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**Intergenerational Transmission of Women's Educational Attainment in South Korea:**

**An Application of Multi-group Population Projection Model***

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**Intergenerational Transmission of Women's Educational Attainment in South Korea: An Application of Multi-group Population Projection Model**


## Abstract

Using a multi-group population projection model, I study the implications of educational mobility and differential demographic rates on the intergenerational transmission of women's educational attainment in South Korea. Departing from the conventional approach in social stratification, I examine how socioeconomically differentiated groups reproduce themselves. The followings are my main findings. First, I find that differential demographic rates do not have a substantial influence on the educational distribution under conditions of substantial educational mobility. Second, both intergenerational association and structural change matter for the educational distribution in the long run: stronger intergenerational association and more structural change imply rising women's education. Finally, social mobility and differential fertility are found to be interdependent processes that jointly influence differential population replacement. Broad sociological implications and policy implications of these findings are discussed.

**Beyond net association**

This study examines the intergenerational transmission of women's educational attainment in South Korea. I model intergenerational transmission of educational attainment as a process jointly determined by educational mobility, differential fertility and differential mortality. Departing from the conventional approach to studying social mobility, I examine the implications of differential demographic rates, structural change, and the association of education between generations for the intergenerational transmission of socioeconomic status as a whole.

The conventional approach in examining social mobility has focused on the mechanisms whereby parental socioeconomic resources in industrialized societies are transmitted to their offspring, controlling for change in marginal distributions of socioeconomic outcomes between generations. This approach is common for occupational and educational mobility studies (Erickson and Goldthorpe 1992; Mare 1981). Although these studies demonstrate how offspring's socioeconomic outcomes depend on parental socioeconomic status, the implications of socioeconomic differentials in demographic processes for status transmission have not been widely studied. This is unfortunate because intergenerational transmission of socioeconomic status is intrinsically *"the process by which a socioeconomically differentiated population reproduces itself"* (Mare 1997: 265). From demographic research, we know that demographic processes and socioeconomic status are interdependent. Socioeconomic status is an important determinant of demographic behaviors: better educated women marry later (Mare and Winship 1991), fertility level is negatively associated with educational attainment (Bongaarts 2003) and a mortality differential by socioeconomic status is consistently observed (Elo and Preston 1996; Mare 1990). Demographic behaviors in turn influence socioeconomic outcomes of offspring: sibship size is negatively associated with educational attainment (Guo and VanWey 1999) and father's age is positively associated with educational outcomes (Mare and Tzeng 1989). This feedback is difficult to model in the conventional approach based on micro-level statistical relationships (Mare 1997).

The conventional approach has not paid enough attention to structural change, either. Most research attempts to control for structural change in assessing the association between family background and socioeconomic outcomes, instead of exploring the implications of structural change for status transmission. The two most influential works in this field are exemplary in this regard. Erickson and Goldthorpe (1992) compared similarities and differences in the net associations between parental and offspring's occupations across countries, controlling for country-specific structural differences. Mare's 'school transition model' (1981) examined how the association between educational attainment and family socioeconomic background changed in the United States over time, net of distributional change in educational attainment. These studies and their replications (e.g., Shavit and Blossfeld 1993) have shown geographic invariance and temporal stability of intergenerational associations, which suggests persistent inequality patterns in industrialized countries despite apparent diversity. Structural change is typically treated as a confounder that is not worth studying for its own sake. It is natural to regard the net association as central for understanding social stratification, because this measures how family background affects socioeconomic outcomes. However, structural change should be crucial for differential population replacement. Upward mobility should be prevalent if a society experiences rapid educational or occupational upgrading regardless of the strength of the intergenerational association. The implications of structural change on differential population replacement are also difficult to study using the conventional approach.[1]

Finally, intergenerational associations have been interpreted in a limited way in studies using the conventional approach. This has been interpreted as an indicator of social inequality: a stronger association implies less social mobility. However, the implications of intergenerational associations for differential population replacement have not been widely studied. This is unfortunate because intergenerational associations may affect differential population replacement under certain conditions. For example, if reproduction rates are higher for the less educated groups, a strong association implies that the level of education would decrease in the next

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[1] Recent studies in educational mobility, however, have examined the implications of structural change for the net association, to some extent. Studies based on "maximally maintained inequality" (MMI) hypothesis found that the intergenerational association is weakened when "a given level of education is saturated for the upper classes" (Hout, Raftery, and Bell 1993: 25). Although the implications of distributional change drew attention in the MMI hypothesis, the main concern is still the net association. Distributional change matters only because it affects the net association.

generation. Hence, the intergenerational association influences differential population replacement in addition to capturing social fluidity. The conventional approach based on micro-statistical relationship is not appropriate for addressing this issue.

In sum, we need to go beyond the conventional approach to understand the intergenerational transmission of socioeconomic status as a whole. We need a model that simultaneously accounts for net association, structural change, and socioeconomic differentials in demographic behaviors, in order to understand differential population replacement. In this study, I apply Mare's (1997) 'population renewal model' based on multi-group population projection methods to understand how women's educational attainment is transmitted across generations in Korea.

**The Korean context**

<Figure 1> about here

Studying differential population replacement is particularly relevant to the Korean context because of its fast and fundamental socioeconomic and demographic changes over the past 50 years. Figure 1 illustrates rapid educational expansion and fertility decline in Korea. While less than 10 percent of reproductive women in 1980 received tertiary education, this figure amounts to about 60 percent in 2005. However, the intergenerational association remained relatively constant. Interestingly, the impact of family background on the low level educational transition decreased earlier than the impact on the higher level transition did (Park 2004, 2007), which is consistent with the MMI hypothesis (Rafetery and Hout 1993). Figure 1 also shows that the level of fertility dropped dramatically regardless of educational attainment[2]. The better educated women delayed childbearing and produced fewer births than the less educated women. However, no particular trend of educational differential is observed, suggesting persistent differential fertility during the fertility decline (Jun 2002).

The combination of rapid educational expansion and persistent differential fertility has a very interesting implication for differential population replacement. These two trends may offset each other in affecting women's educational distribution in the next generation: differential fertility may slow down the pace of educational expansion because of higher reproduction rates of less educated women. In this study, I assess the strength and interdependence of educational mobility and observed fertility differentials for the differential population replacement in South Korea.

