting forces is its nature not its existence. According to the Easterlin group the force that offsets the underlying positive income effect is related to parent's aspirations for *their own* standard of living. Over time, both current and aspiration income levels rise, leaving the net effect of these two forces unclear. According to the Becker

group, the offsetting force is related to parents' aspirations for *their children's* material standard of living. As parent's income rise, they want to increase their average expenditure per child, thus increasing the cost to them of an appropriately raised child. The increasing cost of children with higher standards of living, therefore, would offset the effect of higher income.

In recent years the differences between the Easterlin and Becker schools has narrowed considerably. Sanderson (1976:473) wrote:

> The two specifications differ not only in that, holding other things constant, the Becker group expects the desired level of expenditures per child to be positively related to parental income, while the Easterlin group expects desired bequests (and expenditures) per child to be independent of parental income.

By introducing the notion of "child quality" the Becker group moved close to Easterlin's position. "Child quality" depends on the level of expenditures per child and on a host of other influences over which the parents have little or no control. This extension allows the Becker school to analyze fertility also in an intergenerational context. To see how close the two positions may be, Sanderson (1976:473) quotes the following words of Becker:

> Our conclusions about the effect of economic growth on the number of children are similar to those reached by Richard Easterlin in his important work on fertility ... Both Easterlin's and our own analysis are based on changes in the economic position of children relative to their parents.

Therefore, according to the Becker theory, an increase in the real wage would raise LFPR and simultaneously reduce fertility, since the opportunity costs of childbearing have gone up. This theory would then predict a countercyclical behavior of fertility (see Butz and Ward 1979). Since during the 1960s, and up to the mid-1970s the economic performance for most

countries was satisfactory, more women joined the labor force and reduced their childbearing activities. At the end of the 1970s, the world fell into a recession from which no recovery has yet been attained. This economic development should have led to rising fertility rates. Such a phenomenon was indeed observed for most Western countries (see Figure 2).

One can also use Easterlin's arguments to account for the development of fertility rates. Starting in the 1970s, cohorts, which were born in the years of the baby boom, began to enter the labor markets. Because of their size they had difficulties in finding jobs* and therefore postponed marriage and childbearing. Beginning in the mid-1980s smaller cohorts will enter the labor force, which will bring again higher fertility rates. The increase in fertility rates, which is experienced in some countries, could be interpreted in this way.

For the Eastern countries the applications of these theories seems to be difficult, since they operate under a different economic environment. Nevertheless it seems worthwhile to test these hypotheses. But until now not enough information has been available to carry out this task.

As the cursory consideration showed, the development of fertility and labor supply seem to be in line with both theories -- Easterlin's and Becher's. To make a profound statement on the validity of the theories, sophisticated statistical methods have to be used. The next section will propose a test of the "New Home Economics" approach. First empirical results are only partly in line with this theory.

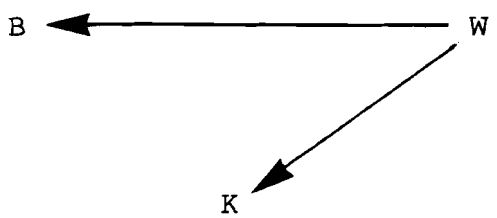
6. A SUGGESTION FOR TESTING THE "NEW HOME ECONOMICS" APPROACH

The proposed test is based on the notion of "causality" which was reintroduced by Granger (1969) into econometrics. A random variable X is said to cause a random variable Y, if the knowledge of past realization of X will help to linearly predict Y given past realizations of Y. The causality is said to be instantaneous if the current realization of X will help to predict Y (for a discussion of equivalent definitions and

*This is documented by the high unemployment rates for young people.

applications, see Sims (1972) and Pierce and Haugh (1977)). As Zellner (1979) has pointed out, the concept of causality has only a meaning within a given theoretical framework, since otherwise the investigator is not sure that the detection of a causal relationship between two variables is not just a reflection of a third variable causing the two other. The problem is very much like the spurious correlation problem in regression analysis. A second point worth mentioning is that the notion only applies to linear relationships. For this reason it seems appropriate in practice to use least-square estimators.

