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The role of locus of control in adulthood outcomes: Evidence from Australian twins[☆,☆☆]

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ABSTRACT

We study the impact of locus of control on adulthood outcomes. We address the issue of omitted shared family background and genetic factors using data on monozygotic (MZ) and dizygotic (DZ) twins from Australia. Estimation results are highly sensitive to controlling adequately for shared background and genes. While the associations between locus of control and most adulthood outcomes are statistically significant and similar across OLS and DZ twins fixed effect models, they are insignificant in the MZ twins fixed effect models. Two important exceptions emerge. Locus of control remains significantly associated with regular physical exercise and occupational rank, in line with the previous literature. We discuss the implications of our findings.

1. Introduction

Incorporating non-cognitive skills into economic analysis is an important development over the past two decades. The role of such skills in shaping individual behaviour has been examined in a number of socio-economic contexts, including health, educational attainment, employment status, earnings and proclivity to engage in risky behaviour (see Heckman and Rubinstein, 2001; Nyhus and Pons, 2005; Groves, 2005; Heckman et al., 2006; Mueller and Plug, 2006; Flossmann et al., 2007; Heineck and Anger, 2010; Fletcher, 2013; Gensowski, 2018).

Locus of control is one of the most frequently studied non-cognitive skills in economics. This trait captures the extent to which individuals perceive success or failure in life as being self-determined (internal) versus the role of chance or control of others (external). Prior studies investigate the association between locus of control and a variety of economic behaviour and suggest that individuals with a stronger internal locus of control tend to: save more (Cobb-Clark et al., 2016), have a

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healthier lifestyle (Cobb-Clark et al., 2014), more readily adopt new technology in agricultural production (Abay et al., 2017), invest more time in parenting (Lekfuangfu et al., 2018), have higher earnings (e.g. Piatek and Pinger, 2016; Heineck and Anger, 2010; Schnitzlein and Stephani, 2016), invest in more intensive job search (e.g. Caliendo et al., 2015; McGee, 2015; McGee and McGee, 2016) and return to employment more rapidly after a health shock (Schurer, 2017) and child birth (Berger and Haywood, 2016).

The literature proposes a number of distinct theoretical mechanisms underlying the positive association between (internal) locus of control and socio-economic outcomes. An internal locus of control is deemed to increase the perceived benefit of human capital accumulation and reduce the psychic costs of exerting effort. Thus, an internal locus of control tends to increase human capital acquisition (broadly defined), and boost labour market returns (Cobb-Clark, 2015). On the other hand, a strong internal locus of control may increase the level of independence of the individual, i.e. less likely to accept advice from others and consequently less adept at successful teamwork (Avtgis, 1998). Thus the overall impact of locus of control is an empirical question and cannot be predicted *a priori*.

There are a number of econometric issues arising from adoption of cross-sectional methods in estimating the role of locus of control in economic behaviour. Locus of control may be correlated with the error term, leading to biased and inconsistent estimates. There are several potential reasons; Cobb-Clark and Schurer (2013) examine measurement error and reverse causation, Cebi (2007) and Abay et al. (2017) discuss the role of omitted variables. The majority of literature side-steps the above issues by assuming locus of control is pre-determined and the behavioural model correctly specified. Support for this approach is garnered by recent literature suggesting locus of control is relatively stable for the working-age population (see Specht et al., 2013; Cobb-Clark and Schurer, 2013). This has led analysis to focus on individual variation using cross-sectional methods, particularly OLS (Abay et al., 2017).

A long-established literature in genetics argues that all non-cognitive/personality traits share a component that is heritable (see the review by Beauchamp et al., 2011, page 64). Miller and Rose (1982) and Pedersen et al. (1989) suggest that between 30 and 50% of variation of locus of control is attributable to genetics. Since genetic factors in turn likely affect socio-economic outcomes, prior empirical estimates of the impact of locus of control may suffer from significant omitted variable bias.

Our focus is on estimating the effect of locus of control on adulthood outcomes, i.e. educational attainment, occupation and employment status, income and healthy habits. We employ a novel twin design, drawing samples of monozygotic (MZ) and dizygotic (DZ) twins from the Australian Twins registry, to mitigate the potential omitted variable problem. In terms of econometric results, we begin with OLS, our estimates largely replicate prior literature, with internal locus of control associated with better adulthood outcomes. DZ twin fixed effect estimates are similar to the OLS results, though slightly smaller in magnitude. However, the MZ twin fixed effect locus of control estimates are in general both statistically and economically insignificant. Thus in general the cross-sectional methods may over-estimate the effect of locus of control. However, there are two important exceptions in terms of MZ results, with significant locus of control effects for outcomes relating to occupational rank and physical exercise surviving the twin fixed effects method, i.e. even after controlling for omitted variables.

Finally, we explore the sensitivity of our results to the potential role of measurement error, reverse causality, a within-family externality and alternative constructions of the locus of control measure. The results are found to be relatively robust. We utilise the Household, Income and Labour Dynamics in Australia (HILDA) data to explore the sensitivity of locus of control effects to an alternative sample and fuller specification. The OLS estimates derived from our twins sample and the HILDA general sample are similar, providing indicative evidence in support of the external validity of our twins sample.

The remainder of the paper is structured as follows. Section 2 examines the econometric methodology. Section 3 describes the data. Section 4 details the main empirical results. Sections 5 and 6 discuss robustness and external validity respectively. Section 7 concludes.

2. Econometric methodology

This paper models the effect of locus of control on a variety of outcome measures, y_{ij}, as follows:

$$y_{ij} = \beta_0 + \beta_1 LOC_{ij} + \boldsymbol{\beta}_2 \boldsymbol{X_{ij}} + \boldsymbol{\beta}_3 \boldsymbol{Z_j} + \mu_{ij}^1 + \mu_j^2 + \epsilon_{ij}, \tag{1}$$

for individual i in twin set j. The key dependant variables include level of education, labour market outcomes (i.e. occupational and employment status and income) and healthy habits (i.e. binge drinking, smoking and exercise regime). The independent variables are as follows; LOC_{ij} is the locus of control, and $\boldsymbol{X_{ij}}$ is a vector of control variables which may vary across individuals within the twin set, including education, marital status and personality measures depending on the specification.[1] $\boldsymbol{Z_j}$ is a vector of observable twin-set characteristics (e.g. age, household size and other observed family background); μ_{ij}^1 is unobserved genetic factors which may differ across twins; μ_j^2 is the unobserved shared family background

[1] In the main analysis, we exclude other personality traits from the specification following the literature (e.g. Andrisani, 1977; Coleman and DeLeire, 2003; Cebi, 2007; Piatek and Pinger, 2016). As part of the robustness check we explore the impact of including personality measures among the covariates. The results are robust to their inclusion as shown in Section 5.

characteristics, such as early childhood experience; and ϵ_{ij} is the error term and is typically assumed to be exogenous in the twins literature.[2]

The OLS estimator for a typical household survey is $\hat{\beta}_1^{OLS} \xrightarrow{p} \beta_1 + \frac{Cov(\mu_{ij}^1+\mu_j^2, LOC_{ij})}{Var(LOC_{ij})}$.[3] The unobserved factors, μ_{ij}^1 and μ_j^2, imply that in general OLS is inconsistent. The current paper utilises a twins design to mitigate the omitted variable problem. Theoretically, the non-shared environmental factors, e.g. different peers or health problems (see Ahlin and Antunes, 2015; Fletcher and Schurer, 2017; Elkins et al., 2017) may lead to considerable within-twins variation in locus of control. In Section 3.3, we demonstrate empirically in our case the variation is substantial even for MZ twins. This validates the adoption of the twin fixed effects estimator.

There is a significant body of economic literature that uses data on twins, see e.g. Ashenfelter and Rouse (1998) and Miller et al. (1995) estimate the rate of return to education and Lundborg (2013) and Webbink et al. (2010) estimate the causal impact of education on health. The twin fixed effects (hereafter 'twin FE') estimator is used to control for unobserved genetic and family background, i.e. μ_{ij}^1 and μ_j^2 respectively. We follow this well-trodden path using independent samples of MZ and DZ twins, to identify the effect of locus of control in adulthood outcomes allowing for the role of omitted variables.

In particular, we assume that adulthood outcomes of each twin follow Eq. (1) ($i = 1, 2$). For the DZ twins, this implies the within-twins difference:

$$y_{1j} - y_{2j} = \beta_1\left(LOC_{1j} - LOC_{2j}\right) + \boldsymbol{\beta}_2\left(\boldsymbol{X}_{1j} - \boldsymbol{X}_{2j}\right) + \left(\mu_{1j}^1 - \mu_{2j}^1\right) + \left(\epsilon_{1j} - \epsilon_{2j}\right), \tag{2}$$

as DZ twins share the same family background but generally have different genetic endowments. As MZ twins share both the same family background and identical genetic factors, the within-twins difference is:

$$y_{1j} - y_{2j} = \beta_1\left(LOC_{1j} - LOC_{2j}\right) + \boldsymbol{\beta}_2\left(\boldsymbol{X}_{1j} - \boldsymbol{X}_{2j}\right) + \left(\epsilon_{1j} - \epsilon_{2j}\right). \tag{3}$$

The above two equations imply the twin FE estimators for DZ and MZ twins are $\hat{\beta}_1^{FE,DZ} \xrightarrow{p} \beta_1 + \frac{Cov(\Delta LOC_j,\ \Delta\mu_j^1)}{Var(\Delta LOC_j)}$ and $\hat{\beta}_1^{FE,MZ} \xrightarrow{p} \beta_1$, respectively, where Δ denotes the within-twin-set difference. Clearly, while (2) purges the impact of μ_j^2, the DZ twin FE estimator is still inconsistent due to the existence of μ_{ij}^1.[4] In contrast, the MZ twin FE estimator is consistent, as it further purges the impact of μ_{ij}^1. The difference between these two estimators for the DZ and MZ samples allows us to understand the degree of bias generated by genetic factors.

While the MZ twin FE estimator purges the omitted variables μ_{ij}^1 and μ_j^2, this does not necessarily fully resolve the issue of correlation between locus of control and the error term. Residual endogeneity may still exist in $\Delta\epsilon_{ij}$ (i.e. Bound and Solon, 1999; Neumark, 1999). Behrman and Rosenzweig (2004) show that substantial variation of birth weight exists within MZ twin sets, and this variation predicts schooling attainment. Similarly, Sandewall et al. (2014) find that MZ twins may differ in cognitive skills which in turn are a strong predictor of educational attainment.[5] Given this, the twin FE estimator may not uncover the true causal effect, as twin differences in locus of control may not be equivalent to the random toss of a coin. However, even in this situation the fixed effects estimator is likely to be less biased than the OLS alternative, as the evidence in Section 4 illustrates.