**Multi-group population projection**

A multi-group population projection model, developed by Mare (1997, 1996), allows us to examine the intergenerational transmission of women's educational attainment in Korea taking

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[2] The total fertility rate (TFR) fluctuated around 6.0 until the 1960s, but has rapidly declined since then. The TFR continued to fall even below the replacement level in the 1980s, and recently reached the lowest level around the world (World Health Organization 2008).

into account differential fertility and mortality. Using information on differential mortality and fertility and intergenerational educational mobility, we can construct a *generalized Leslie transition matrix*, $M_t$ (Mare 1997: 274):

$$M_t = \begin{bmatrix} 0 & 0 & B_{10t} & B_{15t} & B_{20t} & B_{25t} & B_{30t} & B_{35t} & B_{40t} \\ S_{0t} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & S_{5t} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & S_{10t} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & S_{15t} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & S_{20t} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & S_{25t} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & S_{30t} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & S_{35t} & 0 \end{bmatrix}$$

$S_{xt}$ s are squared sub-matrices of which elements are 5-year age-specific survival and intragenerational mobility probabilities, and $B_{xt}$ s are squared sub-matrices of which elements are 5-year age-specific birth rates and intergenerational mobility probabilities. The dimension of the sub-matrices is determined by the number of education groups. I classify education groups into three categories because of data limitations: primary and less, secondary, and tertiary education. In general, the multi-group projection model allows individuals to change their states at any time (Rogers 1995). However, I assume that educational attainment is determined at the time of birth because I rely on a series of aggregate cross-sectional data and do not have information on intragenerational educational mobility. Given my interest in the change in the overall educational distribution of women, this assumption should not be consequential for the analysis. This implies that $S_{xt}$ s are diagonal sub-matrices of which diagonal elements are 5-year survival probabilities of each education group. $B_{xt}$ s reflect educational differentials in fertility and educational mobility. A typical element in $B_{xt}$ s is $({}_5F_x + ({}_5L_{x+5}/{}_5L_x)*{}_5F_{x+5})*E_{ij}$ (where ${}_5F_x$ is the education-age-specific maternity rate, ${}_5L_x$ is the education specific person-years lived between age $x$ and $x+5$, and $E_{ij}$ is the outflow probability from education group $i$ to $j$). Upon constructing a *generalized Leslie transition matrix,* we can calculate projected educational distribution 5×n years later:

$$P_n = (M_{n-1}) \cdots (M_2)(M_1)P_1 \quad - (1)$$

(where $P_1$ is an initial population distribution by age and educational attainment)

*Constant rates vs. transitory rates*

In general, multi-group population projection models examine trends and implications of differential population replacement: change in ethnic composition (Hout and Goldstein 1994), religious composition (Hout et al. 2001), poverty distribution (Musick and Mare 2004), women's educational distribution (Mare 1997, 1996) and IQ distribution (Preston and Campbell 1993). The goal of this approach is to understand differential population replacement rather than to make accurate predictions. Two different approaches have been used for this purpose.

First, we can use static mobility and demographic rates, and examine equilibrium distribution. One of the most important findings in mathematical demography is that age distribution in a closed population would reach 'equilibrium' if the age-specific fertility and mortality rates remained constant over the long run (Keyfitz and Caswell 2005). Rogers (1995: 118 – 119) showed that the 'equilibrium' exists in multi-group cases if the mobility rates between groups as well as differential demographic rates remain constant.[3] This property allows us to examine the implications of current vital and mobility rates for the differential population replacement. For example, if observed educational mobility rates and differential fertility rates yield the same 'stable-equivalent' states as do observed mobility rates with (hypothetical) no differential fertility rates, we would conclude that the long-term implications of differential fertility is inconsequential.

Alternatively, we can use changing mobility and demographic rates. When we are interested in understanding the implications of changing mobility and demographic rates on the current educational distribution and provided there are sufficient historical data, we can calculate projections forward to the present with the initial distribution and transitory demographic and mobility rates. As in the case of projection with constant rates, we can calculate projections with observed or hypothetical mobility and demographic rates. Comparing the educational distributions resulting from different scenarios will tell us the implications of educational mobility and differential demographic rates for the present population distribution. For example,

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[3] To reach 'equilibrium', the transition matrix should not be primitive. The conditions for 'imprimitivity' are more complicated in multi-group cases than single group cases (Rogers 1995). However, except for unrealistic extreme cases (e.g., extremely high fertility differential and high immobility), transition matrices used in this study are not primitive, which means that each transition matrix yields 'equilibrium'.

if the projection with observed mobility and differential fertility yields the same distribution as the distribution from a projection with (hypothetical) no differential fertility, this would imply that differential fertility during the projection period would not greatly influence differential population replacement. This approach is more realistic than the projections based on unchanging vital and mobility rates. However, without sufficiently long historical data, this projection should not be very illuminating. In this study, I will make projections using transient and constant rates.

**Research Questions**

The following sets of questions are examined to study the implications of educational mobility and differential fertility for the differential population replacement.

1. *What are the implications of intergenerational educational mobility for population replacement, holding constant differential fertility? Without any intergenerational association, what would the educational distribution in Korea look like? What are the implications of the intergenerational association for differential population replacement? How influential is the structural change?*
2. *What are the implications of differential fertility by education for population replacement, holding constant educational mobility? Without differential fertility, what would the*

*educational distribution in Korea look like? How strong must differential fertility be to have a substantial impact on differential population replacement?*

3. *How do educational mobility and differential fertility interact in influencing population replacement? How dependent is educational mobility on differential fertility and vice versa?*

To examine the implications of educational mobility for differential population replacement, I use observed and hypothetical educational mobility rates. Hypothetical mobility matrices include independence, no structural mobility matrix, and a set of hypothetical immobility matrix. First, the independence mobility matrix fits the marginal distribution to the observed mobility matrix and imposes no association between mother's and daughter's education. A projection using the independence matrix yields a hypothetical distribution of women's education if there were no intergenerational association in women's education. Comparing the resulting distributions from this scenario with those from the observed mobility matrix tells us the influence of the intergenerational association on women's educational distribution. Second, no structural mobility matrix is characterized by a mobility matrix where the intergenerational association is the same as the observed matrix, but the distribution of daughters' education is constrained to be equal to mothers' education. This represents situations in which no structural change occurred and the association between mothers' and daughters' education were equal to the observed. Comparing this with the observed matrix would tell us the influence of structural change on the resulting distribution, controlling for the influence of the intergenerational association in education.[4] Finally, I examine how change in the intergenerational association affects differential population replacement by using a set of hypothetical educational mobility matrices in which I change the intergenerational associations gradually, holding the marginal distribution constant. This approach allows us to examine if higher intergenerational association implies higher level of women's educational attainment in the next generations, given observed differential fertility and marginal distribution. In the result section, I will discuss how to manipulate intergenerational association and marginal distribution in more detail.

To examine the implications of differential fertility for population replacement, I use three different sets of differential demographic rates; (1) observed differentials, (2) no differential fertility with observed differential mortality and (3) a set of hypothetical differential fertility rates. A comparison between (1) and (2) will show the overall influence of differential fertility on population replacement. Given the very strong educational mobility in Korea, the influence of differential fertility should not be great. Hence, I use hypothetical differential fertility rates to see how strong the differential fertility must be to influence the differential population replacement substantially. In the result section, I discuss how to manipulate hypothetical differential fertility rates in more detail.

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[4] In this model, I cannot fit the marginal education distribution of mothers and daughters to the data.

Finally, I examine how educational mobility and differential demographic processes interact in producing differential population replacement. For example, if there were no educational mobility, the influence of differential fertility would be great: groups with higher reproduction rates would, ultimately, be dominant. By contrast, if upward mobility is prevalent, the influence of differential fertility would not be great: the portion of highly educated women would be high, regardless of the level of differential fertility. Hence, I will examine how the implications of educational mobility and differential fertility are mutually dependent.

