Inequality of Opportunity in Japan:
A behavioral genetic approach

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Abstract

This study examined the extent to which the inequality of opportunity exists in Japan, using a classical twin design. Participants were 1,006 working, male twins (738 identical and 268 fraternal twins; age 20–60) recruited via a web-based survey. Participants responded to the questions of academic achievement at the ninth grade, years of education, and annual income. Univariate genetic analyses revealed that individual differences in each of the three variables are substantially influenced by the following factors: genetic (27%–35%), family environment (34%–47%), and individual-specific environment (26%–30%). Gene-environment interaction analyses revealed that genetic and environmental etiologies of education and income differ across age/cohort; for education, genetic influences are weaker and family environmental influences are stronger in the older age/cohort, whereas for income, the former is stronger and the latter is weaker for the older age/cohort. Finally, multivariate genetic analyses revealed that family environmental factors unrelated with academic achievement exert strong influences on income, in part, via education. These results suggest that inequality of opportunity exists among Japanese males even when genetic influences are controlled for. This paper discusses the need for future research on the inequality of opportunity, using a genetically informative design.

Keywords: Twin method, Behavior genetics, Inequality of opportunity

JEL classification: I24

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Introduction

The concept of "equality of opportunity" has received much attention from philosophers, social scientists, and policy makers. Equal opportunity is a prerequisite for fair competition. When opportunity is unequal from the beginning of the competition, unequal outcomes cannot be justified, as they reflect where and in what kind of family was each individual born, rather than differences in the amount of efforts made and chosen by each individual. While there are different ways to define the concept (e.g., Roemer, 1998; Dworkin, 2000), Rawls (2001) defined "fair equality of opportunity" as follows:

> Supposing that there is a distribution of native endowments, those who have the same level of talent and ability and the same willingness to use these gifts should have the same prospects of success regardless of their social class of origin, the class into which they are born and develop until the age of reason. (Rawls, 2001, pp.44)

His definition, albeit influential, is still too broad for empirical researchers who examine the degree of equality/inequality of opportunity in specific societies or countries. Thus, in this paper, the authors provide an operational definition; equality of opportunity is violated if rich/educated parents can afford (whereas poor/less educated parents cannot afford) more education for their offspring, which lead to offspring's economic success. Under this definition, intergenerational reproduction of education years and income can be good indices of equality of opportunity.

Hertz et al. (2007) summarized estimates of father-son correlation of education years across 42 countries. Most of the estimates (r) ranged between .30 and.50, with the lowest estimates being .10 in Ethiopia, and the highest being.66 in Peru. In Japan, no comparable estimates are available, but Kikkawa (2006) reported a *phi* value of .47 for whether or not parents with bachelor's degree reproduce offspring with the same degree. Given this intergenerational reproduction of education, it is reasonable to assume that there may be intergenerational reproduction of economic success in many countries. Blanden (2013) summarized estimates of father-son correlation of income among 12 countries. Most of the estimates (r) ranged between .20 and .40, with the lowest estimates being .14 in Denmark and .52 in Brazil. In Japan, Sato and Yoshida (2007) reported a comparable estimate of .27. The two indices suggest that Japanese society has unequal opportunities to a certain degree, similar to other developed countries.

Many social scientists tried to uncover the possible mechanisms behind the intergenerational reproduction of educational and economic success. In Japan, empirical research revealed that academic achievement in middle school influences years of education (Katase, 2005; Yano, 2007), which in turn influences one's income (Nakamuro & Inui, 2012; Senoh & Higeta, 2011). Parental

education and income influence this causal pathway in various ways; for example, parent's income is directly passed on to offspring (Hoshi, 2001), rich parents invest more money to ensure that their offspring is academically successful (Akabayashi et al., 2010), rich parents can afford more education (Yano, 2011; Yamada, 2011), and educated parents are more capable of socializing their offspring as academically successful (Akabayashi et al., 2010; Kikkawa, 2006).

However, the influence of genetic factors is missing from the existing literature, as well as from the social science discourse in general. Genes may not only influence parents' education and income, but also be transmitted to the offspring and influence the offspring's educational and economic success. Subsequently, when such confounding influences of genetic factors are considered, some of the parental effects that were believed to be environmental may substantially decrease or completely disappear.

A discipline called behavior genetics provides the methodology to quantify the effects of genes. As noted above, the correlation between outcomes of parents and offspring reflects both genetic and family environmental effects. Thus, in ordinary circumstances, researchers cannot separate nature from nurture. However, behavior genetics can do so by utilizing information from special populations, such as the correlation of various demographic characteristics (e.g. identical twin siblings reared apart, biological parents and adopted children, adopted children and genetically unrelated siblings; Plomin et al., 2008). A method most frequently used by behavior geneticists is a classical twin design, which examines the similarity of identical twins and fraternal twins reared together. While identical twin siblings share a family environment and all of their genes, fraternal twin siblings, like ordinary singleton siblings, share a family environment but only half of the genetic variability. Thus, if the correlation of identical twins is higher than that of fraternal twins, it suggests the presence of genetic influences. In addition, if identical and fraternal twins are equally similar, it suggests the effects of the environment shared by twin siblings (shared environmental effects). Finally, if neither identical nor fraternal twins are similar, it suggests the presence of effects of the environment unique to each individual (nonshared environmental effects; see Method section for more details).

By using this method, more than half a century of behavior genetics research has revealed that every human trait is, in part, heritable. Turkheimer (2000) reviewed the literature and proposed the "three laws of behavior genetics"; (1) all human behavioral traits are heritable, (2) the effect of being raised in the same family is smaller than the effect of genes, and (3) a substantial portion of the variation in complex human behavioral traits is not accounted for by the effects of genes or families. Although specific estimates of genetic and environmental influences vary across countries, the three laws were shown to be applicable to Japanese population as well (see Ando et al., 2013 for a review).