One other potential issue with the twin FE estimator is that it may exacerbate the attenuation bias caused by measurement error, as the within-twins difference removes substantial variation in the "signal" but may not remove a commensurate amount of "noise". In Section 5, we further discuss this issue and demonstrate that our results are unlikely to be driven by measurement error.[6]

3. Data

3.1. Data description

The data employed in the current paper is from a mail survey conducted in 1988 to 1991 on the older cohort (or the Canberra sample) of twins enroled in the Australian National Health and Medical Research Council Twin Registry (ATR hereafter). All the respondents were aged 24 and over in 1988. The survey gathered information on each respondent's family

[2] Variables without subscript i are common to both twins within a particular twin set.

[3] All of the omitted variable formulae assume either the bivariate case of simple regression or alternatively that none of the included variables other than locus of control are correlated with the error term, see Wooldridge (2010).

[4] Theoretically speaking, $\hat{\beta}_1^{FE,DZ}$ may be larger, smaller or equal to $\hat{\beta}_1^{OLS}$ depending upon the relative sizes of $Cov(\mu_{ij}^1 + \mu_j^2, LOC_{ij})$, $Var(LOC_{ij})$, $Cov(\Delta LOC_j,\ \Delta\mu_{ij}^1)$, $Var(\Delta LOC_j)$ and sampling error.

[5] Another possible source of bias is the differential parental treatment of twin pairs, due to different endowments and child disposition. However, this bias is likely to be much smaller for MZ twins than that for DZ twins or regular siblings. As MZ twins share much more similar endowments parents are likely to find it more difficult to treat identical twins differentially (Ashenfelter and Rouse, 1998).

[6] The twins strategy has an advantage over the individual fixed effect model. Since the locus of control of working-age population is generally stable (Specht et al., 2013; Cobb-Clark and Schurer, 2013), the individual fixed effect model may be more vulnerable to the measurement error issue and less likely to capture the long-run effect if the time span of the data is short (also see the discussion in Abay et al., 2017).

background, socioeconomic status, including education, employment status, occupation, income, religion, political preference, healthy habits and personality. In addition and of particular importance for the current paper, the survey collected information pertaining to locus of control for female respondents. This survey together with other related ATR surveys spawned a number of important studies in economics (e.g. Miller et al., 1995, 2001; Webbink et al., 2008; Webbink et al., 2011; Plug et al., 2014).

We restrict attention to female twins, as unfortunately the survey did not ask male respondents about their locus of control. In the survey, there are 1830 complete sets of female twins. As our focus is mainly on those in the labour market, we further restrict the sample to respondents aged between 24 and 60 and exclude students and those with missing values for the covariates. This leaves us with 1145 complete sets of female twins for the analysis, comprising 722 sets of MZ twins and 423 sets of DZ twins.[7,8]

3.2. Construction of key variables

The empirical analysis examines the impact of locus of control on a sequence of adulthood outcomes including level of education, occupational and employment status, individual income and healthy habits. This section describes the derivation of the key variables used in the empirical analysis.

3.2.1. Locus of control

The locus of control measure is derived from the Psychological Coping Resources component of the Mastery Module proposed by Pearlin and Schooler (1978). The measure captures the extent to which an individual believes the outcomes of life events are under their own control. The measure is included in the widely-used household survey, Household, Income and Labour Dynamics in Australia (HILDA) which has generated a number of important studies relating to locus of control (e.g. Cobb-Clark and Schurer, 2013; Cobb-Clark et al., 2014, 2016).

In particular, our locus of control measure is constructed based on how strongly the respondent agrees or disagrees with the following seven statements:

1. There is really no way I can solve some of the problems I have;
2. Sometimes I feel that I'm pushed around in life;
3. I have little control over things that happen to me;
4. What happens to me in the future mostly depends on me;
5. I can do just about anything I really set my mind to;
6. I often feel helpless in dealing with the problems of life;
7. There is little I can do to change many important things in my life.

In the current context answers for each of the 7 items are coded along a four-point scale, i.e. strongly agree (1), agree (2), disagree (3) and strongly disagree (4). Items 4 and 5 reflect the internal locus of control, while the others reflect an external focus.[9] As this is the first twin study in economics using this measure of locus of control, we conduct an exploratory factor analysis. Fig. 1 illustrates that the information contained in the seven questions may be summarised by the first factor.[10] Fig. 2 further demonstrates that the seven questions form two distinct clusters according to the loadings of the first factor; i.e. items 4 and 5 (internal locus of control) and the other five (external locus of control). This is consistent with Cobb-Clark and Schurer (2013), Cobb-Clark et al. (2014) and Caliendo et al. (2015). We also conduct a test of the internal consistency of the seven questions, the Cronbach's α is 0.73.[11]

Given the above findings, we follow the literature in constructing two measures of locus of control. We reverse items 4 and 5 and take the sum of all 7 items as the main measure. For the alternative measure once again items 4 and 5 are reversed and we use the first predicted factor from the analysis. The advantage of the first measure is transparency, while the advantage of the alternative is that it contains less measurement error (Piatek and Pinger, 2016). As the factor measure represents a generated regressor, we employ bootstrapped standard errors in this case and use it in the robustness check.[12] For ease of interpretation, we standardise both measures to have a mean of zero and a standard deviation of one. The higher the value, the stronger the internal locus of control.

3.2.2. Outcome variables

Outcome variables include educational attainment, labour market related variables together with healthy habits. The education related variables are constructed based on the question asking the respondent their highest completed educational

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[7] Zygosity was determined from self-reported questions which are shown to have in excess of 95% agreement rate with blood typing (Cederlöf et al., 1961; Martin and Martin, 1975; Magnus et al., 1983; Posner et al., 1996). For the questionable or inconsistent self-reported answers, twins were contacted for further information, and usually twins provided pictures to help to determine zygosity.

[8] Note that the sample size differs slightly across regressions in Sections 4 and 5 due to differing numbers of missing values for each outcome variable.

[9] Note that these seven questions are identical to those contained in HILDA, but HILDA uses a Likert 7-point response scale.

[10] Eigenvalues of all other factors are less than one

[11] Note that the value of Cronback's α indicates the presence of measurement error. We discuss the robustness of our results with respect to measurement error in Section 5.

[12] We are grateful to an anonymous referee for pointing this out.

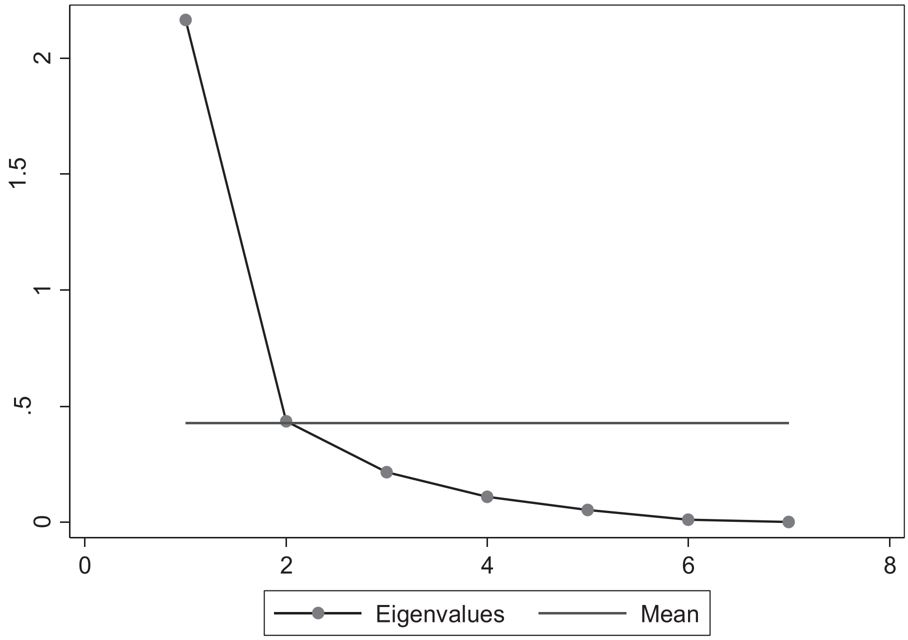


Fig. 1. Scree plot of eigenvalues after factor.
Notes: The horizontal line shows the mean value of the eigenvalues of all the seven factors.

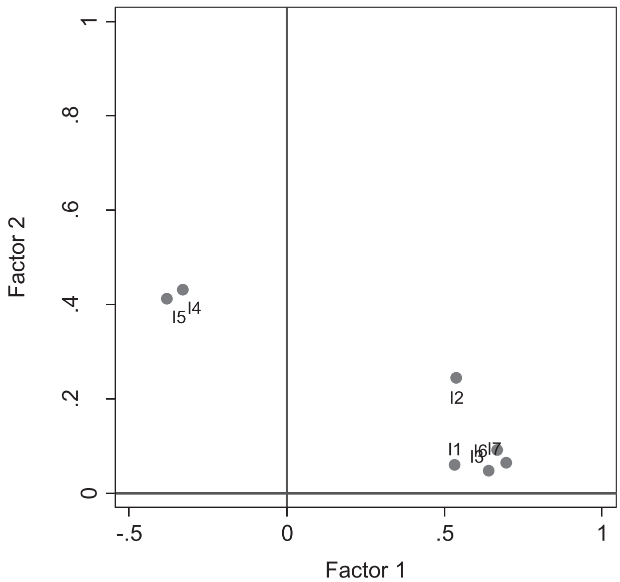


Fig. 2. Factor loadings.

level. Following Miller et al. (1995), we first recode the categories “less than 7 years’ schooling”, “8–10 years’ schooling”, “11–12 years’ schooling”, “apprenticeship, diploma, etc.”, “technical or teachers’ college”, “university first degree” and “university post-graduate training” to provide an equivalent years of formal schooling: i.e. 5, 9, 11.5, 11.5, 13, 15 and 17 years respectively. This is our primary continuous education variable. The other education outcome is a dummy variable representing whether or not the individual attained a university degree or higher.

The labour market outcome variables capture employment and occupational status, as well as income. Specifically, the employment information is obtained from the question asking the respondent to select the most appropriate category from a mutually exclusive list: “student”, “unemployed”, “part-time”, “homemaker”, “full-time”, “retired” and “other”.[13] We con-

[13] Note that we exclude from our sample, twin sets in which one or both siblings are students.

struct two dummy variables capturing employment status. One reflects whether or not the respondent works either full or part-time, and the other identifies full-time employment status only.

The survey asked each respondent to describe in detail “their usual and regular lifetime occupation”. These descriptors are subsequently recoded as nine major Australian Standard Classification of Occupations (ASCO) groups: “managerial and administrative”, “professional”, “para-professional”, “trades”, “clerical”, “sales and personal service workers”, “plant and machine operators and drivers”, “labourer and related workers” and “homemakers, students and others”. We then define a dummy variable for higher ranked occupational status if worked within managerial, administrative and professional.