**Previous Research**

Demographic models for social mobility were initially developed in the 1950s and the 1960s. Prais (1955) adopted a stable population theory to study social mobility: occupational distributions approach a 'stable-equivalent' state independent of the initial state when mobility rates remain constant over time. Although he recognized possible complications due to demographic processes, his model did not take into account differential fertility and mortality (Prais 1955: 80). Judah Matras published a series of papers that incorporated differential demographic processes into social mobility in the 1960s. He applied Prais (1955)'s model to empirical mobility tables (Matras 1960), incorporated differential fertility by occupation (Matras 1961), and examined the effect of fertility timing on population distribution in later periods (Matras 1967). All these studies are based on multi-group projection using constant rates. These earlier interests in the implications of differential demographic processes were recently revived by Robert Mare and his colleagues.

Mare's works demonstrate how the distribution of educational attainment in one period is influenced by educational mobility, differential fertility and mortality of earlier periods (Mare 1997, 1996).[5] His findings suggest that differential fertility and mortality did not matter much for the distribution of educational attainment in the United States in the 20th century because of substantial educational mobility. Similar models have also been used to study the transmission of poverty status and family structure (Musick and Mare 2004) and IQ transmission across generations (Preston and Campbell 1993). These works also show that differential fertility does not matter much because of substantial intergenerational mobility. These studies set the foundation for understanding how the distribution of population characteristics is jointly determined and for evaluating the relative importance of each component.

## Data

### *Fertility*

To estimate age-specific fertility rates by education, I use the census and the birth registration records between 1980 and 2005. From the census, I compute the number of women for 5-year age groups and three education categories (less than primary education, at least some secondary

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[5] Mare and Maralani (2006) recently developed a more comprehensive model that also accounts for assortative mating.

education, and at least some college). This means that $S_{xt}$ s and $\mathrm{B}_{\mathrm{xt}}$ s in the transition matrix are 3×3 sub-matrices. More refined information is available since 1990, but I do not use it because of comparability across periods. The census data do not report the educational distribution for women aged less than 15. In addition, using the reported educational distribution for women aged 15 to 19 is problematic because many women in this age group remain in school (particularly for recent cohorts). Because the model assumes that educational attainment is determined at the time of birth, I should use completed education. Hence, I impute the education distribution of women younger than age 20 with the educational distribution of women 5 to 20 years later. For example, the educational distribution of women aged 0 to 4 in 1980 is assumed to be the same as the distribution of women aged 20 to 24 in 2000. This is equivalent to assuming no differential mortality before age 20 for this cohort of women. However, this imputation does not work for women born after 1985. For these women, I assume the same educational distribution as the women born between 1980 and 1984. It is equivalent to assuming no further educational expansion for women born after 1985. Although this differs from reality, the bias introduced by this detraction should not be large given the fairly high level of educational attainment for women born between 1980 and 1984.[6] Using the birth registration data, I

[6] I considered imputing the missing information by extrapolation. However, about 75 percent women aged 20 – 24 in 2005 received at least some college education and the annual increase in percent having tertiary education among aged 20 – 24 is 2 percent on average. This implies that almost every woman born after 1995 would have some tertiary education, which sounds unrealistic too. Although either assumption does not reflect the real trends well, no expansion

compute the number of women who gave birth between 1980 and 2005 by age and education. Combining the census and the birth registration data, I compute age-specific fertility rates by each education group, which are shown in Table A1. We observe earlier childbearing of the less educated compared to women with more education. Whereas women with primary education have more children until their early 20s, women with tertiary education have higher fertility rates in their early 30s. The educational differentials in the timing of childbearing could exert downward pressure on the educational distribution of future generations if educational mobility were modest.

*Mortality*

The Korean vital registration system does collect educational attainment of the deceased, but this information is not publicly available. I do not have the access to this data set, and therefore cannot compute differential mortality schedules directly. To overcome this data limitation, I combine life-table estimates provided by the Korean Statistical Office (www.kosis.kr) and a scholarly publication that reports mortality ratios by education (Kim 2002). Using the formula to

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seems to me better given the (1) already high proportion of women with tertiary education in 2005 and (2) difficulty of opening new colleges or increasing the number of entrant of existing institutions in the short run.

convert mortality rates to survival probability in life tables (Preston et al. 2001: 49)[7], I compute age-specific survival probabilities by each education group.[8] This is shown in Table A1. Better educated women enjoy more favorable mortality conditions, but the difference between the groups is not great. The small differentials imply a weak effect of differential mortality on the population distribution.

*Educational mobility*

To compute educational mobility, I use data from the Korean Labor and Income Panel Study (KLIPS), an annual longitudinal survey representative of Korean individuals and households. The KLIPS sample is an equal probability sample of households from 7 metropolitan cities and urban areas, and was designed to yield 5,000 households and their members (aged 15 and over) in the first wave (1998). I use the fourth wave of data (2001), where mother's education was asked for the first time, through the ninth wave (2006). Table 1 shows educational mobility rates for different birth cohorts. We can observe that upward mobility becomes increasingly prevalent over time.

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[7] $_nq_x = \frac{n \cdot {_n m_x}}{1+(n-{_n a_x})\cdot {_n m_x}}$ (where $_nq_x$: probability of dying between age $x$ and $x+n$, $_nm_x$: mortality rate between age $x$ and $x+n$, and $_na_x$: person-year lived by the dead between age $x$ and $x+n$). The $_nm_x$ is multiplied by mortality ratios of each education group to the overall population as presented by Kim (2002).

[8] Because the mortality ratios by education are available only for women older than age 25, no mortality differential is assumed for women younger than age 25.

<Table 1> about here

Differential demographic rates are available for cohorts born between 1980 and 2005, as shown in Table A1. However, educational mobility rates are not available for them because most of them have not yet completed their schooling. If we know the marginal distributions and the odds ratios between origin and destination, we can reconstruct contingency tables uniquely (Agresti 2002: 345 – 6). Mother's educational distribution (origin) is available from the census data between 1980 and 2005, but daughter's educational distribution (destination) and intergenerational association are not directly available for this period. Hence, I need to make assumptions to have educational mobility table. First, educational distribution of women aged 20 – 24 in 2005 available from the census data is assumed to be equal to daughter's educational distribution for all years. Actually, this is a good approximation of educational distribution of women born between 1981 and 1985. Using this as daughter's educational distribution for 1980 and 1985 does not seem problematic, but this is probably inaccurate for later years. However, this assumption does not introduce a great bias given the fairly high level of educational attainment for women born between 1980 and 1984 (See footnote 6 for a more lengthy discussion of assuming no further educational expansion). Table A2 shows the marginal distributions used in the analysis. Second, I substitute the intergenerational association of those born in the 1970s for those born between 1980 and 2005 into these projection models. This is equivalent to assuming that the intergenerational association for women born between 1980 and

2005 is the same as that for women born in the 1970s. Table A3 shows the odds ratios between mother's and daughter's education for three birth cohorts. Consistent with previous studies (Park 2004, 2007), the intergenerational association did not decline dramatically over cohorts. In sum, I make educational mobility table based on (1) the intergenerational association observed for women born in the 1970s, (2) observed reproductive women's educational distribution of every 5 year (1980 – 2005) as mother's educational distribution, and (3) educational distribution of women aged 20 – 24 in 2005 as daughter's educational distribution.