Although the problem of causal direction between fertility and female employment has been addressed many times in the literature (see, for example, Cramer (1980)), to my knowledge, the notion of causality in the sense of Granger has not yet been applied. As explained in the previous section, the approach taken by the Becker school asserts that the fertility and the participation decision is taken simultaneously given the wage rates determined exogenously in the labor market (see Schultz (1981: 99)). In the language of Granger this means that fertility and labor force participation do *not* cause each other but are *both* caused by wages. Denoting a causal relation with an arrow. The "new home economics" approach would suggest the following figure:



Setting up the following regressions

$$B_t = \sum_{j=1}^{m_1} a_{1j}B_{t-j} + \sum_{j=1}^{n_1} b_{1j}K_{t-j} + \sum_{j=1}^{r_1} c_{1j}W_{t-j} + d_1 + u_t$$

$$K_t = \sum_{j=1}^{m_2} a_{2j}K_{t-j} + \sum_{j=1}^{n_2} b_{2j}B_{t-j} + \sum_{j=1}^{r_2} c_{2j}W_{t-j} + d_2 + v_t$$

$$W_t = \sum_{j=1}^{m_3} a_{3j} W_{t-j} + \sum_{j=1}^{n_3} b_{3j} B_{t-j} + \sum_{j=1}^{r_3} c_{3j} K_{t-j} + d_3 + w_t$$

where

B = fertility rate

K = labor force participation rate

W = logarithm of women's real wage rate

u,v,w = normally distributed disturbance terms with mean zero

The hypothesis that employment does not cause fertility is rejected when, in the estimation of the first equation, the b_{1j} are statistically different from zero. A similar test for the hypothesis that fertility does not cause employment can be carried out by "looking" at the b_{2j} in the second equation. On the other hand, if in the third equation, the b_{3j} *and* the c_{3j} are statistically not different from zero, it can be inferred that wages are indeed exogenous to the system, as is asserted by the "new home economics".*

Since this test requires the estimation of many parameters —depending on the lag lengths $m_1, m_2, m_3, n_1, n_2, n_3$, and p_1, p_2, p_3— it will be only carried out for the United States, because appropriate time series were available from 1947 on. Since the purpose of this paper is to illustrate how the concept of causality can be applied, the analysis in this section is restricted to the group of women aged 20-24. This means that the variables B, K, and W should ideally be age-specific. This presents no problem for the fertility and the labor force participation rate since age-specific time series are easily available. This was not possible for the wage rate. Since the age earnings profile of women is very flat and since the percentage of women working in retail trade is very high, hourly earnings in this industry were taken, as a first approximation for the wage rate. This wage rate was then deflated by the consumer price index to give a real rate.

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*Because no contemporaneous variables are used as regressors, the above three equations present a "simple causal model" (Granger, 1969). The question of "instantaneous" causality will not be treated in this paper.

In the above regression equations, lagged fertility rates are thought to reflect past fertility behavior. But in previous years a fraction of women, which at time t are aged between 20-24, were falling into the younger age group. Simply lagging the age-specific fertility rate for women aged 20-24, would therefore not really capture past fertility behavior. To account for this fact the lagged age-specific fertility rates were set up as follows:

$$B_{t-j} = [(5 - j)F20_{t-j} + j\ F15_{t-j}] / 5 \qquad j = 0,1,2,3,4$$

where

F20 = fertility rate of women aged 20-24

F15 = fertility rate of women aged 15-19

The lag lengths are set on *a priori* grounds to 4 for all variables in all three equations.

Since the detection of causal relationships is based on tests, it is essential that the disturbance terms are identically, independently, normally distributed.* It is therefore necessary to test if the disturbance terms really have these properties, since otherwise the t and F tests would lead to false conclusions. One feature, which contradicts the assumption of independently distributed error terms, is the presence of autocorrelation in the residuals. In this case the least-square estimator would lead to biased variance estimates. The presence of lagged dependent variables worsen the case, since it raises the possibility of violating the least-square assumption and of inconsistent and biased estimates. Furthermore, it can be shown that in such a situation the application of the Durbin-Watson test is inappropriate. One way to overcome these complications is the use of the Lagrange multiplier test for the detection of autocorrelation (Breusch and Pagan 1980). This statistic is asymptotically normally distributed with mean zero and

*It should be noted that because of the presence of lagged endogeneous variables that t and F tests are valid only asymptotically.

variance 1. In Tables 4 and 5, its value is reported in the line labeled LM.

Table 4. Causality test for women aged 20-24.

Statistics	Dependent variable B_t	K_t	W_t
Specification	linear	linear	linear
Estimation period	47-79	47-79	47-79
Degrees of freedom	20	20	20
LM (N(0,1))	.272	3.662*	.451
NORMAL ($X^2(2)$)	2.003	0.008	1.013
LMLIN ($X^2(1)$)	1.204	.011	4.627*
F value of K_{t-j} $1 \leq j \leq 4$	1.286	-	3.000*
F value of W_{t-j} $1 \leq j \leq 4$	3.958*	3.739*	-
F value of B_{t-j} $1 \leq j \leq 4$	-	1.652	3.445*
F value of B_{t-j} and K_{t-j} $1 \leq j \leq 4$	-	-	8.635*

*Indicates that the value of the test statistic is significant at the 5 percent level.