The income measure is constructed based on the following survey question: “Thinking of the income your family makes from all sources–salaries, investments, pensions, and other sources—approximately how much did ***you*** earn before tax (gross) during 1987–88?” The possible answers are “(1) none, (2) under $5000, (3) 5000–10,000, (4) 10,000–15,000, (5) 15,000–25,000, (6) 25,000–35,000, (7) 35,000–50,000, (8) over 50,000.” We convert these ranges to a continuous measure by taking the mid-points of Options 2 to 7, assigning zero to Option 1 and assigning $57,500 to Option 8. We then take the natural logarithm as the key income variable. In the following analysis, we analyse income for two distinct samples. One sample includes all respondents who recorded a positive income, and the other includes all respondents working either full or part-time. The latter captures labour income more definitively.

Finally, we construct three measures of healthy habits: whether the respondent was a smoker, binge drinker, and engaged in frequent exercise. The smoking measure is based on the survey question asking whether the respondent was a smoker at the time of the survey. The binge drinking measure is constructed based on the question “what is the greatest number of drinks you have had in a single day in the past 12 months”. To be consistent with Cobb-Clark et al. (2014), we define having less than 5 drinks in a single day as avoiding binge drinking. The exercise measure is extracted from the question asking the respondent which option best describes their exercise regime: “(1) Don’t know; (2) No leisure exercise or sport; (3) Occasional exercise (2–3 times a month) or regular light gardening; (4) Regular exercise about once a week; (5) Exercise or sports activity a couple of times a week; (6) Jogging, cycling to work, or vigorous sports activity (swimming, etc.) at least 3–4 times a week; (7) Jogging, cycling to work, or vigorous sports activity/exercise daily or more often.” We define Options 6 and 7 as one, Option 1 as missing, and the others as zero. In line with Cobb-Clark et al. (2014), the constructed measure indicates if the respondent engaged in exercise three or more times per week.

3.3. Summary statistics

We begin with Table 1 which presents summary statistics for the sample analysed in the current paper. In particular, the first column shows the mean, standard deviation and sample size for the full sample, the second and third columns differentiate between the DZ and MZ twin samples, and the last column shows the difference in means between the two. The statistics suggest that 66.4% of women were employed, with 38.8% working full-time and 27.8% in managerial, administrative or professional positions. The average natural logarithm of income is 9.5. 78.5% did not smoke at the time of the survey, 53.9% avoided binge drinking in the 12 months prior to the survey, and 13.3% engaged in exercise at least three times per week. The average age of respondents at the time of the survey is 38. The education distribution shows that only 1% of the sample had less than 7 years’ schooling, and the majority (55.7%) had between 8 and 12 years of schooling. 28.6% had an apprenticeship, diploma, technical or teachers’ college as their highest qualification, and only 14.7% had a university degree or above. In addition, 80.1% of the sample were married. The last column shows that the MZ and DZ twins generally have similar characteristics, although the former has more respondents with 8–10 years of schooling.

Regarding our key variable, locus of control, Table 1 shows the mean and standard deviation of both standardised measures for DZ and MZ samples.[14] Fig. 3 further illustrates the distributions of the two measures and the similarity between MZ and DZ twins. We now turn to examining the twins nature of the locus of control measures. Table 2 suggests that our within-twins sample correlations are generally comparable to those in the literature. The sample correlation coefficient for DZ twins is smaller than that of MZ twins, consistent with sharing less genetic background. The magnitude of the correlation coefficients for our samples (i.e. DZ 0.18 and MZ 0.35) demonstrate like other non-cognitive traits, locus of control is shaped by both heritable genetics and environmental factors.[15,16] In our case using Falconer’s formula, the correlation coefficients of locus of control imply genetic factors explain 34% of the variance of locus of control. This is consistent with the prior findings in the literature.[17]

Second, we explore the relationship between the variance of the within-twins-difference vis a vis the individual variance of locus of control;

$$Var\left(LOC_{1j} - LOC_{2j}\right) = Var\left(LOC_{1j}\right) + Var\left(LOC_{2j}\right) - 2\rho\sqrt{Var\left(LOC_{1j}\right)Var\left(LOC_{2j}\right)}, \tag{4}$$

[14] Minor discrepancies exist between the DZ and MZ samples for standardized mean and variance (0 and 1).

[15] The correlation coefficients of the factor measure of locus of control are 0.19 and 0.36 for the DZ and MZ twins in our sample, respectively.

[16] The environment factors (i.e. non-genetic factors) include (but is not limited to) parenting style, childhood adverse experience, adolescence health condition and peer and neighbourhood context (see e.g. Ahlin and Antunes, 2015; Fletcher and Schurer, 2017; Elkins et al., 2017; Elkins and Schurer, 2020).

[17] The Falconer’s formula (see Arbet et al. (2018)) suggests that the share of variation of locus of control attributed to genetic factors is double the difference in the correlation coefficients between the MZ and DZ twins.

Table 1
Summary statistics.

	Total (1)	DZ Twins (2)	MZ Twins (3)	DZ-MZ (4)
Full-time or part-time employed	0.664	0.643	0.675	−0.032
	(0.473)	(0.479)	(0.468)	
	[2262]	[830]	[1432]	
Full-time employed	0.388	0.375	0.396	−0.021
	(0.487)	(0.484)	(0.489)	
	[2262]	[830]	[1432]	
Higher ranked occupation	0.278	0.256	0.290	−0.034*
	(0.448)	(0.437)	(0.454)	
	[2242]	[816]	[1426]	
Log annual income	9.509	9.501	9.514	−0.013
	(0.876)	(0.870)	(0.880)	
	[1490]	[544]	[946]	
Non-smoker	0.785	0.798	0.778	0.020
	(0.411)	(0.402)	(0.416)	
	[2282]	[842]	[1440]	
Avoid binge drinking	0.539	0.530	0.543	−0.013
	(0.499)	(0.500)	(0.498)	
	[1166]	[398]	[768]	
Exercise 3 times or more per week	0.133	0.117	0.143	−0.025*
	(0.340)	(0.322)	(0.350)	
	[2240]	[826]	[1414]	
LOC: the main measure	0.000	−0.012	0.007	−0.019
		(0.975)	(1.015)	
	[2290]	[846]	[1444]	
LOC: the factor measure	0.000	−0.011	0.006	−0.017
		(0.973)	(1.016)	
	[2290]	[846]	[1444]	
Age	38.286	38.296	38.281	0.015
	(8.921)	(9.042)	(8.853)	
	[2290]	[846]	[1444]	
Less than 7 years' schooling	0.010	0.013	0.008	0.005
	(0.0997)	(0.113)	(0.0908)	
	[2290]	[846]	[1444]	
8–10 years' schooling	0.313	0.285	0.330	−0.045**
	(0.464)	(0.452)	(0.470)	
	[2290]	[846]	[1444]	
11–12 years' schooling	0.244	0.265	0.232	0.033*
	(0.430)	(0.441)	(0.422)	
	[2290]	[846]	[1444]	
Apprenticeship, diploma, etc.	0.138	0.147	0.132	0.015
	(0.345)	(0.354)	(0.339)	
	[2290]	[846]	[1444]	
Technical or teachers' college	0.148	0.149	0.148	0.001
	(0.356)	(0.356)	(0.355)	
	[2290]	[846]	[1444]	
University first degree	0.091	0.093	0.089	0.004
	(0.287)	(0.291)	(0.285)	
	[2290]	[846]	[1444]	
University post-graduate degree	0.056	0.048	0.060	−0.012
	(0.230)	(0.215)	(0.238)	
	[2290]	[846]	[1444]	
Married	0.801	0.792	0.807	−0.015
	(0.399)	(0.406)	(0.395)	
	[2290]	[846]	[1444]	

Note: The summary statistics of the full sample, the MZ twins and the DZ twins are shown in Columns (1), (2) and (3), respectively. Standard deviations are shown in the parentheses, and samples sizes are shown in the brackets. Column (4) shows the difference between DZ twins and MZ twins.

*** Significant at 1% level.

** significant at 5% level.

* significant at 10% level. The significance levels are derived from t-test.

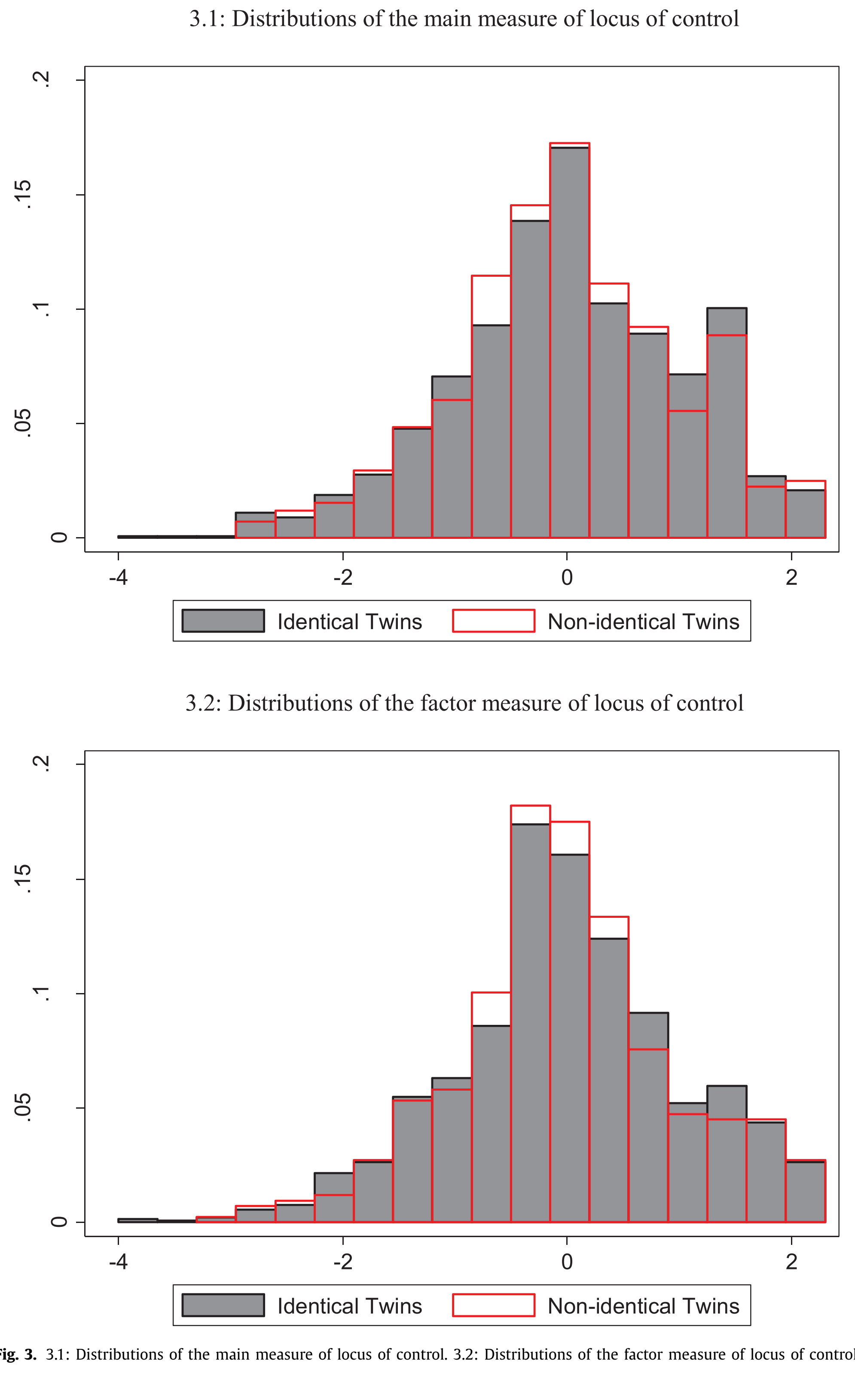


Fig. 3. 3.1: Distributions of the main measure of locus of control. 3.2: Distributions of the factor measure of locus of control.