**Results: transitory rates**

<Table 2> about here

In this section, I discuss the results that use transitory mobility and differential demographic rates. Using three different mobility matrices (observed, independence, and no structural change) for each year and four different sets of demographic rates (observed, no differential at all, fertility differential only, and mortality differential only), I calculate 12 projections with transitory rates. The results using observed demographic rates and various mobility rates are presented in Table 2. The projected distributions from alternative demographic rates are almost identical with those shown in Table 2. This implies that differential demographic rates were not large enough to affect the educational distribution. Given the substantial fertility differentials by education observed in this period, this result may be counter-intuitive. This result could be a consequence of a short projection period. Projections shown in Table 2 span only 25 years, which may be too short for differential demographic rates to be influential. However, given no effect of differential demographic rates on 'equilibrium' distribution (to be discussed later), the time span of projection should not be an important factor. The more feasible explanation is the dominant role of social mobility. Earlier studies (Mare 1997, 1996) point to the importance of educational mobility that offsets the effect of differential fertility on population distribution, which is consistent with the patterns shown in Table 2.

The projected distributions shown in Table 2 imply that intergenerational association and structural change jointly affect educational distribution. Surprisingly, projected distributions implied by no association and no structural change are almost identical. All these projections yield a lower level of women's education than observed mobility rates imply: whereas slightly less than 50 percent of women in 2005 would receive tertiary education in projections with the observed mobility rates, only about 25 percent would do so in the other two projections. In other words, educational attainment would be lower without intergenerational association or structural change. This means that intergenerational association, as well as change in marginal distribution, contributes to the rising women's educational attainment in Korea. Obviously, structural change is an important factor of educational expansion. However, why does the intergenerational association contribute to the rising women's educational attainment? This may suggest that intergenerational association is not only *a measure of social inequality* but also *contributes to educational expansion*. The section that follows explores this possibility in greater detail.

**Results: equilibrium distribution**

*Observed educational mobility, independence and no structural change*

<Table 3> about here

In this section, I discuss the results that use constant mobility and differential demographic rates. Three different mobility matrices (observed, independence, and no structural change) and four different sets of demographic rates (observed, no differential at all, fertility differential only, and mortality differential only) for each year yield 72 transition matrices. Each transition matrix has a left eigenvector that represents an equilibrium distribution implied by each set of mobility and demographic rates. As in the case of transitory rates, differential fertility rates do not affect the 'stable-equivalent' states. In other words, equilibrium distribution is not dependent upon the differential fertility. However, differential fertility matters for the time to converge to equilibrium. The last two columns in Table 3 display how long the convergence takes for each projection. We can see that no fertility differential yields faster convergence. This makes sense because higher reproduction rates of less educated women delay educational expansion, which will not stop until the educational distribution reaches equilibrium. Hence, observed fertility differentials matter for differential population replacement in that they slow down the pace of reaching equilibrium.

The first panel in Table 3 shows the implied equilibrium distribution by assumed marginal distribution and intergenerational association, and observed differential mortality and fertility. Two patterns are worth noting. First, the equilibrium distribution is highly skewed to the high end: if current educational mobility persists over the long period of time, around 90 percent of women would have a tertiary education. Second, the level of women's education implied by the later period is a bit lower than the earlier periods imply. This may seem counter-intuitive given the educational expansion observed between 1980 and 2005. However, projections with the assumed marginal distribution in the later periods yield lower level of educational attainment because origin distributions in the later periods are imposed to be more similar to the destination distribution than those in the earlier periods. While only 8.2 percent of reproductive women in 1980 had tertiary education, more than half of reproductive women in 2005 did so (see Table A2). Obviously, the latter is closer to the assumed destination distribution (educational attainment of women aged 20 – 24 in 2005). Because the destination distribution may not be equal to educational attainments of daughters at each time point[9], the comparison between projections would not tell us the trend in differential population replacement. Instead, this tells us the implications of structural change for the equilibrium distribution. Because the impact of

[9] It is likely to underestimate the level of daughter's education because it assumes that the level does not go up after 2005.

differential demographic rates is minimal, the differences in marginal distribution of mother's education are largely responsible for the differences among the equilibrium distribution of each projection. The higher level of educational attainments obtained from the projections with earlier distribution implies that the more structural change increases educational attainment. However, the magnitude is not great. There is only a 10 percent difference in percent tertiary between the projections with marginal distributions in 1980 and those with the marginals in 2005. Given the fairly large difference in the marginal distribution of origin, this difference seems modest at best. If we knew the correct marginal distribution of daughter's education for each year, the difference would be even smaller. This implies that the change in marginal distribution experienced between 1980 and 2005 does not have substantial implications for the differential population replacement process in Korea.

The second and third panel in Table 3 displays equilibrium distributions under independence and no structural change. Under independence, marginal distribution in origin does not make any difference in outflow mobility rates. The marginal distribution in the destination solely determines the mobility rates because daughter's educational attainment is not dependent on the level of mother's education at all and is only constrained by the initial destination distribution of each projection. Interestingly, the equilibrium distribution is almost identical to the initial destination distribution. This implies that educational expansion would stop when it reaches the initial marginal distribution of destination. Without further structural change or intergenerational association, the initial destination distribution determines the equilibrium distribution. When I used the educational distribution of women aged 20 – 24 in 2005 as the initial destination distribution (not reported in Table 3), about 75 percent have tertiary education at the equilibrium, which is much lower than those reported in the first panel in Table 3. This means that the lack of intergenerational association would lower the level of educational attainment at the equilibrium, holding other things constant. This finding leads us beyond the narrow interpretation of intergenerational association in the conventional approach: intergenerational association is *not only a measure of social inequality but also contributes to educational expansion.*

Equilibrium distributions under assumptions of no structural change are very similar to the marginal distributions of destination (that is the same as origin) used in the mobility matrix. Strength of intergenerational association does not matter at all for the educational distribution in the future, simply because the educational distribution does not change over time. [10] Hence, the equilibrium is identical to the initial destination distribution in the mobility matrix if differential demographic patterns are not excessively influential.[11] From these projections, we can conclude that (1) structural change does not matter for differential population replacement under independence and (2) intergenerational association has no implication for differential population

[10] Prais (1955) proved this property mathematically without considering differential demographic processes.

[11] This is why the equilibrium distributions under independence and no structural change are similar to each other.

replacement under assumptions of no structural change. In other words, some structural change is necessary for the intergenerational association to be influential for the differential population replacement, and vice versa.