In order to assess the degree of equality/inequality of opportunity, the amount of shared

environmental effects is crucial, but its meaning needs some clarification. First, shared environmental effects represent *between-family* environmental variation that results in similarity between family members as compared with non-family members. Second, it is *unobserved total main environmental effects* of family background. Third, compared with the term "family environment," the meaning of "shared environmental effects" is both *narrower*, in a sense that it does not include individual specific family environment, and *broader*, in a sense that it includes main effects of region of residence, and so on. Formulated in this way, the amount of shared environmental influences implies the *maximum* degree of intergenerational reproduction of given traits due environmental effects alone, and not due to genetics. Thus, the amount of shared environmental influences can be a good measure of equality/inequality of opportunity while considering the confounding influence of genes.

Until recently, the focus of behavior genetic research has been limited to psychological, psychiatric, and epidemiological domains. Consequently, a limited number of studies have estimated genetic and environmental effects on academic achievement, education years, and income. With regard to academic achievement, some studies did not observe shared environmental effects but only genetic and nonshared environmental effects (Markowitz et al., 2005; Nielsen, 2006), whereas others did observe shared environmental effects (Calvin, 2012; Luciano et al., 2006). Although estimates are not consistent across the samples, in general, genetic effects explain about 40% to 70% of the total variation, whereas shared environmental effects explain less than 20% of the same. With regard to education years, Le et al. (2011) summarized the estimates across different cohorts in Australia; regardless of cohorts, genetic effects explained about 40% to 50% of the total variation, whereas shared environmental effects explained about 15% to 25% of the same. Somewhat larger shared environmental effects were reported in Norway (47%; Heath et al., 1985), Finland (37% for males and 42% for females; Silventoinen et al., 2004), and the United States (25% for males and 50% for females; Silventoinen et al., 2004), in addition to genetic effects (ranging between 18% and 48%, depending on the samples). With regard to income, Bjorklund et al. (2005) reported that genetic effects explained 20% of the variation in Sweden, whereas shared environmental effects explained 16% of the same. These findings suggest that even when genetic effects are controlled for, the family in which a person is born substantially influences his or her prospect of success, especially in terms of education years.

However, previous literature is limited in several respects. To date, no study has utilized Japanese twin data to estimate genetic and environmental effects on academic achievement, education years, and income. Behavior genetic methods decompose variation in a particular population into genetic and environmental sources; therefore, estimates of genetic and environmental effects in Japan may considerably differ from those in other countries. In addition, even in the same country, it is likely that estimates differ across characteristics of populations, such as age and cohort.

With the exception of Le et al. (2011), differences in estimates due to age/cohort have not been systematically examined. Finally and most importantly, no previous study has examined how academic achievement, education years, and income are interrelated via genetic and environmental effects. For example, suppose education years and income are positively correlated, and shared environmental effects were observed for both. In this case, the positive correlation may be due to shared environmental effects common to both. Alternatively, it may be due to genetic or nonshared environmental effects common to both, with shared environmental effects being independent. Policy implications will differ depending on which of these situations is true.

Given these limitations in the previous literature, the purpose of the present study is to examine the degree of equality/inequality of opportunity in Japan by using a classical twin design. For this purpose, we (1) estimated genetic and environmental effects on academic achievement, education years, and income; (2) examined how they differ across age/cohort; and (3) examined how the three variables are interrelated via genetic and environmental effects. This was accomplished by applying multivariate behavior genetic analyses to Japanese twin data collected through a web-based survey.

Method

Participants and procedures

Participants were 1,006 Japanese male twins (738 identical and 268 fraternal twins). The data were collected through a web-based survey in Japan between the months of February and March 2012. We conducted the survey through Rakuten Research, which is affiliated with Rakuten, a major Internet shopping site (similar to Amazon.com or eBay), and monitors over 2.2 million people. In order to analyze genetic and environmental effects on income as well as academic achievement and education years, our sample targeted twins who were non-students, between the ages of 20 and 60. In this web-based survey, one member of a twin pair was responsible for reporting data regarding himself and his twin sibling at a time. Female twins were omitted from our analyses because the income of females depends more on marital status, whether they quit their job when giving birth to their children, and when and how they re-enter the labor market after quitting, all of which make it difficult for twin siblings to report the other siblings' income. For more details and descriptive statistics on the sample, see Nakamuro and Inui (2012).

Measurement

Academic achievement was measured by a single item with a five-point Likert scale (from "1 = low" to "5 = high"): "When you were 15 years old, how high was your twin sibling's and your academic achievement as compared with the same-age peers in your school? Please rate in reference to the school record at that time." Participants who chose "6 = don't know" were excluded from

analyses on academic achievement. Education years were measured by an item "What are the highest academic credentials of your twin sibling and you?" Participants chose from 27 categories and the categories chosen were transformed into education years. Finally, income was reported for the fiscal year of 2010 with 16 categories; response categories in the original questionnaire ranged from 1 (= no income or <JPY 0.5 million) through 16 (>JPY 15 million). We set the minimum (1) to zero and maximum (16) to 15 for analysis. For categories between 2 (JPY 0.5–0.99 million) and 15 (JPY 10–14.99 million), we took the median value for analysis. The resultant JPY value was further transformed into its natural logarithm.

Statistical analyses

Age and gender effects have been shown to bias behavioral genetic analyses (McGue & Bouchard, 1998); therefore, each variable was adjusted for these effects by regressing each on age and gender and by utilizing the residual scale score in all subsequent analyses.

Traditional univariate genetic analysis decomposes observed (phenotypic) variance (V_P) into variances in additive genetic (V_A), shared (common) environmental (V_C), and nonshared environmental (V_E) effects. In equation form, this is represented as follows:

$$V_P = V_A + V_C + V_E \qquad (1)$$

Additive genetic variance reflects variation in multiple genotypes, whose influences are small and additive, and which together form a quantitative phenotype. Shared environmental variance reflects variation in environmental characteristics that makes family members resemble each other and differ from members of other families. Nonshared environmental variance reflects variation in environmental characteristics that are unique to each individual and makes family members different from each other even if they live together. Nonshared environmental variance also includes measurement errors.