Table 2
Within-twins correlation coefficients of locus of control.

		DZ (Non-identical) Twins	MZ (Identical) Twins
Our sample		0.18[a]	0.35[a]
Miller & Rose (1982)		0.18[b]	0.46[b]
Pedersen et al. (1989)	Responsibility	0.30[c], 0.18[d]	0.36[c], 0.30[d]
	Life direction	0.23[c], 0.15[d]	0.32[c], 0.30[d]
	Luck	0.18[c], 0.32[d]	0.02[c], 0.28[d]
Mosing et al. (2012)		0.11[a]	0.29[a]

Note: Pedersen et al. (1989) report the three sub-scales of locus of control, and all the other studies report the within-twins correlations of the unified index of locus of control. The correlation coefficients of our sample are computed based on the main measure.
[a] denotes the female twins sample.
[b] denotes the twins sample including both females and males.
[c] denotes the twins sample who were reared apart, including both females and males.
[d] denotes the twins sample who were reared together, including both females and males.

where ρ is the within-twin set correlation coefficient. Theoretically speaking, as the cross-individual variances for twin 1 and twin 2 are the same, i.e. $Var(LOC_{1j}) = Var(LOC_{2j})$, Eq. (4) may be simplified as

$$Var\left(LOC_{1j} - LOC_{2j}\right) = 2(1-\rho)Var\left(LOC_{1j}\right). \tag{5}$$

This formula suggests that if the correlation coefficient is less than 0.5 the within twins variance will be larger than the individual variance. As stated above correlation coefficients for both DZ and MZ are lower than 0.5. Thus, in our context within twin difference variances are larger than cross-individual variances. Specifically, the within difference variances are 1.57 for the DZ twins and 1.34 for the MZ twins.[18] Similar findings were reported in Chew et al. (2018). This demonstrates that there is substantial within-twins variation which may be exploited by the twin FE method. We plot the distribution of the within-twins difference in locus of control. Consistent with the above results, Fig. 4 shows that the distribution for the DZ twins is slightly flatter than that of the MZ twins, and the distributions in Fig. 4 are more dispersed than those in Fig. 3.

4. Econometric results and omitted variable bias

We present estimates for the main measure of locus of control for each of our outcome variables in Table 3. With the exception of the education related outcome variables (i.e. years of schooling and university degree or above), we estimate two distinct specifications. The baseline model includes the locus of control in both OLS and twin FE estimation together with a quadratic in age in the former. The extended model adds education and marital status for both OLS and twin FE estimation. Comparison between these two specifications allows one to gauge the extent to which locus of control works via educational attainment and marital status. For the education related outcome variables, we employ only the baseline specification, as education is generally pre-determined to marriage. We illustrate results estimated separately for samples of DZ and MZ twins.

Panel 1 of Table 3 focusses on educational acquisition. The OLS results are generally consistent with the literature (e.g. Coleman and DeLeire, 2003 and the cases in Cebi (2007) where cognitive skills are not controlled for in the regression), suggesting there is a significant association between an internal locus of control and higher educational attainment.[19] The DZ twin FE estimates remain statistically significant with the same sign as the OLS estimates. However, for the MZ twin sample, the twin FE estimates are numerically small and statistically insignificant.

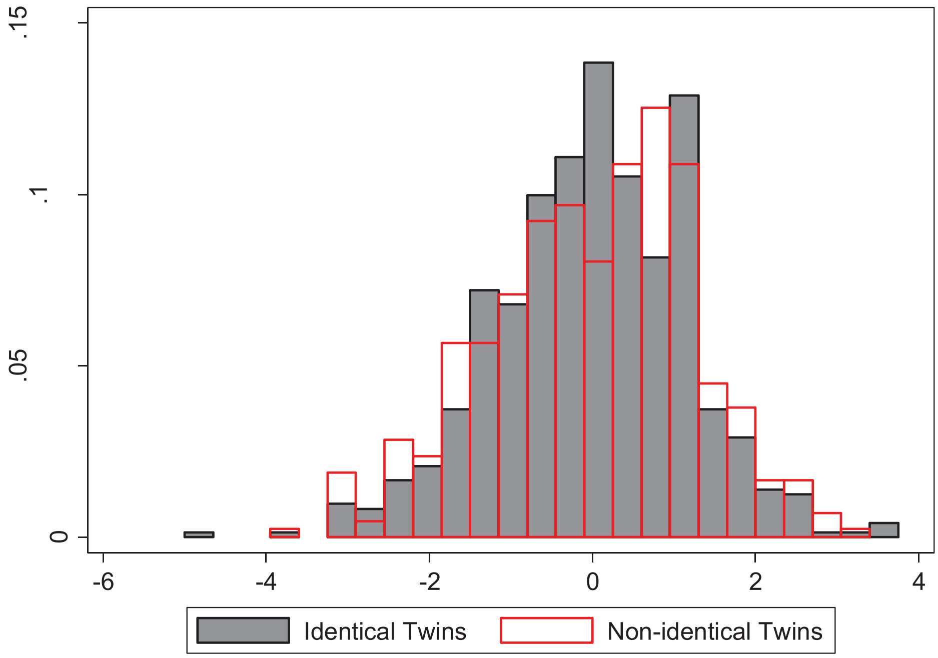
Specifically, the OLS results suggest that a one standard deviation (s.d.) increase in locus of control is associated with a significant increase of 0.41 and 0.349 years of additional schooling and a 6.1% and 3.7% increased chance of attaining a university degree or higher for DZ and MZ twins, respectively. The DZ twin FE results suggest an equivalent 1 s.d. increase in locus of control is associated with a significant increase of 0.205 years of schooling and a 5.1% increased chance of attaining a university degree or higher. All the above results are statistically significant at the 5% level. On the other hand, the MZ twin FE results drop to 0.098 years and a 1.6% increased chance, which as stated earlier are both statistically insignificant.

Panel 2 illustrates the results for two distinct employment status variables for both baseline and extended specifications. As Heckman et al. (2006) report, the OLS results show that an internal locus of control is associated with a higher probability of being employed for females. The other results illustrate a similar pattern to the above, i.e. the DZ twin FE estimates are statistically significant and large in size, but the MZ twin FE estimates are numerically small and insignificant (i.e. −1.7 to

[18] The calculation of the within difference variance is based on the within-twins correlation coefficient and cross-individual variances for twin 1 and twin 2. Specifically, from the sample $Var(LOC_{1j})$ and $Var(LOC_{2j})$ are 0.96 and 0.94 for the DZ twins and 1.03 and 1.03 for the MZ twins. Note that $Var(LOC_{1j})$ and $Var(LOC_{2j})$ are not exactly the same due to sampling error.

[19] Due to data constraints, we cannot exactly replicate the regression specification in the prior literature using twins data for the education and other outcome variables. Thus, we cannot directly compare coefficient sizes with the literature.

4.1: Distributions of the within-twins difference on the main measure of locus of control



4.2: Distributions of the within-twins difference on the factor measure of locus of control

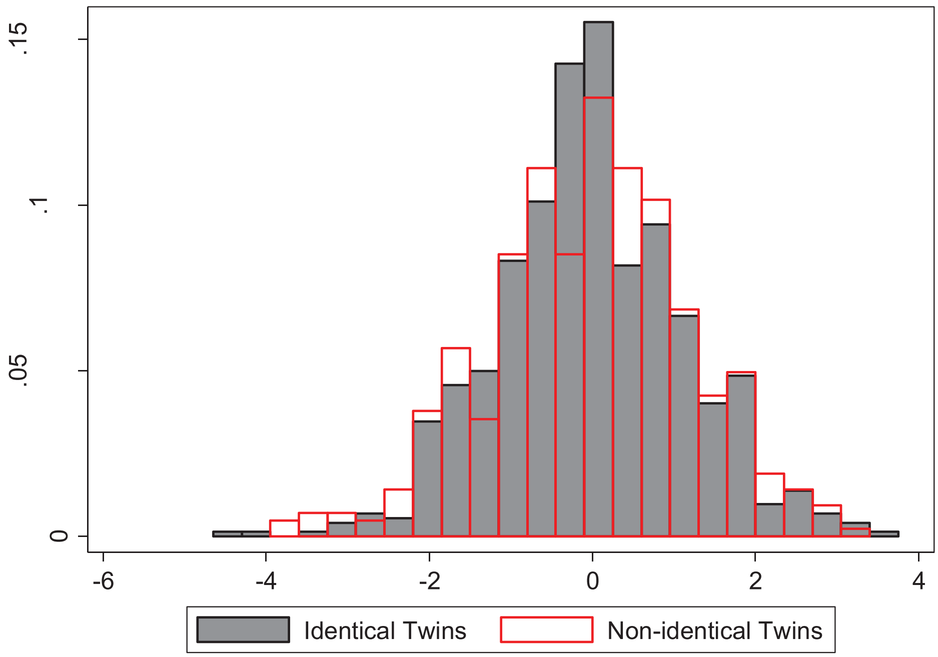


Fig. 4. 4.1: Distributions of the within-twins difference on the main measure of locus of control. 4.2: Distributions of the within-twins difference on the factor measure of locus of control.

Table 3
Various Estimates based on the main measure.