*Impact of differential fertility on equilibrium distribution*

<Table 4> about here

In the multi-group population projections discussed above, the observed differential fertility does not have a big impact on the equilibrium distributions. The differential fertility influences only the time to convergence: no fertility differentials imply faster convergence. Then, we can ask, "How strong should differential fertility be to influence the equilibrium distribution?" Table 4 provides an answer. The first column shows the hypothetical fertility ratios between adjacent education groups used in the projections. For example, a fertility ratio of 1.5 means that age-specific fertility ratio of primary education to secondary or secondary to tertiary is equal to 1.5. I further assume that age-specific fertility rates for women with secondary education are the same as average age-specific fertility rates in 2005.[12] I use the educational distribution of reproductive women and women aged 20 – 24 in 2005 as the marginal educational distribution, and observed odds ratios of women born in the 1970s as the intergenerational association. The equilibrium distribution implied by each projection shows the negative association between differential

[12] The choice of reference fertility rate does not affect the equilibrium distribution, so this choice does not make difference in these models.

fertility and the educational attainment at equilibrium: whereas 88 percent will end up with college education under no differential fertility, only 65 percent of women receive a college education if the fertility ratio between adjacent groups is 5.0. This difference is substantial in the equilibrium distribution, but fertility differentials are much smaller than this in most societies. In Table 4, we can see that a fertility ratio of 1.5 does not have a substantial impact on the equilibrium distribution. However, even this level of fertility differential is unrealistically large. This is much greater than observed differentials in Korea (See Figure 1). This explains why differential fertility does not influence the equilibrium distribution under the observed educational mobility in Korea. This confirms the dominance of educational mobility in differential population replacement.

*Impact of intergenerational association on equilibrium distribution*

<Figure 2> about here

I noted earlier that it is difficult to assess the implication of structural change for differential population replacement without considering the intergenerational association and vice versa. To make a sensible assessment of the impact of the intergenerational association, I use hypothetical mobility matrices for which I manipulate percent immobile, using the assumed marginal distribution in 1980. A set of hypothetical mobility matrices is created as follows. First, I assume uniform distributions of origin and destination. Second, I change percent immobile 33 percent (that represents independence) and 90 percent (that represents the strong intergenerational association), assuming symmetry[13]. Third, I compute the sets of odds ratios for each hypothetical mobility matrix. Then, I substitute the assumed marginal distributions of 1980 for the uniform distribution. This substitution is necessary because uniform distributions of both origin and destination imply no structural change where we cannot evaluate the implication of intergenerational association.[14] Finally, I compute the outflow educational mobility rates from each matrix, and apply these rates to projection. I used differential demographic rates in 1980 when differential fertility was the greatest. The equilibrium distribution and time to reach equilibrium are given in Figure 2. The x-axis represents percent immobile for each mobility matrix, which captures the strength of intergenerational association. The y-axis on the left is relevant to the educational distribution, and the y-axis on the right is for time to reach the equilibrium distribution.

Figure 2 shows that the increase in percent immobile leads to higher educational attainment at equilibrium under the differential demographic regimes in 1980. Because percent immobile is a good indicator of intergenerational association, this analysis supports the claim that higher intergenerational association leads to more educational expansion. Hence, a strong

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[13] Although symmetry is certainly an unrealistic assumption given the secular trend of educational expansion over time, I impose this assumption because it is easy to fix the marginal distribution under this assumption. Given the interest in evaluating the implications of intergenerational association on differential population replacement, this assumption is inconsequential for the results.

[14] This substitution makes percent immobile vary 50 to 80 percent instead of 33 to 90 percent.

intergenerational association *not only represents great educational inequality but also promotes educational expansion*. In addition, we can see that a stronger intergenerational association increases the amount of time until equilibrium is reached. This is the case because higher intergenerational association yields equilibrium distributions that deviate more from the original distribution than does lower intergenerational association. In sum, higher association implies greater educational expansion and longer time to reach equilibrium.

*Joint impact of mobility and differential fertility*

<Figure 3> about here

Table 4 shows the impact of differential fertility on differential population replacement, and Figure 2 shows the positive impact of intergenerational association on the level of educational attainment at the equilibrium. In this section I ask: to what extent does the impact of one factor depend on the other? Figure 3 illustrates how these two interact to affect differential population replacement. We can see that the impact of intergenerational association on differential population replacement is dependent on the level of fertility differentials. Stronger intergenerational association implies more educational expansion if fertility ratios between adjacent education groups are smaller than 2.5. If fertility ratios are about 2.5, intergenerational association does not matter. If fertility ratios are greater than 3.0, more association yields lower educational attainment. This means that the higher reproduction rates of the less educated women would push the educational attainment down when educational immobility is prevalent. This is a concern raised by *Bell Curve* (Hernstein and Murray 1994), which has been widely examined and criticized. The projection results provide further evidence against their claim, because this downward trend is only the case if fertility ratios are greater than 2.5 and intergenerational association is extremely strong. None of these two conditions are likely to be confirmed in empirical data, which shows that their claims or concerns are demographically groundless.

**Summary and discussion**

Using multi-group population projection models, I studied the implications of educational mobility and differential demographic rates on differential population replacement in South Korea. First of all, I found that differential demographic rates do not greatly influence differential population replacement: projections using observed demographic rates yield the same educational distributions as those using (hypothetical) no differential demographic rates, holding constant educational mobility rates. As shown in Table 4 and Figure 3, differential fertility needs to be unrealistically large to influence differential population replacement. This result suggests that differential demographic rates are not important in the population distribution in the long run under conditions of significant social mobility, and is consistent with previous studies (Mare 1997; Musick and Mare 2004; Preston and Campbell 1993). Second, I found that structural change matters for differential population replacement: the greater the structural change, the higher the educational attainment at equilibrium. However, the influence of structural change is not found to be large. Even substantial educational upgrading in Korea between 1980 and 2005 implies only modest increases the percent of women with tertiary education at equilibrium (See Table 3). Finally, I found a significant impact of intergenerational association on differential population replacement: stronger association implies more educational expansion. This result leads us beyond a narrow interpretation of intergenerational association. In most studies, intergenerational association is interpreted as an indicator of social inequality. For example, stability of intergenerational association in educational attainment has been used as evidence for *'persistent inequality'* (Shavit and Blossfeld 1993). However, the result from this study suggests that strong intergenerational association also promotes educational expansion.

Among these findings, the positive relationship between intergenerational association and educational expansion has an important sociological implication. Because the level of education and intergenerational association captures societal development and social inequality respectively, the positive association between them provides evidence that societal development does not necessarily reduce social inequality. Instead, this finding suggests that a stronger intergenerational association would promote educational upgrading under certain circumstances: modest differences in reproduction rates by socioeconomic groups and stable intergenerational mobility regimes. In other words, this finding suggests an intrinsic trade-off between socioeconomic development and reduction of social inequality, to some extent, indicating the difficulty of balancing development and equity.