These three parameters can be estimated by comparing the similarities between of identical and fraternal twin siblings. Identical twins reared together share all of their genes in addition to family environment. Therefore, genetic and shared environmental effects contribute to not only the variance of each sibling but also the covariance between siblings. Fraternal twins also share family environment, but they share, on an average, only half of their genetic variability. Therefore, while genetic effects contribute to the variance of each fraternal twin sibling, only half of the genetic effects are involved in the covariance between fraternal siblings. Shared environmental effects contribute to both, the variance of each sibling and covariance between siblings, as is the case for identical twins. In equation from, these are represented as

$$Cov_{ID} = V_A + V_C \qquad (2)$$
$$Cov_{FR} = 0.5V_A + V_C \qquad (3)$$

where Cov_{ID} and Cov_{FR} represent the covariance of identical and fraternal twins, respectively. With these equations, the three parameters can be estimated by multi-group structural equation modeling (Figure 1; see Neale & Maes, 2002, for more methodological details). This univariate genetic analysis was conducted separately for each of the following variables: academic achievement, education years, and income.

Although the univariate analyses mentioned above were conducted by pooling together the entire sample, the strength of genetic and environmental effects may well be different across participants' age or cohort (due to cross-sectional nature of the survey, the effects of age and cohort cannot be differentiated in the present study). Such moderating effects of age/cohort can be incorporated by the G × E interaction model (Purcell, 2002). In equation form,

$$V_{pj} = (a + \beta_a AGE_j)^2 + (c + \beta_c AGE_j)^2 + (e + \beta_e AGE_j)^2 \qquad (4)$$

where AGE_j represents age/cohort of the subsample; V_{pj} represents observed, phenotypic variance of the subsample whose age/cohort is AGE_j; a, c, and e represent the main effects of genes, shared environment, and nonshared environment, respectively; β_a, β_c, and β_e represent moderating effects of age/cohort for each of the genetic, shared and nonshared environmental effects, respectively. For example, a positive and statistically significant value of β_a indicates that genetic effects become stronger for the older ages/cohort. Age/cohort may also have main effects on each variable; therefore, mean structure also needs to be modeled. In equation form,

$$\mu_j = \alpha + \beta_\mu AGE_j \qquad (5)$$

where μ_j represents the expected mean of a subsample whose age/cohort is AGE_j, α represents intercept, and β_μ represents the effects of age/cohort on the mean of a dependent variable. Statistical significance of each parameter was assessed by fixing or freeing each parameter and comparing the Akaike's Information Criterion (AIC) of each model. The analyses were conducted separately for academic achievement, education years, and income.

Finally, in order to examine how academic achievement, education years, and income are interrelated through genetic and environmental effects, multivariate genetic analyses were conducted. When two or more variables are measured, not only variance of each variable but also covariance between variables can be decomposed into genetic, shared, and nonshared environmental sources. More generally, phenotypic variance-covariance matrix (Σ_p) can be decomposed into the sum of

genetic (Σ_a), shared environmental (Σ_c), and nonshared environmental variance-covariance matrices (Σ_e). This is simply an extension of formula (1):

$$\Sigma_p = \Sigma_a + \Sigma_c + \Sigma_e \qquad (6)$$

The underlying logic behind multivariate analysis is the same as the univariate one. For example, when researchers measure education years and income for each sibling at a time, they can calculate cross-correlations (i.e., the correlation between education of one sibling, and income of the other sibling). When the cross-correlation is higher for identical twins than for fraternal twins, it suggests common genetic effects between the two variables because differences across type of twins are attributable only to the greater genetic similarity of identical twins than that of fraternal twins. Similarly, a cross-correlation that is equally high for identical and fraternal twins suggests the presence of shared environmental effects common to the two variables; a cross-correlation that is low for both identical and fraternal twins while the two variables are correlated within individuals suggests the presence of nonshared environmental effects common to the two variables.

The most basic model in multivariate analyses is the Cholesky decomposition. In the Cholesky decomposition, each of the genetic, shared, and nonshared environmental variance-covariance matrices are decomposed into the product of a lower triangular matrix and its transpose. In equation form,

$$\Sigma_a = L_a \times L_a{}' \qquad (7)$$
$$\Sigma_c = L_c \times L_c{}' \qquad (8)$$
$$\Sigma_e = L_e \times L_e{}' \qquad (9)$$

where L_a, L_c, and L_e, represent the lower triangular matrix for genetic, shared environmental, and nonshared environmental effects, respectively. The Cholesky decomposition is a kind of saturated model with a minimum assumption required for twin data analyses (e.g., equal variance and its etiology between the two siblings), and is conducted only to confirm whether genetic, shared and nonshared environmental variance-covariance matrices are positive definite.

Figure 2 is a graphical representation of the Cholesky decomposition. Due to the saturated nature of the model, changing the order of variables does not alter goodness of fit. However, when there is a temporal or theoretical order in variables, such as in academic achievement, education years, and income in the present study, path coefficients can be interpreted such that the first latent factor (e.g., A1 for genetic effects in Figure 2) influences all the variables (a_{11}, a_{21}, a_{31}), the paths from the second factor (A2) represent effects after the influences from the first latent factor is accounted for (a_{22}, a_{32}), and a path from the third factor (A3) includes unique effects that are not

accounted for by the first and the second latent factors (a_{33}). For the purpose of the present study, the strengths of paths from shared environmental factors (C1–C3) are important because they suggest the degree of inequality of opportunity even controlling for genetic effects. All analyses were conducted using the computer program Mx (Neale et al., 2004).