Variables	Panel A: DZ (Non-identical) Twins				Panel B: MZ (Identical) Twins			
	OLS		FE		OLS		FE	
	Baseline (1)	Extended (2)	Baseline (3)	Extended (4)	Baseline (5)	Extended (6)	Baseline (7)	Extended (8)
Panel 1: Education								
Years of schooling	0.410***		0.205**		0.349***		0.098	
	[0.085]		[0.099]		[0.071]		[0.063]	
Observations	846		846		1444		1444	
R-squared	0.125		0.013		0.113		0.004	
Number of twin sets			423				722	
P-value of Hausman test[1]			0.011				0.002	
University degree or above	0.061***		0.051***		0.037***		0.016	
	[0.012]		[0.016]		[0.011]		[0.011]	
Observations	846		846		1444		1444	
R-squared	0.048		0.025		0.042		0.003	
Number of twin sets			423				722	
P-value of Hausman test[1]			0.424				0.086	
Panel 2: Employment								
Full-time or part-time employment	0.071***	0.051***	0.059**	0.051**	0.041***	0.035***	−0.017	−0.011
	[0.017]	[0.016]	[0.023]	[0.024]	[0.012]	[0.012]	[0.019]	[0.019]
Observations	830	830	830	830	1432	1432	1432	1432
R-squared	0.038	0.121	0.015	0.069	0.032	0.088	0.001	0.03
Number of twin sets			415	415			716	716
P-value of Hausman test[1]			0.521	0.989			0.000	0.004
Full-time employment	0.080***	0.055***	0.064***	0.053**	0.050***	0.044***	0.018	0.029
	[0.016]	[0.015]	[0.022]	[0.023]	[0.013]	[0.013]	[0.019]	[0.019]
Observations	830	830	830	830	1432	1432	1432	1432
R-squared	0.048	0.233	0.018	0.131	0.04	0.168	0.001	0.067
Number of twin sets			415	415			716	716
P-value of Hausman test[1]			0.420	0.931			0.053	0.406
Panel 3: Occupation								
Higher ranked occupation	0.075***	0.026*	0.062***	0.035*	0.044***	0.012	0.037**	0.029*
	[0.016]	[0.014]	[0.024]	[0.020]	[0.013]	[0.010]	[0.016]	[0.015]
Observations	816	816	816	816	1426	1426	1426	1426
R-squared	0.035	0.352	0.02	0.233	0.032	0.36	0.008	0.158
Number of twin sets			408	408			713	713
P-value of Hausman test[1]			0.505	0.607			0.666	0.238
Panel 4: Income								
Full sample	0.166***	0.122***	0.141**	0.106*	0.088***	0.067**	0.036	0.040
	[0.036]	[0.035]	[0.055]	[0.057]	[0.029]	[0.027]	[0.041]	[0.040]
Observations	544	544	544	544	946	946	946	946
R-squared	0.048	0.181	0.026	0.097	0.033	0.144	0.002	0.046
Number of twin sets			272	272			473	473
P-value of Hausman test[1]			0.599	0.716			0.147	0.469
Employed sample	0.171***	0.117***	0.133**	0.100	0.093***	0.079***	−0.003	−0.005
	[0.046]	[0.043]	[0.063]	[0.064]	[0.031]	[0.028]	[0.043]	[0.043]
Observations	330	330	330	330	618	618	618	618
R-squared	0.056	0.215	0.029	0.082	0.053	0.159	0.000	0.021
Number of twin sets			165	165			309	309
P-value of Hausman test[1]			0.499	0.759			0.007	0.024

(*continued on next page*)

Table 3 (*continued*)

Variables	Panel A: DZ (Non-identical) Twins				Panel B: MZ (Identical) Twins			
	OLS		FE		OLS		FE	
	Baseline (1)	Extended (2)	Baseline (3)	Extended (4)	Baseline (5)	Extended (6)	Baseline (7)	Extended (8)
Panel 5: Healthy Habits								
Not a current smoker	0.004	−0.003	−0.024	−0.023	−0.007	−0.016	−0.015	−0.020
	[0.015]	[0.015]	[0.017]	[0.017]	[0.012]	[0.012]	[0.012]	[0.012]
Observations	842	842	842	842	1440	1440	1440	1440
R-squared	0.03	0.064	0.005	0.028	0.009	0.042	0.002	0.02
Number of twin sets			421	421			720	720
P-value of Hausman test[1]			0.102	0.234			0.533	0.770
Avoid binge drinking	−0.043	−0.041	−0.064*	−0.057	−0.019	−0.026	0.002	−0.004
	[0.027]	[0.027]	[0.037]	[0.037]	[0.017]	[0.017]	[0.022]	[0.022]
Observations	398	398	398	398	768	768	768	768
R-squared	0.029	0.033	0.015	0.026	0.031	0.051	0	0.016
Number of twin sets			199	199			384	384
P-value of Hausman test[1]			0.521	0.613			0.354	0.313
Exercise 3+ times per week	0.035***	0.034***	0.043**	0.043**	0.044***	0.042***	0.028**	0.029**
	[0.011]	[0.012]	[0.019]	[0.019]	[0.010]	[0.010]	[0.014]	[0.014]
Observations	826	826	826	826	1414	1414	1414	1414
R-squared	0.019	0.033	0.013	0.034	0.021	0.028	0.006	0.016
Number of twin sets			413	413			707	707
P-value of Hausman test[1]			0.607	0.563			0.204	0.320

Notes: Standard errors are clustered at twin set level.

*** Significant at 1% level.

** Significant at 5% level.

* Significant at 10% level. The dependant variable in Panel 4 is the natural logarithm of income. In addition to locus of control, the baseline OLS specification includes constant term, age and age square; the extended OLS specification includes constant term, age, age square, education attainment dummies and marriage dummy; the baseline FE specification includes no other covariate, and the extended FE specification includes education attainment dummies and marriage dummy. The R-squared for the OLS estimator is the overall R-squared, while the R-squared for the FE estimator is within R-squared.

[1] Hausman test is used to test the equality between OLS and FE estimates.

2.9% for both measures and specifications). In addition, the extended specification estimates are generally smaller than those of the baseline for both OLS and twin FE estimates, suggesting locus of control works partially through education attainment and marital status.

The results for occupational status are illustrated in Panel 3 and differ from the above findings in two important regards. First, the inclusion of education attainment and marital status substantially reduces the size and statistical significance of the locus of control estimates, suggesting important indirect pathways. Second, the baseline MZ twin FE estimate is statistically significant at the 5% level, and even in the extended model the FE estimate remains statistically significant at the 10% level. The magnitude of the respective estimates suggest that a one standard deviation increase in locus of control is associated with a 3.7 and 2.9% greater likelihood of attaining a higher status. Compared to the mean of this outcome variable, this effect is sizeable, corresponding to a 10 to 13 percent increase in the mean.

Panel 4 presents the results for the income variable. The OLS results are again consistent with the literature (e.g. Heckman et al., 2006; Semykina and Linz, 2007), i.e. an internal locus of control is positively correlated with (labour) income. For both the full sample and the employed sample, the overall pattern of results is very similar to those in Panels 1 and 2. In particular, the MZ twin FE locus of control estimates are once again small and statistically insignificant. The estimates range between −0.005 and 0.04.

The last panel reports the results for health-related habits. In contrast to the other panels, the results demonstrate that locus of control is not significantly correlated with smoking, for either OLS or twin FE estimates. The results also suggest that locus of control is negatively correlated with binge drinking avoidance, while only the baseline DZ twin FE result is statistically significant at the 10% level. The sign although somewhat counter-intuitive aligns with Cobb-Clark et al.'s (2014) finding, and rationale that individuals with an internal locus of control are more confident of controlling the effects of drinking. Finally and somewhat interestingly, the results suggest that locus of control is significantly correlated with exercise for both OLS and twin FE in both baseline and extended specifications. While the MZ twin FE results are once again smaller than OLS, the FE estimates still suggest a sizeable effect, i.e. a one standard deviation increase in locus of control leads to a 2.8 to 2.9% greater likelihood of doing more exercise, which corresponds to 20 percent of the mean of the exercise variable.

In sum, Table 3 demonstrates that the OLS results imply large and significant effects of locus of control across a myriad of adulthood outcomes. The results mimic much of the existing literature with an internal locus of control tending to improve outcomes. Interestingly, once we adopt a twin FE approach for the MZ sample, the locus of control effects diminish in size and are no longer significantly different from zero for all outcome variables other than occupational status and physical exercise. Hausman tests further confirm that the MZ twin FE estimates are statistically significantly smaller than OLS estimates for education outcomes, employment outcomes and income for the employed sample.[20]

One interpretation of our results in Table 3 is that the OLS results suffer from omitted variable bias, with unobserved family characteristics and genetics positively correlated with locus of control. In this case OLS would be upward biased and the role of locus of control over-emphasised by recent literature. As genetics and family background are identical across MZ twins, fixed effects would solve the omitted variable problem under the assumption that the twin difference in error term, $\Delta\epsilon_{ij}$, is uncorrelated with locus of control. A caveat is that the MZ twin FE estimator may still suffer from residual endogeneity in $\Delta\epsilon_{ij}$. For example, there may be competition between twins within the womb and/or subsequent differential treatment by parents. The recent literature reports differences in birthweight (Behrman and Rosenzweig, 2004) and cognitive ability (Sandewall et al., 2014) between MZ twins, confirming the potential bias of the twin FE estimator, see Bound and Solon (1999) and Neumark (1999).

It is important to note that despite the above caveat, the twin FE estimator remains useful in tightening the upper bound of the locus of control estimates. If endogenous variation across twin sets is larger than within twin set, then the twin FE estimator will suffer from less bias than OLS. Further, if locus of control is positively correlated with the omitted variables, then the twin FE estimates may be regarded as the upper bound on the locus of control effect.

We follow Ashenfelter and Rouse (1998) to test whether the endogenous variation across twin sets is larger than the associated variation within the twin set. We compute the correlations of average locus of control with average characteristics for a set of socioeconomic variables over each twin set to indicate the OLS bias. We also compute the correlations of within-twins difference in locus of control with the within-twins difference for the same set of socioeconomic variables to indicate the bias in the twin FE estimator. Table 4 illustrates the results for both MZ and DZ twin samples. The results show that between-twin-set correlations are generally much larger than within-twin-set correlations, especially for the MZ sample. Moreover, the within-twin-set correlations for the DZ sample are larger than those for the MZ sample. This suggests that the twin FE estimator is less biased than the OLS estimator, and the twin FE estimator for the MZ sample is likely to be less biased than that of the DZ sample.