**Appendices**

Table A1 Age-specific fertility rates and survival probability, 1980 – 2005*

| | | # births per 1,000 women | | | 5-year survival probability | | |
|---|---|---|---|---|---|---|---|
| year | age | primary | secondary | tertiary | primary | secondary | tertiary |
| 1980 | 15-19 | 75.5 | 8.3 | 0.3 | 0.992 | 0.992 | 0.992 |
| | 20-24 | 214.7 | 116.4 | 75.7 | 0.991 | 0.991 | 0.991 |
| | 25-29 | 243.8 | 237.5 | 240.4 | 0.978 | 0.995 | 0.996 |
| | 30-34 | 115.4 | 113.8 | 117.2 | 0.966 | 0.994 | 0.995 |
| | 35-39 | 44.0 | 39.0 | 31.5 | 0.976 | 0.991 | 0.994 |
| | 40-44 | 16.8 | 13.2 | 9.6 | 0.961 | 0.988 | 0.992 |
| 1985 | 15-19 | 112.3 | 8.9 | 0.6 | 0.995 | 0.995 | 0.995 |
| | 20-24 | 188.4 | 132.6 | 32.0 | 0.994 | 0.994 | 0.994 |
| | 25-29 | 113.5 | 160.9 | 177.0 | 0.981 | 0.996 | 0.997 |
| | 30-34 | 27.6 | 40.5 | 64.0 | 0.972 | 0.995 | 0.996 |
| | 35-39 | 8.0 | 8.7 | 10.3 | 0.976 | 0.992 | 0.994 |
| | 40-44 | 2.2 | 2.3 | 1.9 | 0.964 | 0.988 | 0.992 |
| 1990 | 15-19 | 66.2 | 6.2 | 0.1 | 0.996 | 0.996 | 0.996 |
| | 20-24 | 124.9 | 85.2 | 57.7 | 0.996 | 0.996 | 0.996 |
| | 25-29 | 78.2 | 161.2 | 194.1 | 0.982 | 0.996 | 0.998 |
| | 30-34 | 20.3 | 46.5 | 93.3 | 0.973 | 0.995 | 0.997 |
| | 35-39 | 4.9 | 9.4 | 17.4 | 0.981 | 0.993 | 0.996 |
| | 40-44 | 1.1 | 1.7 | 2.0 | 0.966 | 0.989 | 0.993 |
| 1995 | 15-19 | 41.1 | 8.9 | 0.1 | 0.997 | 0.997 | 0.997 |
| | 20-24 | 114.2 | 99.0 | 18.3 | 0.997 | 0.997 | 0.997 |
| | 25-29 | 122.2 | 199.5 | 167.7 | 0.975 | 0.996 | 0.998 |
| | 30-34 | 42.3 | 64.7 | 97.3 | 0.966 | 0.995 | 0.997 |
| | 35-39 | 9.9 | 14.3 | 21.5 | 0.981 | 0.994 | 0.997 |
| | 40-44 | 1.6 | 2.3 | 3.1 | 0.972 | 0.991 | 0.995 |
| 2000 | 15-19 | 42.4 | 9.8 | 0.1 | 0.998 | 0.998 | 0.998 |
| | 20-24 | 70.9 | 85.3 | 14.3 | 0.998 | 0.998 | 0.998 |
| | 25-29 | 90.1 | 182.7 | 137.3 | 0.970 | 0.997 | 0.998 |
| | 30-34 | 46.4 | 80.3 | 111.3 | 0.960 | 0.995 | 0.998 |
| | 35-39 | 11.8 | 16.0 | 24.4 | 0.981 | 0.994 | 0.997 |
| | 40-44 | 1.7 | 2.5 | 3.9 | 0.972 | 0.992 | 0.996 |
| 2005 | 15-19 | 32.0 | 5.3 | 0.1 | 0.998 | 0.998 | 0.998 |
| | 20-24 | 61.8 | 50.9 | 7.5 | 0.998 | 0.998 | 0.998 |
| | 25-29 | 50.2 | 118.0 | 85.7 | 0.970 | 0.997 | 0.998 |
| | 30-34 | 39.7 | 71.8 | 103.1 | 0.963 | 0.996 | 0.998 |
| | 35-39 | 13.2 | 16.8 | 25.0 | 0.984 | 0.995 | 0.998 |
| | 40-44 | 2.1 | 2.3 | 3.3 | 0.977 | 0.993 | 0.997 |

* Sources: Census(1980 – 2005), Vital Statistics (1980 – 2005), Kim (2002)

**Table A2 Educational distribution of Korean Women, aged 15 – 44 (1980 – 2005)**

| Year | Primary | Secondary | Tertiary |
|---|---|---|---|
| 1980 | 36.5% | 55.3% | 8.2 |
| 1985 | 21.1 | 67.1 | 11.8 |
| 1990 | 11.9 | 69.6 | 18.5 |
| 1995 | 5.9 | 62.3 | 31.8 |
| 2000 | 3.5 | 54.2 | 42.3 |
| 2005 | 1.4 | 44.8 | 53.8 |
| aged 20 – 24 in 2005 | 0.3 | 24.6 | 75.1 |

* Sources: Korean Census, 1980 – 2005

**Table A3 Trends in odds ratios***

| Mother's Education | Daughter's Education | 1950s | 1960s | 1970s | Overall |
|---|---|---|---|---|---|
| P vs. S | P vs. S | 6.46 | 50.53 | 2.21 | 11.83 |
| | S vs. T | 5.79 | 4.14 | 3.01 | 5.75 |
| | P vs. T | 37.41 | 209.38 | 6.66 | 68.08 |
| S vs. T | P vs. S | 0.75 | 0.06 | 0.22 | 0.33 |
| | S vs. T | 10.27 | 2.74 | 9.97 | 5.74 |
| | P vs. T | 7.71 | 0.16 | 2.17 | 1.87 |
| P vs. T | P vs. S | 4.85 | 3.00 | 0.48 | 3.85 |
| | S vs. T | 59.50 | 11.37 | 30.06 | 33.01 |
| | P vs. T | 288.62 | 34.14 | 14.46 | 127.03 |

* Sources: The Korean Labor and Income Panel Study (KLIPS), 2001 - 2006
P: primary, S: Secondary, T: Tertiary

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**Table 1 Trends in educational mobility (percent)***

| | *Daughter's education* | | | |
|---|---|---|---|---|
| *Mother's education* | Primary | Secondary | Tertiary | Total (N) |
| *Primary* | | | | |
| Born in 1950s | 20.8 | 70.7 | 8.5 | 100.0 (993) |
| Born in 1960s | 4.3 | 75.0 | 20.7 | 100.0 (957) |
| Born in 1970s | 1.1 | 54.4 | 44.5 | 100.0 (659) |
| *Secondary* | | | | |
| Born in 1950s | 3.2 | 57.5 | 39.3 | 100.0 (65) |
| Born in 1960s | 0.0 | 45.5 | 54.5 | 100.0 (205) |
| Born in 1970s | 0.3 | 28.2 | 71.5 | 100.0 (760) |
| *Tertiary* | | | | |
| Born in 1950s | [0.0] | [14.8] | [85.2] | [100.0] (10) |
| Born in 1960s | 0.0 | 23.9 | 76.1 | 100.0 (21) |
| Born in 1970s | 0.0 | 4.0 | 96.0 | 100.0 (77) |

* Sources: The Korean Labor and Income Panel Study (KLIPS), 2001 - 2006

[ ]: based on less than 20 cases.