Results and Discussion

Results of the univariate analyses are shown in Figure 3. Each of the genetic, shared and nonshared environmental influences were nearly equally important in each of the three variables. Notably, shared environmental effects were substantial, accounting for 34%, 47%, and 41% of the observed variation in academic achievement, education years, and income, respectively. These results suggest that the environment of family of origin plays an important role in attaining educational and economic success even when the confounding of genetic effects is considered.

Table 1 shows the model fit results on the moderating effects of age/cohort. These effects were not observed for academic achievement, but for education years and income. For education years, the full model (Model 1) with moderating effects of age/cohort on each of the genetic, shared, and nonshared environmental effects fit best. Figure 4 shows the proportion of variance explained by each of the genetic, shared, and nonshared environmental effects as a function of age/cohort. As noted in the Method section, the cross-sectional nature of the present study did not allow us to differentiate the effects of age from cohort. However, given the historical situation in Japan, where the number of adults who re-seek education once they enter the labor market is limited, the moderating effects may be due to cohort rather than age. In addition, for the older cohort, the economic situation of the family, residential area, and parents' educational aspiration may have mattered more in determining whether one received higher education.

For income, a model with moderating effects of age/cohort fit best only on shared and nonshared environmental influences (Model 4). Figure 5 shows the proportion of variance explained by each of the genetic, shared, and nonshared environmental effects as a function of age/cohort. The strength of genetic effects was constant across age/cohort; therefore, its relative strength increased for the older age/cohort as the strength of the shared environmental effects drastically decreased. Here again, it is not possible to differentiate effects of age from cohort. However, the smaller shared environmental effects on income, despite the larger shared environmental influences on education years for the older age/cohort, suggest that the results may be due to age rather than cohort. This suggests that while the environment of the family of origin plays an important role in explaining one's economic success in younger people, its effects decay and are overshadowed by the genetic endowment and environment unique to each individual as one gets older. However, it should be noted that cohort effects may also be present and the decay of family environmental effects observed

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in older participants may not fully apply to the younger cohort, where regular/non-regular employment is substantially associated with the possession of a bachelor's degree (Kosugi, 2010).

Results of the Cholesky decomposition are presented in Figure 6. Genes influencing academic achievement are also responsible for income, whereas those influencing education years are not. For shared environmental influences, a factor influencing academic achievement is also influencing education years, but not for income. However, importantly, a shared environmental factor that is independent of academic achievement was found to influence years of education as well as income, suggesting the presence of inequality of opportunity. There are shared environmental influences unique to income, but we cannot know from the present results whether they are due to wealth bequest, or to some unmeasured ability contributing to economic success. For nonshared environmental effects, all paths were positive and significant. Though small in effect size, education years are associated with income via the first and second factors. These results are consistent with the findings of Nakamuro and Inui (2012), based on data from the same survey. They utilized differences in identical twin pairs to control for genetic and shared environmental effects and reported a small Mincerian return on education (4.5%).

Finally, several methodological limitations should be noted. The most important limitation of the present study is unreliability of assessment. It is reasonable to assume that reporting information about one's sibling (especially for income) introduced bias and it mimicked the large shared environmental influences observed in the present study. Further, academic achievement was reported retrospectively and subjectively. Clearly, there is a need for a prospective panel survey for twins that employs more accurate assessment techniques. In addition, one's level of education may be more than just the number of years. Examining effects of having a bachelor's degree, different academic majors, and selectivity of schools would be a promising arena for future research.

Conclusion

Despite these limitations, the present study is among the first to show that inequality of opportunity exists in Japan even when genetic factors are controlled for. Specifically, for Japanese males, (1) individual differences in academic achievement, education years, and income are substantially influenced by shared family environment as well as genes, (2) family environmental influences on education are larger for the older cohort, whereas family environmental influences on income are larger for the younger ages, and (3) differences in family environment partly determines income via years of education, independently of academic achievement. Nevertheless, the fundamental message is that equality/inequality of opportunity need to be examined through studies using a genetically informative design.

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References

Akabayashi, H. et al. (2010). Kodomo no gakuryoku niha nani ga kankei shiteiruka: JHPS kodomo tokubetsu chosa no bunseki kekka kara (What are associated with children's academic achievement? Empirical results from the JHPS special survey for children). *Joint Research Center for Panel Studies Discussion Paper Series*, 2010-009, 1-29.

Ando, J. et al. (2013). Two cohort and three independent anonymous twin projects at the Keio Twin Research Center (KoTReC). *Twin Research and Human Genetics*, 16, 202-216.

Bjorklund, A. et al. (2005). Influences of nature and nurture on earnings variation: A report on a study of various sibling types in Sweden. In S. Bowles et al. (Eds.) *Unequal chances: Family background and economic success*. NJ: Princeton University Press.

Blanden, J. (2013). Cross-Country rankings in intergenerational mobility: A comparison of approaches from economics and sociology. *Journal of Economic Surveys*, 27, 38-73.

Calvin, C. M. et al. (2012). Multivariate genetic analyses of cognition and academic achievement from two population samples of 174,000 and 166,000 school children. *Behavior Genetics*, 42, 699-710.

Dworkin, R. (2000). *Sovereign virtue: The theory and practice of equality*. MA: Harvard University Press.

Heath, A. C. (1985). Education policy and the heritability of educational attainment. *Nature*, 314, 734-736

Hertz, T. et al. (2007). The inheritance of educational inequality: International comparisons and fifty-year trends. *The B.E. Journal of Economic Analysis & Policy*, 7, Article 10.

Hoshi, A. (2001). The determinants of the possession of property in a present family. *Journal of Population Problems*, 57, 36-48.

Katase, K. (2006). *Yume no yukue: Kokosei no kyoiku-shokugyo asupireshon no henyo (Destination of dreams: Changes in educational and occupational aspiration among high-school students)*. Miyagi: Tohoku University Press.