[20] One concern may be that the insignificant MZ twin FE estimates are caused by lack of within-twins variation. However, as discussed in Section 3, the variance of within-twins difference in locus of control for the MZ sample is large enough (i.e. 1.34 for MZ and 1.57 for DZ), but the results for the DZ sample remain significant. In addition, lack of variation in the explanatory variable usually results in large standard errors, but the insignificant MZ FE estimates are mainly caused by the small coefficient magnitudes, rather than large standard errors. In fact, compared with the DZ results, the standard errors for the MZ results are even smaller. This indicates that the within-twins variation for the MZ sample is large enough to allow the fixed effects estimator to precisely estimate the effect. Hence, we believe that the insignificant MZ twin FE results are caused by the removal of more unobserved heterogeneity, rather than lack of within-twins variation.

Table 4
Remaining omitted variable bias: Between and within family correlations of the main measure of locus of control and other variables.

	Panel 1: MZ twins		Panel 2: DZ twins	
	Between-twin-set	Within-twin-set	Between-twin-set	Within-twin-set
Own years of schooling	0.220***(P<0.001)	0.062*(P = 0.098)	0.257***(P<0.001)	0.113**(P = 0.020)
Spousal years of schooling	0.171***(P<0.001)	0.029(P = 0.535)	0.172***(P = 0.005)	0.130**(P = 0.036)
University degree or above	0.152***(P<0.001)	0.053(P = 0.157)	0.203***(P<0.001)	0.157***(P = 0.001)
Spousal University degree or above	0.153***(P<0.001)	0.053(P = 0.252)	0.096(P = 0.123)	0.153**(P = 0.013)
Full-time or part-time employment	0.173***(P<0.001)	−0.034(P = 0.362)	0.171***(P = 0.001)	0.122**(P = 0.013)
Spousal full-time or part-time employment	0.089*(P = 0.051)	0.030(P = 0.513)	0.078(P = 0.201)	0.075(P = 0.223)
Full-time employment	0.168***(P<0.001)	0.035(P = 0.348)	0.203***(P<0.001)	0.135**(P = 0.006)
Spousal full-time employment	0.084*(P = 0.065)	0.022(P = 0.628)	0.118*(P = 0.054)	0.022(P = 0.722)
Higher ranked occupation	0.122***(P = 0.001)	0.090**(P = 0.017)	0.193***(P<0.001)	0.139***(P = 0.005)
Higher ranked occupation of Spouse	0.136***(P = 0.003)	−0.013(P = 0.769)	0.089(P = 0.154)	−0.014(P = 0.823)
Ln income	0.160***(P = 0.001)	0.039(P = 0.400)	0.223***(P<0.001)	0.162***(P = 0.007)
Spousal ln income	0.152***(P = 0.002)	0.077(P = 0.120)	0.233***(P = 0.001)	0.012(P = 0.863)
Smoking	−0.017(P = 0.644)	−0.042(P = 0.259)	0.031(P = 0.526)	−0.068(P = 0.161)
Spouse was smoking	0.034(P = 0.456)	0.001(P = 0.991)	−0.007(P = 0.909)	−0.062(P = 0.309)
Doing exercise	0.160***(P = 0.001)	0.077**(P = 0.040)	0.114**(P = 0.020)	0.117***(P = 0.017)
Spouse was doing exercise	0.133***(P = 0.004)	0.051(P = 0.267)	0.107*(P = 0.082)	0.114*(P = 0.064)

Notes:.
*** Significant at 1% level.
** Significant at 5% level.
* Significant at 10% level. Between-twin-set correlations are correlations of average twin-set locus of control with average twin-set characteristics, and within-twin-set correlations are correlations of the within-twin-set differences in locus of control with within-twin-set differences in other characteristics.

5. Robustness of results

In this section we explore additional econometric issues discussed in the literature and conduct a set of robustness checks. We present only the twin FE results for the baseline specification due to space restrictions.[21]

5.1. Measurement error

In the economics literature, measurement error is widely discussed; see Cobb-Clark and Schurer (2013) for an excellent overview in the context of locus of control. In the presence of measurement error, the OLS estimator is generally inconsistent and suffers from attenuation bias due to the correlation between measurement error and the mis-measured variable. Measurement error is also potentially important in the context of the twin FE estimator. The within-twins difference removes part of the “signal” but may not remove a commensurate amount of “noise”, reducing the “signal to noise” ratio and potentially magnifying the level of attenuation bias compared to the OLS estimator.

Recall our earlier key results; we found that as in the rest of the literature using OLS, locus of control plays a large and significant role in determining most adulthood outcomes. However, once we switch to the MZ twin FE estimator, which controls for unobserved family and genetic background, the estimated effect of locus of control declines in magnitude and significance, in almost all cases. One plausible interpretation of the discrepancy as argued earlier is that adoption of OLS leads to omitted variable bias. Assuming a positive correlation between the omitted variable and locus of control, the bias will inflate the estimated effect. Once one controls for the omitted variables, the locus of control effects diminish in size and significance.

An alternative possibility underlying the insignificant MZ twin FE estimates is measurement error, given the twin FE estimator is likely to accentuate the attenuation bias. Conventionally, the literature takes the report by the co-twin as an instrumental variable to solve the measurement error (e.g. Ashenfelter and Krueger, 1994; Miller et al., 1995). Unfortunately, such a report by the co-twin on locus of control is unavailable in the current survey.

We believe that the small and insignificant MZ twin FE estimates are unlikely to be due to measurement error. We provide three distinct reasons. First, Piatek and Pinger (2016) suggest that the locus of control measure derived from factor analysis is subject to less measurement error than our main measure. If the measurement error causes large bias in our estimation and use of the factor measure mitigates the problem, then we would expect to see a large difference in results across the two locus of control measures. We present the twin FE results based on both this factor measure in Columns 2 and 7 of Table 5 and the main measure in Columns 1 and 6. Comparison of results across the two measures reveals very little difference.

Second, attenuation bias is inversely correlated with the variance of the within-twins difference in (mis-)measured locus of control and positively correlated with the size of measurement error (i.e. the variance of measurement error). Thus, one

[21] The twin FE results for the extended specification are largely consistent with those for the baseline, and the OLS results for both baseline and extended specifications are similar to those in Table 3 and generally consistent with the literature. The OLS results and twin FE results for the extended specifications are available upon request.

Table 5
Robustness checks.

	Panel A: DZ (Non-identical) Twins					Panel B: MZ (Identical) Twins				
	Base Results (1)	Factor Measure (2)	ORIV (3)	Personality Measures (4)	Unconnected Twins (5)	Base Results (6)	Factor Measure (7)	ORIV (8)	Personality Measures (9)	Unconnected Twins (10)
Panel 1: Education										
Years of schooling	0.205**	0.216**	0.243**	0.208*	0.010	0.098	0.104	0.126	0.109	−0.022
	[0.099]	[0.102]	[0.112]	[0.111]	[0.198]	[0.063]	[0.065]	[0.079]	[0.071]	[0.145]
Observations	846	846		812	176	1444	1444		1400	318
R-squared	0.013	0.014		0.036	0.000	0.004	0.004		0.012	0.000
Number of twin sets	423	423		406	88	722	722		700	159
F-test Statistics[1]			39.81					35.99		
P-value of Hausman test[2]	0.011	0.022		0.665	0.179	0.002	0.001		0.019	0.013
University degree or above	0.051***	0.054***	0.060***	0.049***	0.038	0.016	0.016	0.020	0.022*	0.003
	[0.016]	[0.016]	[0.018]	[0.018]	[0.032]	[0.011]	[0.011]	[0.014]	[0.012]	[0.026]
Observations	846	846		812	176	1444	1444		1400	318
R-squared	0.025	0.027		0.044	0.016	0.003	0.003		0.012	0.000
Number of twin sets	423	423		406	88	722	722		700	159
F-test Statistics[1]			39.81					35.99		
P-value of Hausman test[2]	0.424	0.544		0.862	0.3611	0.086	0.051		0.161	0.029
Panel 2: Employment										
Full-time or part-time employment	0.059**	0.055**	0.058**	0.044*	0.111**	−0.017	−0.023	−0.027	−0.010	0.012
	[0.023]	[0.024]	[0.026]	[0.026]	[0.049]	[0.019]	[0.018]	[0.023]	[0.021]	[0.040]
Observations	830	830		798	174	1432	1432		1388	318
R-squared	0.015	0.012		0.036	0.062	0.001	0.002		0.008	0.001
Number of twin sets	415	415		399	87	716	716		694	159
F-test Statistics[1]			37.96					36.73		
P-value of Hausman test[2]	0.521	0.581		0.502	0.555	0.000	0.000		0.001	0.211
Full-time employment	0.064***	0.057***	0.062**	0.061**	0.048	0.018	0.018	0.024	0.022	−0.001
	[0.022]	[0.022]	[0.025]	[0.026]	[0.048]	[0.019]	[0.019]	[0.024]	[0.023]	[0.045]
Observations	830	830		798	174	1432	1432		1388	318
R-squared	0.018	0.014		0.026	0.012	0.001	0.001		0.017	0.000
Number of twin sets	415	415		399	87	716	716		694	159
F-test Statistics[1]			37.96					36.73		
P-value of Hausman test[2]	0.42	0.435		0.999	0.243	0.053	0.051		0.139	0.132
Panel 3: Occupation										
Higher ranked occupation	0.062***	0.061***	0.067***	0.066**	−0.019	0.037**	0.037**	0.047**	0.041**	0.036
	[0.024]	[0.022]	[0.026]	[0.026]	[0.039]	[0.016]	[0.017]	[0.020]	[0.017]	[0.032]
Observations	816	816		790	176	1426	1426		1384	312
R-squared	0.02	0.019		0.033	0.002	0.008	0.008		0.048	0.008
Number of twin sets	408	408		395	88	713	713		692	156
F-test Statistics[1]			35.27					35.09		
P-value of Hausman test[2]	0.505	0.419		0.283	0.208	0.666	0.419		0.905	0.065

(*continued on next page*)

Table 5 (*continued*)