To assess the normality of the disturbance terms a test was developed by Jargue and Bera (1980). It is based on two properties which characterize the normal distribution: the third moment is zero and the fourth moment is three times the square of the variance. The value of this test statistic is reported in the line labeled NORMAL and it is distributed as chi-square with two degrees of freedom.

Table 5. Causality test for women aged 20-24.

Statistics		Dependent variable: log (B_t)	Dependent variable: log(K_t)	Dependent variable: W_t
Specification		log-linear	log-linear	log-linear
Estimation period		47-79	47-79	47-79
Degress of freedom		20	20	20
LM (N(0,1))		.286	4.088*	.625
NORMAL ($X^2(2)$)		1.490	.203	1.853
LMLOG ($X^2(1)$)		6.729*	13.947*	3.391
F value of log (K_{t-j})	$1 \leq j \leq 4$	.624	-	2.679
F value of W_{t-j}	$1 \leq j \leq 4$	2.697	6.540*	-
F value of log (B_{t-j})	$1 \leq j \leq 4$	-	3.011*	3.980*
F value of log (B_{t-j}) and log (K_{t-j})	$1 \leq j \leq 4$	-	-	9.607*

*Indicates that the value of the test statistic is significant at the 5 percent level.

A further point worth discussing is the specification of the functional form. In this context it seems especially interesting to discriminate between the linear and the log-linear specification. Since the log of the female real wage rate was used for all applications, this question is only relevant for the fertility and the labor force participation rate. To explain the tests used it is necessary to introduce the Box-Cox transformation with parameter λ of a variable x:

$$x \rightarrow \frac{x^{\lambda} - 1}{\lambda}$$

Depending on the value of λ the Box-Cox transform is either x itself, when $\lambda = 1$ or the logarithm of x, when $\lambda = 0$. By taking the linear specification as the null hypothesis it is possible to test whether λ equals one. If it is not equal to one, the

linear specification will be rejected. The resulting test statistic is distributed as chi-square with one degree of freedom and is reported under the label LMLIN. On the other hand, it is also possible by taking the log-linear specification as the null hypothesis to test whether λ equals zero. If it is not equal to zero the log-linear specification will be rejected. The distribution is the same as LMLIN and it is reported under the label LMLOG. A further "test" similar to the one discussed above is proposed by Sargan. A value of SARGAN smaller than one would imply that the data prefer a linear specification; if its value is greater than one a log-linear specification is more appropriate.

The results for the three regressions using the linear specification are reported in Table 4. Given the values of LM and NORMAL the assumption of identically, independently, and normally distributed error terms cannot be rejected at a 5 percent significance level for the fertility and the wage equation. In the labor force participation equation, on the other hand, the LM-test indicates the presence of high autocorrelation, which leads to biased variance estimates and therefore to unreliable F tests. The values of LMLIN suggest that the linear specification is appropriate for the fertility and the labor force participation equation and not the wage equation.

From the F statistics in the fertility equation it can be deduced that the labor force participation does not cause fertility but that fertility is caused by the wage. Since the other two equations are misspecified either because of functional form, or because of autocorrelation, the F statistics are not reliable. Therefore, no conclusion about causality can be drawn from them. Consequently the underlying theory can only be confirmed for the fertility behavior. These results seem to be very robust with respect to the choice of the lag length.

The results for the log-linear specification are reported in Table 5. This change in the functional form is rejected by the LMLOG statistic for the fertility and the labor force

participation equation, but not for the wage equation. Furthermore, it is seen from the LM statistic that the autocorrelation in the labor force participation equation has not been removed. It is therefore possible to draw conclusions only from the wage equation. The F test of the hypothesis that all coefficients of log (B_{t-j}) $(1 \leq j \leq 4)$ in the wage equation are zero, must be rejected at a 5 percent significance level. On the other hand, the same hypothesis for the labor force participation cannot be rejected. But taking these hypotheses together, it must again be rejected. This means that the wage is caused by fertility and by fertility and labor force participation taken together. This conclusion contradicts the hypothesis that the wage is exogeneous to fertility and labor participation, as it is asserted by the "New Home Economics" approach.

From all the results together, it is clear that more effort is necessary to assess the validity of the "Becker" approach. It seems especially important to analyze the specification of the equations, which is particularly true for the labor force participation equation. Furthermore, it is necessary to investigate in the problem of instantaneous causality, which was neglected in this paper. Since the degrees of freedom were not very high the extension of this method to samples from other countries might prove very useful.

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