Kikkawa, T. (2006). *Education and social inequality: Contemporary educational credentialism in Japan* (in Japanese). Tokyo: University of Tokyo Press.

Kosugi, R. (2010). Wakamono to Shoki Kyaria: "Hi-Tenkei" karano shuppatsu no tameni (Young adults and early career: For departure from non-regular employment). Tokyo: Keiso Shobo.

Le A. T. et al. (2011). Opportunity and educational outcomes in Australia. *The Economic Record*, 87, 125–135.

Luciano, M. et al. (2006). The heritability of conscientiousness facets and their relationship to IQ and academic achievement. *Personality and Individual Differences*, 40, 1189–1199

Markowitz, E. M. et al. (2005). The etiology of mathematical and reading (dis)ability covariation in a sample of Dutch twins. *Twin Research and Human Genetics*, 8, 585-593.

Nakamuro, M. and Inui, T. (2012). Estimating the returns to education using a sample of twins: The case of Japan. RIETI Discussion Paper Series, 12-E-076, 1-26.

Neale, M. C. et al. (2004). *Mx software and documentation*. http://www.vcu.edu/mx/

Neale, M. C. and H. H. M. Maes (2002). *Methodology for genetic studies of twins and families*. Dordrecht: Kluwer Academic Publishers.

Nielsen, F. (2006). Achievement and ascription in educational attainment: Genetic and environmental influences on adolescent schooling. *Social Forces*, 85, 193-216.

Plomin, R., et al. (2008). *Behavioral Genetics. (5th edition)*. NY: Worth Publishers.

Purcell, S. (2002). Variance components models for gene-environment interaction in twin analysis. *Twin Research*, 5, 554-571.

Rawls, J. (2001). *Justice as fairness: A restatement* edited by E. Kelry. MA: Harvard University Press.

Roemer, J. E. (1998). *Equality of opportunity*. MA: Harvard University Press.

Sato, Y. and Yoshida, T. (2007). Hinkon no sedaikan rensa no jissho kenkyu: Shotoku ido no kanten kara (An empirical study on intergenerational reproduction of poverty in terms of income mobility). *Japanese Journal of Labour Studies*, 563, 75-83.

Seno, W. and Higeta, T. (2011). Some characteristics of, and issues in higher education in Japan: Implied by the "rate of return to education" (in Japanese). *NIER Research Bulletin*, 140, 249-263.

Silventoinen, K. et al. (2004). Heritability of body height and educational attainment in an international context: Comparison of adult twins in Minnesota and Finland. *American Journal of Human Biology*, 16, 544-555.

Turkheimer, E., (2000). Three laws of behavior genetics and what they mean. *Current Direction in Psychological Science*, 9, 160-164.

Yamada, K. (2011). Family background and economic outcomes in Japan. *Research Collection School of Economics (Open Access)*, Paper 1246, 1-32.

Yano, M. (2007). Kokosei no shingaku kodo to daigaku seisaku: Koko no genzai (Education continuance/discontinuance by high-school students and higher education policy: Contemporary high schools). *IDE Gendai no Koto Kyoiku*, 489, 13-19.

Yano, M. (2011). *"Shukanbyo" ni natta nippon no daigaku: 18sai shugi, sotsugyo shugi, oya-futan shugi karano kaiho (Japanese university system as "life-style disease": Liberation from 18-year-old-ism, No-dropout-ism, and parental-burden-ism)*. Tokyo: Nihon Tosho Center.

Table 1. Model-Fit Results on models with different moderating effects of age/cohort.

	outcome								
	Academic achievement			Education years			Income		
Model	*-2LL*	*df*	*AIC*	*-2LL*	*df*	*AIC*	*-2LL*	*df*	*AIC*
1 Full	5367.08	1955	1457.08	**8598.68**	**2004**	**4590.68**	4932.85	2004	924.848
2 No moderation on E	5368.48	1956	1456.48	8601.14	2005	4591.14	4958.53	2005	948.535
3 No moderation on C	5369.01	1956	1457.01	8601.7	2005	4591.7	4945.65	2005	935.652
4 No moderation on A	5367.92	1956	1455.92	8606.29	2005	4596.29	**4932.85**	**2005**	**922.848**
5 No moderation on CE	5371.13	1957	1457.13	8603.87	2006	4591.87	4981.08	2006	969.077
6 No moderation on AE	5370.41	1957	1456.41	8607.33	2006	4595.33	4958.54	2006	946.538
7 No moderation on AC	5369.32	1957	1455.32	8607.92	2006	4595.92	4993.21	2006	981.208
8 No moderation	**5371.13**	**1958**	**1455.13**	8608.55	2007	4594.55	5009.12	2007	995.123