	Panel A: DZ (Non-identical) Twins					Panel B: MZ (Identical) Twins				
	Base Results (1)	Factor Measure (2)	ORIV (3)	Personality Measures (4)	Unconnected Twins (5)	Base Results (6)	Factor Measure (7)	ORIV (8)	Personality Measures (9)	Unconnected Twins (10)
Panel 4: Income										
Full sample	0.141**	0.150***	0.160***	0.147**	0.222**	0.036	0.048	0.061	0.036	−0.027
	[0.055]	[0.052]	[0.059]	[0.061]	[0.099]	[0.041]	[0.041]	[0.051]	[0.045]	[0.084]
Observations	544	544		522	120	946	946		922	212
R-squared	0.026	0.028		0.047	0.072	0.002	0.003		0.021	0.001
Number of twin sets	272	272		261	60	473	473		461	106
F-test Statistics[1]			32.97					31.61		
P-value of Hausman test[2]	0.599	0.702		0.999	0.402	0.147	0.168		0.153	0.183
Employed sample	0.133**	0.139**	0.140**	0.088	0.072	−0.003	0.007	0.000	0.010	−0.070
	[0.063]	[0.063]	[0.063]	[0.072]	[0.126]	[0.043]	[0.041]	[0.050]	[0.050]	[0.096]
Observations	330	330		314	70	618	618		598	140
R-squared	0.029	0.03		0.079	0.011	0.000	0.000		0.032	0.006
Number of twin sets	165	165		157	35	309	309		299	70
F-test Statistics[1]			27.03					23.64		
P-value of Hausman test[2]	0.499	0.54		0.916	0.542	0.007	0.012		0.107	0.047
Panel 5: Healthy Habits										
Not a current smoker	−0.024	−0.023	−0.024	−0.021	−0.006	−0.015	−0.014	−0.017	−0.010	−0.029
	[0.017]	[0.018]	[0.019]	[0.019]	[0.027]	[0.012]	[0.012]	[0.015]	[0.013]	[0.023]
Observations	842	842		810	176	1440	1440		1396	318
R-squared	0.005	0.004		0.017	0.001	0.002	0.001		0.016	0.006
Number of twin sets	421	421		405	88	720	720		698	159
F-test Statistics[1]			39.89					35.86		
P-value of Hausman test[2]	0.102	0.088		0.476	0.086	0.533	0.569		0.473	0.318
Avoid binge drinking	−0.064*	−0.071*	−0.082**	−0.054	−0.072	0.002	−0.003	−0.007	0.005	0.029
	[0.037]	[0.037]	[0.041]	[0.042]	[0.075]	[0.022]	[0.021]	[0.027]	[0.027]	[0.052]
Observations	398	398		386	100	768	768		750	166
R-squared	0.015	0.018		0.046	0.021	0.000	0.000		0.022	0.005
Number of twin sets	199	199		193	50	384	384		375	83
F-test Statistics[1]			20.27					33.14		
P-value of Hausman test[2]	0.521	0.477		0.246	0.808	0.354	0.436		0.964	0.108
Exercise 3+ times per week	0.043**	0.048**	0.054**	0.021	0.002	0.028**	0.027**	0.034**	0.019	0.082***
	[0.019]	[0.020]	[0.022]	[0.022]	[0.041]	[0.014]	[0.013]	[0.017]	[0.016]	[0.030]
Observations	826	826		796	174	1414	1414		1370	316
R-squared	0.013	0.016		0.037	0.000	0.006	0.006		0.012	0.048
Number of twin sets	413	413		398	87	707	707		685	158
F-test Statistics[1]			35.14					35.51		
P-value of Hausman test[2]	0.607	0.341		0.664	0.971	0.204	0.324		0.207	0.742

Notes: Except in Columns 2 and 7 standard errors are clustered at twin set level. In Columns 2 and 7 standard errors are bootstrapped from 500 replications.

*** Significant at 1% level.

** Significant at 5% level.

* Significant at 10% level. The dependant variable in Panel 4 is the natural logarithm of income. Columns 1 to 5 present DZ twin FE results, and Columns 6 to 10 present MZ twin FE results. All the results are estimated from the baseline specification. Columns 1 and 6 show the base results which are the same as those in Columns 3 and 7 of Table 3. Columns 2 and 7 show the results based on the factor measure of locus of control. Columns 3 and 8 show the Obviously Related Instrumental Variable results which takes each item of locus of control questions as a separate measure. Columns 4 and 9 include personality measures as additional control variables. Columns 5 and 10 restrict the sample to respondents who saw their co-twins once or twice a month or less frequently. The R-squared is within R-squared.

[1] The F-test statistics show the strength of instrument variables in the first-stage estimation.

[2] Hausman test is used to test the equality between OLS and FE estimates.

Table 6
Share of measurement error which can fully explain the difference in the FE estimates between the MZ and DZ samples.

	Baseline (1)	Extended (2)
Years of schooling	59%	
University degree or above	63%	
Full-time or part-time employment	–	–
Full-time employment	64%	60%
Higher ranked occupation	58%	46%
Ln income -full sample	62%	61%
Ln income -employed sample	–	–
Not a current smoker	54%	37%
Avoid binge drinking	75%	76%
Doing exercise 3 times or more per week	55%	56%

Note: The share of measurement error is calculated as the share of total variance of the main measure. The share of measurement error is calculated under the assumptions that the measurement error is classical and that the measurement eror is classoical and fully explains the difference in the FE estimates between the MZ and DZ samples. Because measurement error causes attenuation bias, the shares for the outcomes for which the DZ and MZ estimates share opposite signs are not calculated. For the details of the calculation, refer to Online Appendix 1.

might expect attenuation bias to be larger for MZ than DZ twins due to the smaller within-twins difference for the former. However, in our case the measured variances of the within-twins difference in locus of control are of similar magnitude (i.e. 1.34 for MZ and 1.57 for DZ as discussed in Section 3.3). Given this, if the size of measurement error is similar for MZ and DZ samples, the FE estimates will suffer from similar levels of attenuation bias. However, in Table 3 we see that whereas the MZ twin FE estimates are in general numerically small and insignificant, the fixed effect estimates for the DZ sample are large and significant. A comparison with the OLS estimates reveals the MZ twin FE estimates fall dramatically, but the estimates of the DZ twin sample do not. This is suggestive that controlling for unobserved genetic factors, rather than measurement error, underlies the MZ twin FE estimates being small and insignificant.

To further examine the issue, we begin by assuming measurement error is classical and equal-sized across MZ and DZ samples. Consider the following thought experiment; how large would measurement error need to be in order to be *fully* responsible for the difference in FE estimates between DZ and MZ samples? Table 6 shows the calculated shares of measurement error in terms of total variance of the main measure.[22] The results suggest that measurement error would need to be very large for it alone to explain the full difference in FE estimates between DZ and MZ twins. Depending upon the specific outcome, the shares of measurement error would need to range from 37 to 76% of total variance of (mis-)measured locus of control. Cobb-Clark and Schurer (2013) use the longitudinal information to investigate measurement error in locus of control in the HILDA data. They show that measurement error accounts for 13% of the variance of the (mis)measured locus of control under the assumption that the true locus of control is stable and errors appear in the measure across each wave.[23] Given this finding, it appears unlikely that measurement error alone explains the small and insignificant twin FE estimates for the MZ sample.[24]

Third, we employ the Obviously Related Instrumental Variable (ORIV) approach to directly mitigate the measurement error bias. When multiple measures are available, the ORIV approach uses different measures to instrument each other and then adopts a stacked regression design to provide an efficient IV estimate (Gillen et al., 2019). The advantage of this approach is that if the measurement error across measures are uncorrelated, the ORIV approach provides a consistent estimate which is free of attenuation bias. Even if the measurement error across measures is correlated, the ORIV approach still removes the bias caused by the measure-specific error.

As discussed in Section 3, our locus of control measure is constructed from seven items. We now treat each item as a separate measure of locus of control to implement the ORIV estimator. Columns 3 and 8 of Table 5 show the results for ORIV FE estimation for the DZ and MZ twins respectively. Comparing the ORIV results with the results in Columns 1 and 6, we see that while the FEIV estimates are slightly larger than the FE estimates, the FEIV estimates for the MZ sample are much smaller than those for the DZ sample and are also statistically insignificant (at 5%) for the majority of outcome variables,

[22] As measurement error causes attenuation bias, the shares for the outcomes for which the DZ and MZ estimates share opposite signs are not calculated. For the details of the calculation, refer to Online Appendix 1.

[23] Cobb-Clark and Schurer (2013) also calculate the size of measurement error under an alternative assumption. In particular, they assume that the current measure is perfectly measured and all the difference between the current and lagged measures are caused by measurement error. Under this assumption with a four-year span between the current and lagged measures, they find that measurement error accounts for 50% of the variance of the lagged locus of control in HILDA data. However, this is likely to overestimate the size of measurement error, as the difference in the measures between two periods may be due to change in the true locus of control and/or measurement error may also exist in the measure of each wave.

[24] We also considered calculating the size of measurement error by comparing OLS and FE results. This calculation requires the same set of control variables in the OLS and FE estimation. In our context in the OLS estimation we control for twins-invariant characteristics which are not controlled for in the FE estimation. Thus, we are unable to infer the size of measurement error using this method.

suggesting the important role of genetic factors in driving bias. The same two exceptions, as discussed earlier in the context of MZ FE estimates, i.e. outcomes reflecting occupational status and exercise regime continue to hold for MZ FEIV.[25]

5.2. Inclusion of personality measures as covariates

Our main results reported to date exclude personality traits other than locus of control. In this section we examine robustness of our locus of control estimates to the inclusion of other personality measures derived from two instruments: the Eysenck and Tri-dimensional Personality Questionnaires. The former provides personality measures on 4 scales: extraversion, psychoticism, neuroticism, and a lie scale; while the latter provides measures on 3 scales: novelty seeking, harm avoidance and reward dependence. Both instruments are widely used in psychology studies (e.g. Cloninger et al., 1991; Mor, 2010).[26]

The main rationale for the previous exclusion of such traits is it would appear difficult to design a policy intervention which affects locus of control, holding all other personality traits fixed. Locus of control is clearly inter-related with other personality measures, for example, an internal locus of control tends to be correlated with lower neuroticism. Thus, to ensure comparability to studies that include other personality measures as covariates (e.g. Cobb-Clark et al., 2014; Caliendo et al., 2015; Schnitzlein and Stephani, 2016), Columns 4 and 9 of Table 5 show the twin FE results after including personality measures in the specification. The estimates are in general very similar to those in Columns 1 and 6. Two minor exceptions are the twin FE estimates i) for the MZ sample for university-or-above education is now statistically significant at the 10% level; and ii) for both DZ and MZ twins for the exercise measure locus of control effects are now statistically insignificant. The overall pattern of results is preserved.

5.3. Reverse causality

In the current paper we take the locus of control measured at the survey date as the key explanatory variable of interest. This contemporaneous locus of control measure is frequently adopted in the literature (e.g. Caliendo et al., 2015; Abay et al., 2017). One advantage is it may be argued that it contains less measurement error than the lagged locus of control measure (Cobb-Clark and Schurer, 2013).

One potential problem with use of a contemporaneous measure is that it may lead to reverse causality. However, we believe this is unlikely to yield large bias in our labour market and healthy habit related estimates. This is because the literature reports relative stability in locus of control for the working-age population (Specht et al., 2013; Cobb-Clark and Schurer, 2013), and our sample is aged 24 to 60. So, our locus of control measure may be regarded as largely predetermined. Moreover, even if reverse causality exists, the bias is likely to be positive as better economic outcomes tend to lead to a stronger perception of control. Thus, our estimates may be regarded as an upper bound of the effect even if reverse causality exists. Regarding the education-related outcomes, the estimates may be biased due to reverse causality. But again, it may be deemed as the upper bound of the effect, as more schooling tends to strengthen the perception of control (see the discussion in Stipek, 1980).