**Table 2 Projected Educational Distributions of Reproductive Women (Age 15 – 45) by Year (percent)**

| Projection Models* | 1980 | 1985 | 1990 | 1995 | 2000 | 2005 |
|---|---|---|---|---|---|---|
| | | | % Primary school and less | | | |
| 1.Observed distribution | 36.5 | 21.2 | 11.9 | 5.9 | 3.5 | 1.4 |
| 2. Observed rates | | | | | 6.2 | 2.2 |
| 3. Independence | | 25.0 | 16.6 | 10.9 | 12.7 | 11.7 |
| 4. No structural change | | | | | 12.6 | 11.3 |
| | | | % Secondary schooling | | | |
| 1.Observed distribution | 55.3 | 67.1 | 69.6 | 62.3 | 54.2 | 44.8 |
| 2. Observed rates | | | | | 58.6 | 52.1 |
| 3. Independence | | 64.9 | 66.7 | 64.2 | 63.2 | 62.6 |
| 4. No structural change | | | | | 63.4 | 63.1 |
| | | | % Tertiary schooling | | | |
| 1.Observed distribution | 8.2 | 11.8 | 18.5 | 31.8 | 42.3 | 53.8 |
| 2. Observed rates | | | | | 35.2 | 45.6 |
| 3. Independence | | 10.1 | 16.7 | 24.9 | 24.1 | 25.7 |
| 4. No structural change | | | | | 24.0 | 25.6 |

* All projection models used observed differential fertility and mortality.

** Because educational distribution of women age 0 – 14 in 1980 is fixed and projections do not affect it, there is no difference between projection models until 1995.

**Table 3 Equilibrium educational distribution of Korean women, aged 15 – 44**

| Marginal | | Equilibrium distribution | | | Years to reach equilibrium | |
|---|---|---|---|---|---|---|
| Origin | Destination | Primary | Secondary | Tertiary | Observed differentials | No differentials* |
| | | *Observed odds ratios + Observed marginal distribution* | | | | |
| 1980 | Women aged 20 – 24 in 2005 | .01% | 3.7% | 96.2% | 390 | 300 |
| 1985 | | .01 | 3.6 | 96.3 | 505 | 370 |
| 1990 | | .01 | 4.2 | 95.7 | 440 | 395 |
| 1995 | | .01 | 3.8 | 96.1 | 485 | 415 |
| 2000 | | .02 | 9.2 | 90.6 | 405 | 360 |
| 2005 | | .02 | 12.5 | 87.3 | 570 | 530 |
| | | *No association** + Observed marginal distribution* | | | | |
| Any distribution | 1980 | 35.7% | 55.9% | 8.4% | 240 | 300 |
| | 1985 | 20.6 | 67.5 | 12.0 | 295 | 370 |
| | 1990 | 11.6 | 69.8 | 18.6 | 375 | 395 |
| | 1995 | 5.7 | 62.3 | 32.0 | 345 | 415 |
| | 2000 | 3.3 | 54.2 | 42.5 | 395 | 345 |
| | 2005 | 1.3 | 44.7 | 53.9 | 480 | 530 |
| | | *Observed odds ratios + No structural change* | | | | |
| 1980 | 1980 | 37.1% | 55.8% | 7.2% | 230 | 300 |
| 1985 | 1985 | 20.8 | 68.7 | 10.6 | 275 | 370 |
| 1990 | 1990 | 11.9 | 67.2 | 20.9 | 380 | 395 |
| 1995 | 1995 | 5.4 | 65.9 | 28.7 | 385 | 415 |
| 2000 | 2000 | 3.2 | 59.0 | 37.9 | 395 | 375 |
| 2005 | 2005 | 1.3 | 47.5 | 51.2 | 455 | 530 |

* Equilibrium distribution implied by observed fertility differentials and no fertility differentials are similar to each other. The differences only lie in how long it takes to reach equilibrium distribution.

** If no intergenerational association exists, marginal distribution in origin does not influence the projection. Marginal distribution in destination matters only because this completely determines the outflow rates regardless of marginal in origin.

**Table 4 Impact of differential fertility on the equilibrium educational distribution***

| Fertility ratios | Primary | Secondary | Tertiary |
|---|---|---|---|
| No differential | .02% | 11.7% | 88.0% |
| 1.5 | .02 | 15.5 | 84.3 |
| 2.0 | .02 | 19.9 | 79.9 |
| 2.5 | .03 | 24.1 | 75.7 |
| 3.0 | .03 | 27.5 | 72.3 |
| 3.5 | .03 | 30.1 | 69.6 |
| 4.0 | .03 | 32.2 | 67.5 |
| 4.5 | .03 | 33.8 | 65.9 |
| 5.0 | .03 | 35.1 | 64.6 |

*Odds ratios: observed for women born in 1970s
Origin: women 15 – 44 in 2005, Destination: women 20 – 24 in 2005
Reference fertility rates: 2005