Note. -2LL: -2 times log-likelihood; df: degree of freedom; AIC: Akaike's Information Criterion; A: additive genetic effects; C: shared environmental effects; E: nonshared environmental effects.
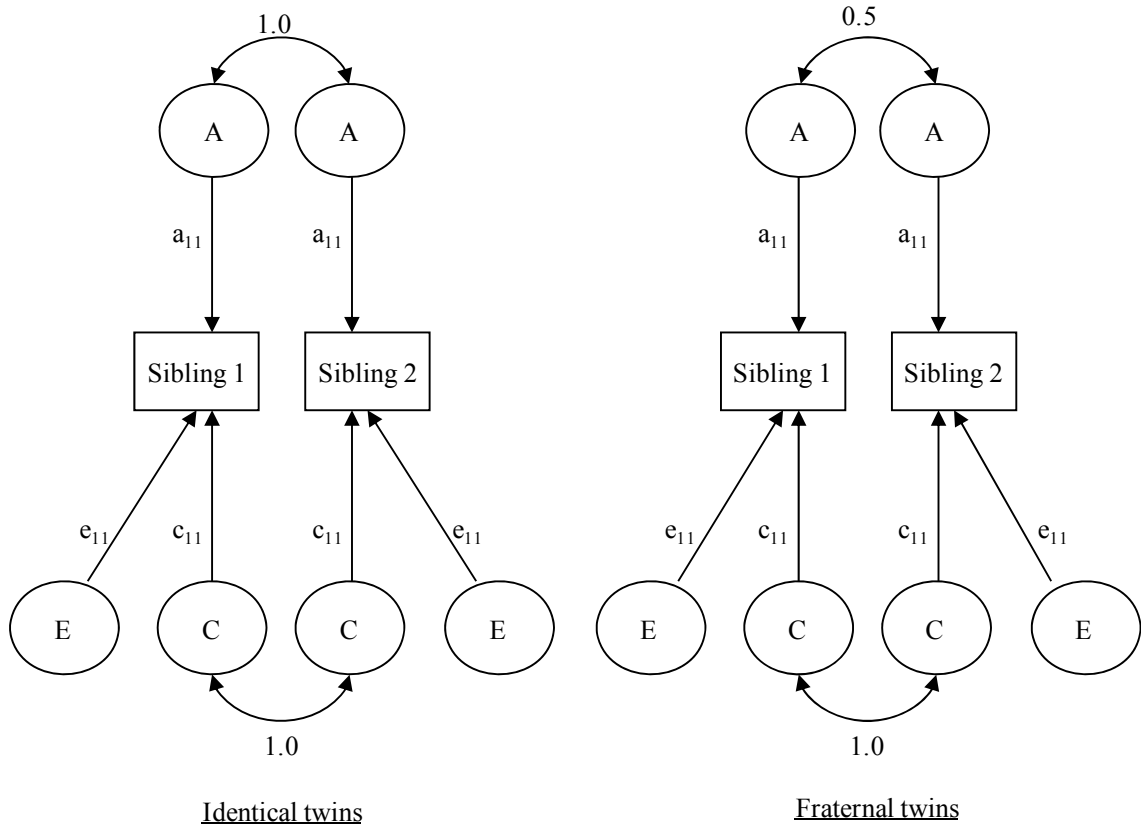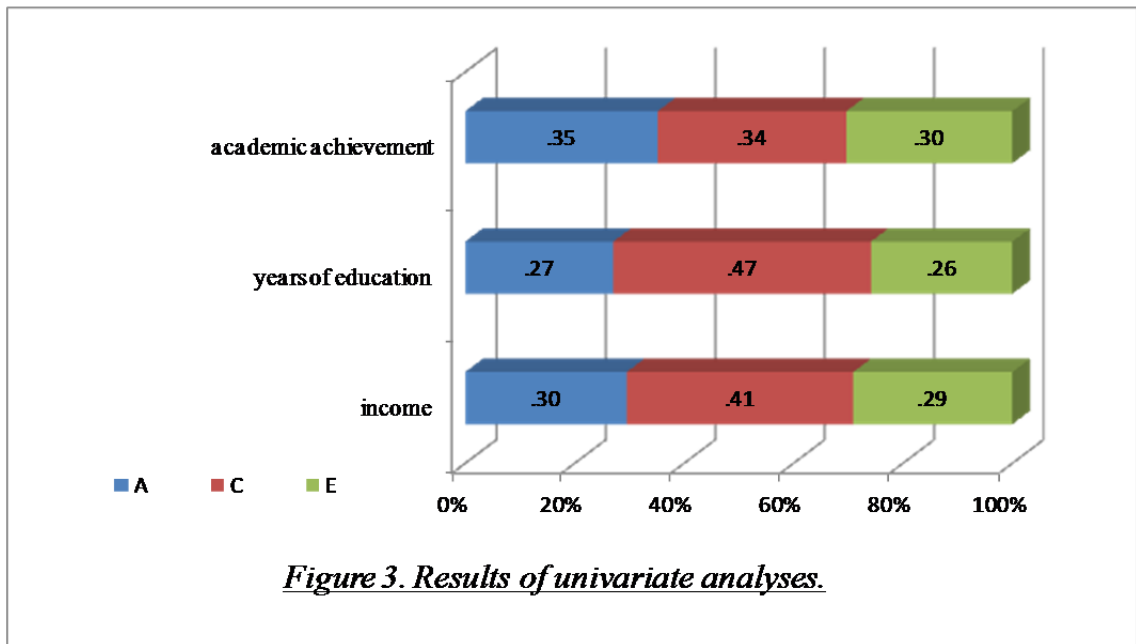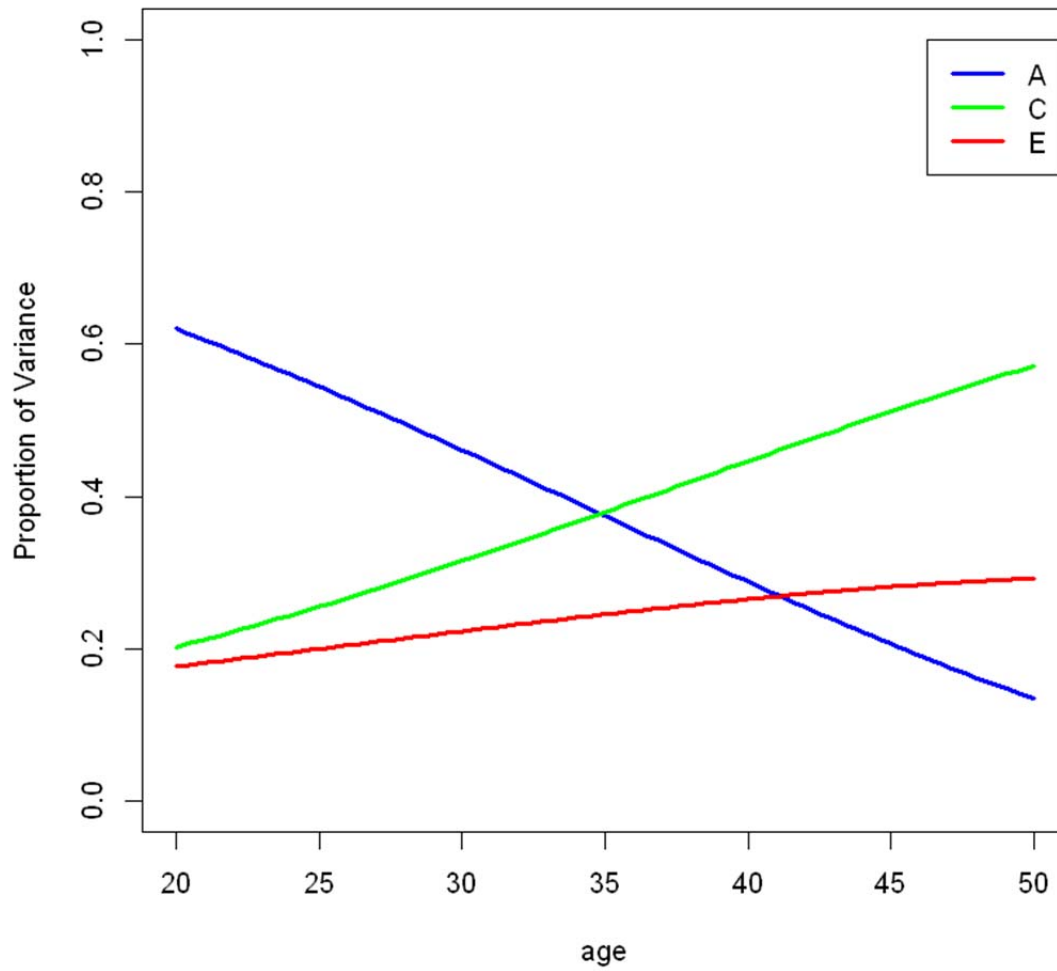
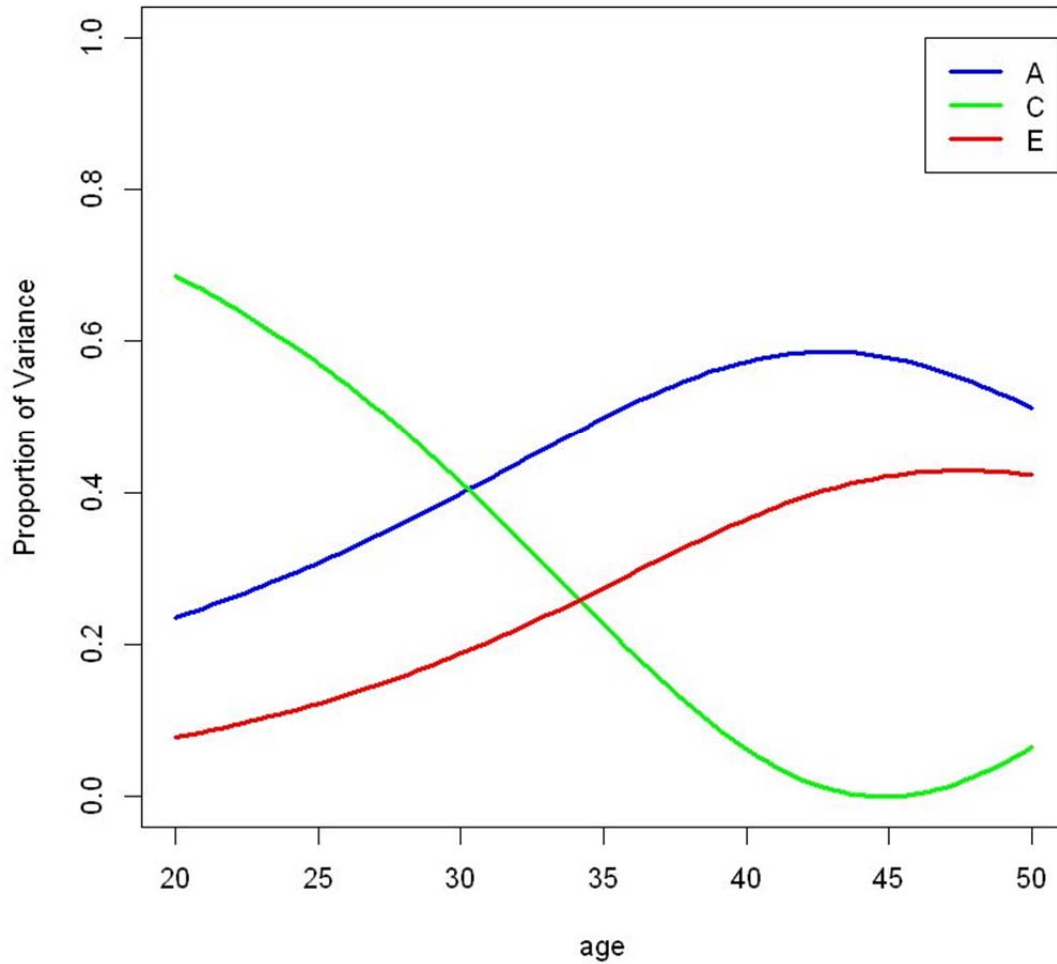*Figure 1. Graphical representation of univariate genetic analysis.*
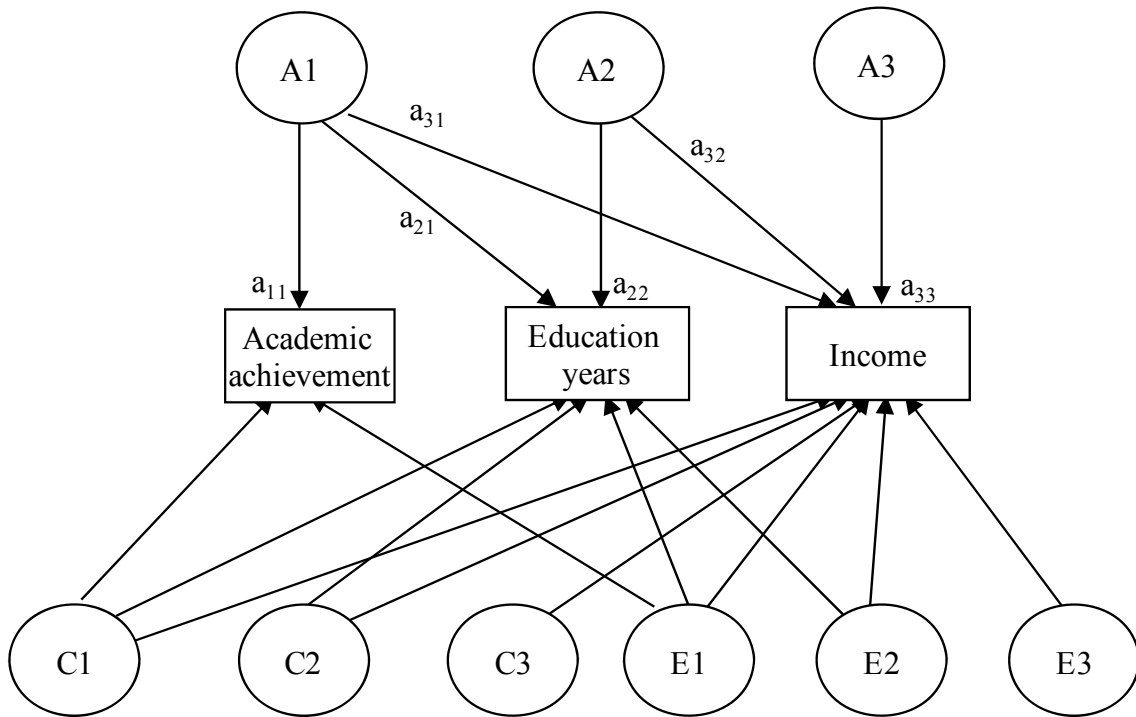
Figure 2. Graphical representation of Cholesky decomposition.