**Figure 1 TFR by Education and Women's Educational Distribution, Aged 15 – 44**

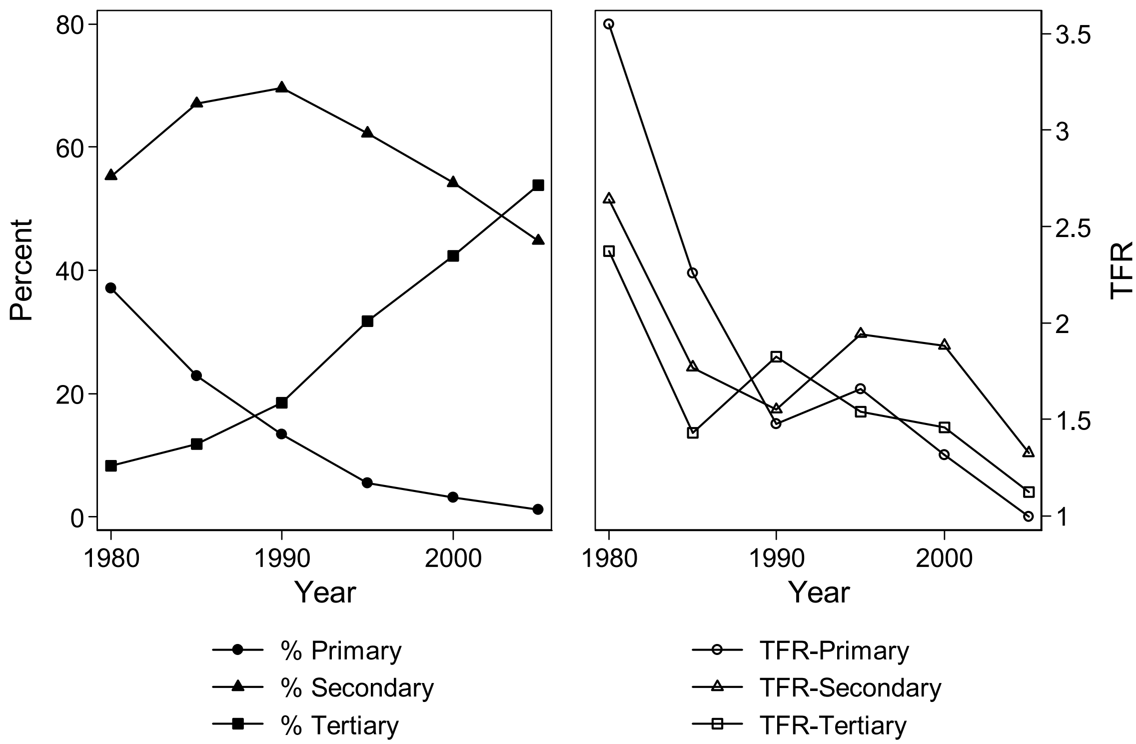
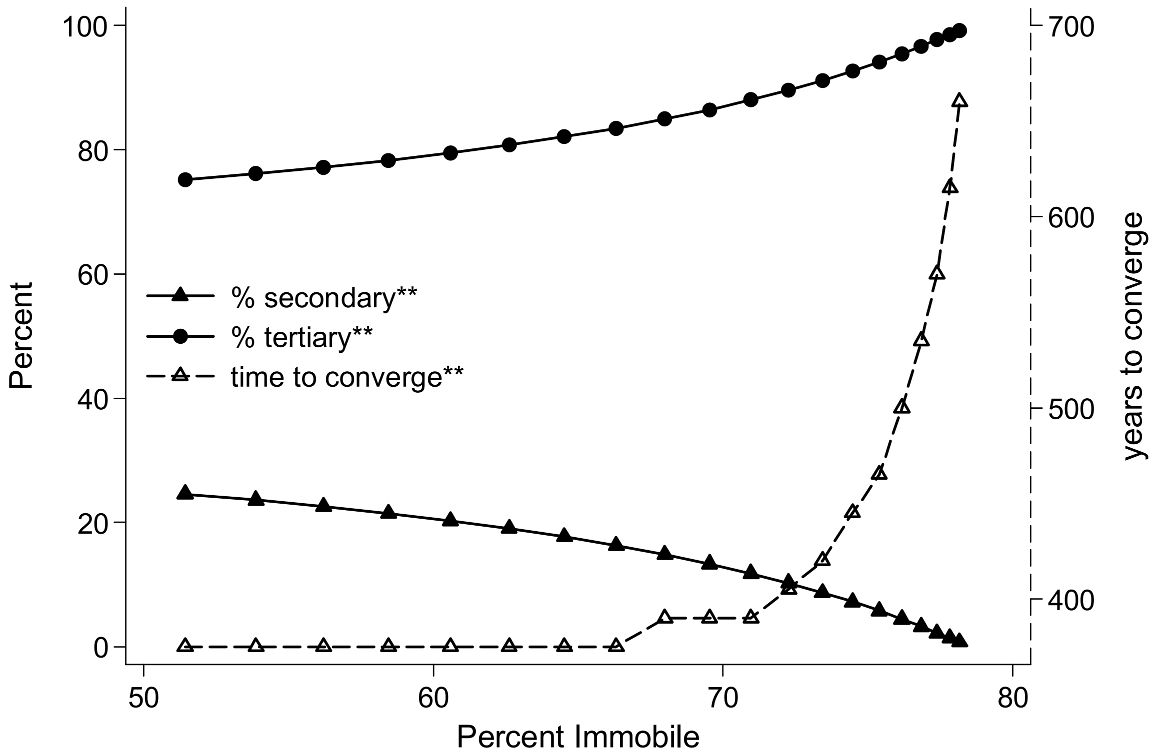
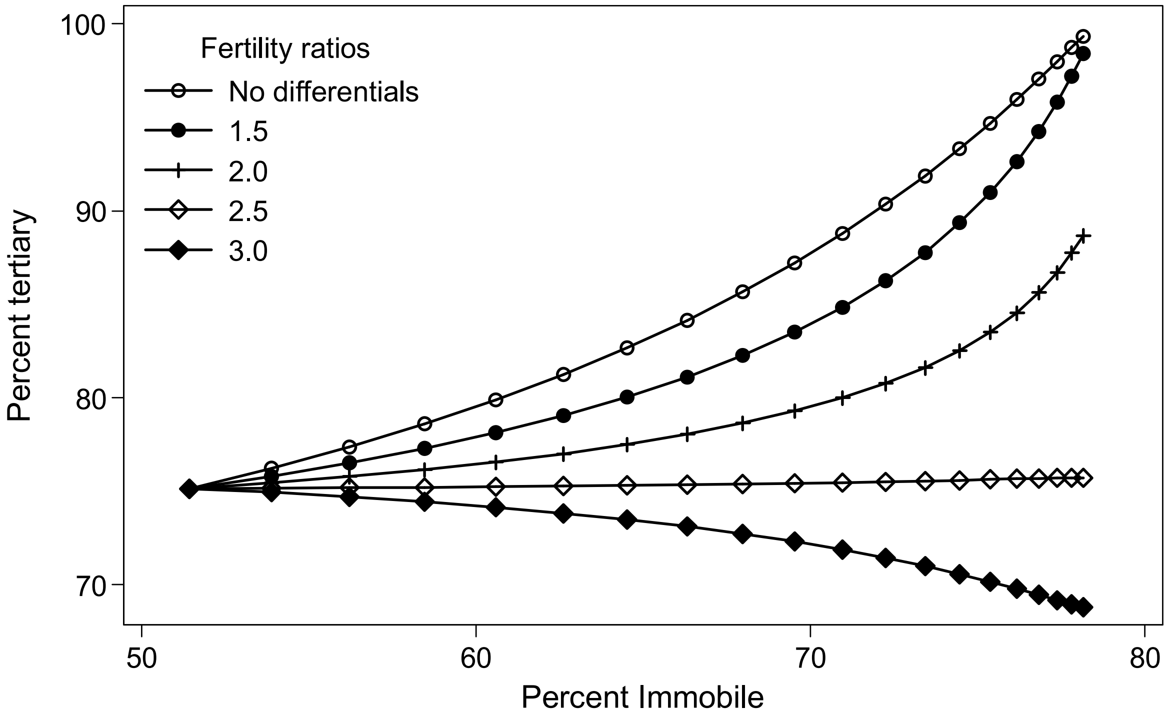


**Figure 2 Impact of educational immobility on equilibrium educational distribution***




* hypothetical educational mobility and observed differential fertility in 1980
** % secondary and % tertiary: left y-axis, time to converge: right y-axis

**Figure 3 Effect of educational mobility and differential fertility on equilibrium educational distribution***




* origin: 1980, destination: 20 - 24 in 2005, reference fertility rates in 1980