*Figure 3. Results of univariate analyses.*

Figure 4. Proportions of variance in education years explained by genetic (A), shared environmental (C), and nonshared environmental influences (E), moderated by age/cohort.

Figure 5. Proportions of variance in income explained by genetic (A), shared environmental (C), and nonshared environmental influences (E), moderated by age/cohort.
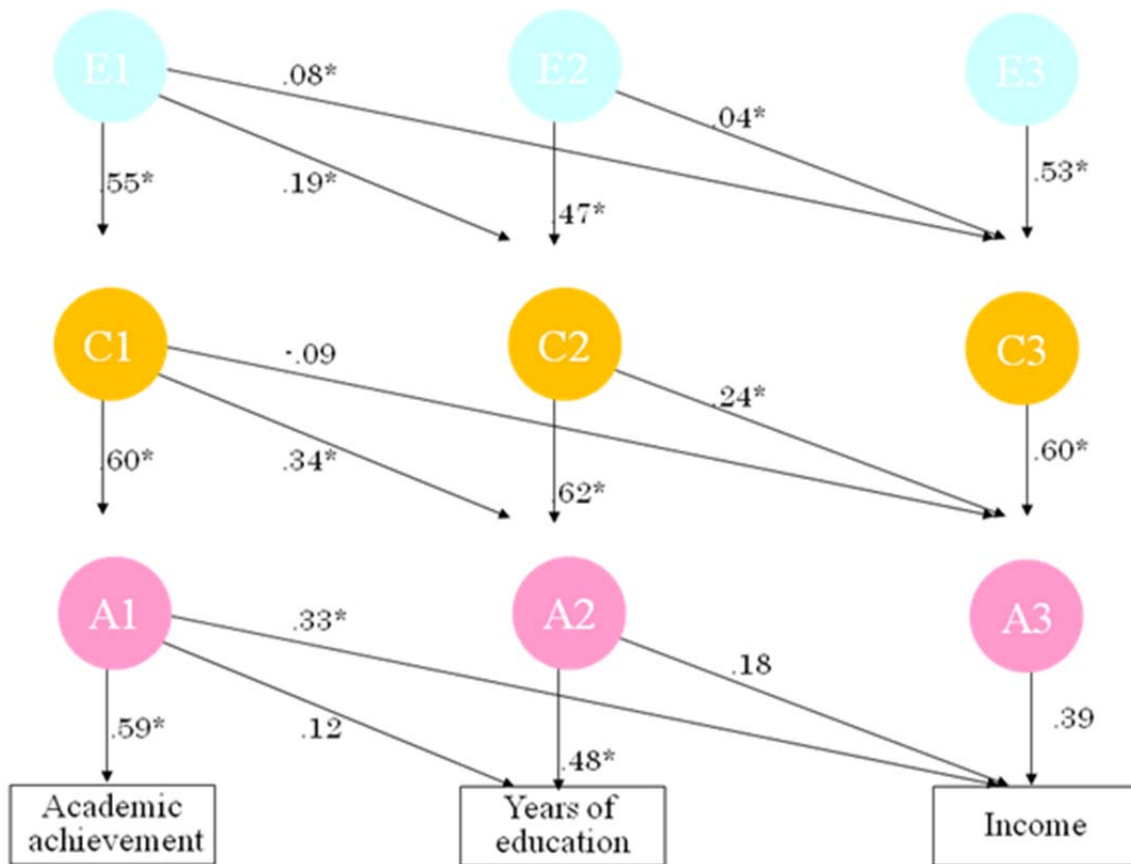
Figure 6. Results of Cholesky decomposition