We have one additional piece of evidence to support the argument that insignificance of MZ twin FE estimates is not due to reverse causality. In Table 3, while the MZ twin FE estimates are small and insignificant, the estimates of the DZ twins are generally large and significant. There is no particular reason to believe that reverse causality bias would differ significantly between the MZ and DZ twin samples. Therefore, the insignificance of the MZ twin FE estimates is unlikely to be induced by reverse causality.

5.4. Within-family externality

One other possibility underlying the small and insignificant MZ twin FE estimates is that the locus of control of one twin may affect the outcome of the other, i.e. a within-family locus of control externality. If such an externality exists, and the locus of control effects of both twin and co-twin on a given twin's outcome have the same sign, the twin FE estimator under-estimates the true effect. The insignificant results for MZ twins combined with significant results for DZ twins may potentially be due to a stronger within-family externality for the former.

One approach in the literature is to use data on siblings to test for the presence of a within-family externality. The underlying assumption is that the externality between twins and non-twin siblings is of a similar magnitude and the non-twin siblings have a larger difference in unobserved ability (Li et al., 2007). However, information pertaining to non-twin siblings is unavailable in our survey, so this approach is infeasible. Instead, we use two alternative strategies to examine the robustness of our results in terms of the externality issue. First, we employ survey information on how often the respondent sees their co-twin. The options for this question include "we lived together", "almost every day", "at least once a week", "once or twice a month", "a few times a year", "less often" and "not at all". We restrict the sample to twin sets who saw one another infrequently, i.e. once or twice a month or less.[27] Presumably the within-twins externality in this sample will

[25] We also collapse the group of seven items for locus of control into two measures, an internal and an external locus, and conduct 2-measure ORIV estimation. The results are presented in Columns 2and 7 of Online Appendix Table 1 and show a similar pattern to those in Table 5. Note that the ORIV estimation which takes each item as a separate measure is more efficient. For the estimation details see Online Appendix 2.

[26] Unfortunately, the survey does not include the Big Five measures.

[27] For respondents who answered this question, roughly half of them saw their co-twins once or twice a month or less.

be smaller. Columns 5 and 10 of Table 5 present the results. The estimates show the same pattern as Columns 1 and 6, i.e. the twin FE estimates for the MZ sample is smaller than those for the DZ sample for the majority of outcomes. Consistent with Columns 1 and 6, the only significant twin FE results for the MZ sample is for the exercise outcome. This suggests our results are robust to the externality issue. However, one caveat is that a large fraction of respondents fail to provide answers to this question, so our robustness check pertains to only 247 twin sets. The smaller sample size may result in loss of estimation efficiency and possible sample selection issues (especially for the DZ twins because of the smaller sample size). Given this, we conduct a second robustness check in Columns 3 and 8 of Online Appendix Table 1. Specifically, we restrict our initial sample to those respondents aged 35 or above to examine the externality. The idea is that as people grow up, they develop their own social networks, and the externality from their twin siblings weakens.[28] The results are similar to those in Table 3, suggesting again that the within-family externality is not the main reason behind the small and insignificant MZ twin FE estimates.

5.5. Non-linear effect of locus of control

The insignificant results in the MZ twin FE estimation may also be due to model mis-specification. In particular, the effect of locus of control may be non-linear. It is possible that locus of control has a positive effect below a certain threshold, and a negative role due to inflexibility and possible stubbornness thereafter; in other words, locus of control may have an inverted-U shape effect. Given this, we include a quadratic in locus of control to test for the nonlinearity, results are relegated to Columns 4 and 9 of Online Appendix Table 1. The MZ twin FE results indicate that the quadratic term is generally statistically insignificant, so the linear specification of locus of control appears appropriate. In addition, we follow Caliendo et al. (2015) in creating an alternative locus of control measure, a dummy variable equal to one for those with an internal locus greater or equal to the median, and zero otherwise. In Columns 5 and 10 of Online Appendix Table 1, we report the results estimated from this dichotomous measure, the results show a similar pattern to our earlier reported results.

6. External validity

The above analysis discusses the internal validity of our twins analysis. In this section, we turn to external validity of our study.

6.1. Sample relevance

The first concern regarding external validity is that our sample was collected in 1988–91 which is almost thirty years prior to the time of writing this paper. Australian society and the role of women have evolved over time, with significant increases in both female levels of education and labour force participation. Given this evolution, the relationship between locus of control and key socio-economic behavioural outcomes for females may have changed over time. As the majority of economic studies of locus of control have appeared in the last decade, one may consider the sample used in our study to have limited relevance to the literature.

Despite some reservations there are a number of reasons why we consider our study still relevant to the existing literature. First, in fact many recent studies analyse samples of cohorts born in significantly earlier times; the National Longitudinal Survey of Youth 79 (NLSY79, is analysed by Cebi, 2007; Ahn, 2015; McGee, 2015) and the National Longitudinal Survey of Young Women (NLSYW by Groves, 2005). Our sample is reasonably comparable to these studies.

Second, we replicate much of our analysis i.e. OLS estimates of locus of control on the same set of outcomes using the first 17 waves of the HILDA survey (i.e. 2001–2017) which is representative of contemporary Australian society. If the relationship between locus of control and outcomes has changed significantly, then we may expect to see different OLS estimates for our twins sample versus the HILDA sample. To make estimates comparable we use essentially the same OLS regression specifications as in Table 3. [29] Table 7 presents the OLS results for the full HILDA female sample.[30] Columns 1 and 2 show the OLS estimates of the baseline and extended specifications, respectively. The replication estimates in these two columns are largely consistent with those in Table 3, and the only key difference is that locus of control is significantly correlated with smoking in HILDA but not in the twins sample. These results indicate that the overall relationship between locus of control and our many outcomes may not have changed significantly. Given this, we argue our analysis is still relevant to recent literature and contemporary Australian society.[31]

[28] Online Appendix Fig. 1 shows that the mean level of the absolute within-twins difference in locus of control increases as age goes up, suggesting that twins diverge and thereby are less likely to affect each other as they grow up.

[29] We also include multiple wave dummies for the HILDA sample.

[30] For the replication details, please refer to Online Appendix 3.

[31] Ideally, we would construct a twin sample from HILDA data and replicate our earlier comparison between OLS and twin fixed effects. Unfortunately, this is not feasible. The HILDA data does not allow one to distinguish between MZ and DZ twins. This distinction is crucial for our prior analysis as only the MZ twin FE results differ significantly from OLS. Second, the sample size of twins identified from the HILDA survey is also extremely small, (i.e. a maximum of 8 sets of twins per wave). We also considered an analysis of sibling fixed effects. The sibling sample is not large (e.g. the maximum sample

Table 7
Various Estimates based on HILDA.

	Consistent with Previous Tables		More Extended
	Baseline	Extended	
	(1)	(2)	(3)
Panel 1: Education			
Years of schooling	0.386***		0.310***
	[0.036]		[0.041]
Observations	74,561		70,478
R-squared	0.068		0.151
University degree or above	0.064***		0.054***
	[0.006]		[0.007]
Observations	74,561		70,478
R-squared	0.033		0.100
Panel 2: Employment			
Full-time or part-time employment	0.091***	0.077***	0.068***
	[0.005]	[0.005]	[0.006]
Observations	74,578	74,553	70,468
R-squared	0.040	0.085	0.117
Full-time employment	0.068***	0.058***	0.048***
	[0.005]	[0.005]	[0.006]
Observations	74,578	74,553	70,468
R-squared	0.022	0.072	0.122
Panel 3: Occupation			
Higher ranked occupation	0.071***	0.039***	0.033***
	[0.007]	[0.005]	[0.006]
Observations	54,337	54,317	51,611
R-squared	0.018	0.327	0.333
Panel 4: Income			
Full sample	0.148***	0.125***	0.107***
	[0.011]	[0.010]	[0.012]
Observations	64,646	64,629	61,271
R-squared	0.073	0.165	0.178
Employed sample	0.089***	0.074***	0.030***
	[0.009]	[0.008]	[0.007]
Observations	47,248	47,233	44,010
R-squared	0.088	0.179	0.411
Panel 5: Healthy Habits			
Not a current smoker	0.045***	0.024***	0.010
	[0.005]	[0.005]	[0.006]
Observations	65,259	65,243	45,002
R-squared	0.017	0.090	0.103
Avoid binge drinking	−0.011	−0.025***	−0.038***
	[0.007]	[0.007]	[0.009]
Observations	20,814	20,811	15,271
R-squared	0.050	0.069	0.121
Exercise 3+ times per week	0.077***	0.075***	0.059***
	[0.005]	[0.005]	[0.006]
Observations	69,077	69,056	47,325
R-squared	0.020	0.024	0.043

Notes: Standard errors are clustered at individual level.
*** Significant at 1% level.**Significant at 5% level.*Significant at 10% level. The dependant variable in Panel 4 is the natural logarithm of income. The regression specifications in columns (1) and (2) are consistent with those in Table 3. In column (3) for all outcomes Big-Five personality measures and state dummies are included as covariates. Number of children is included for the non-education outcomes. Weekly hours worked, occupation and industry fixed effects are included in health measures and income of the employed sample. For income of the employed sample we also include tenure and squared tenure. *Source:* HILDA, waves 1–17.

6.2. Differing specification from the literature

One additional concern regarding external validity is due to data constraints our twins OLS specifications include only limited control variables, i.e. age, squared age, education attainment dummies and marital status. However, recent studies of locus of control usually employ large household surveys and adopt a much richer OLS specification, which may potentially

size for a single wave of the female siblings is 290) and more importantly is unrepresentative. Given that HILDA does not interview siblings who moved out of the household prior to the baseline wave, the constructed female HILDA sibling sample for respondents in the labour market are biased towards younger age groups, unrepresentative of the general female population. Finally, we compare OLS results between the HILDA female sibling sample and HILDA full female sample using our prior specification. We find that the OLS results of the sibling sample differ significantly from those of the full sample, indicating the bias of the sibling sample. (The results are available upon request.) Given this we do not conduct sibling analysis using the HILDA data.

absorb at least part of the effect of omitted family background and genetic factors. Therefore, our analysis may over-estimate the bias due to omitted factors in the extant literature.

An important caveat is that our results cannot quantify the exact extent of omitted variable bias in the literature due to our rather parsimonious specification. However, our central message is that omitted genetic and family background factors may drive substantial bias when simple cross-sectional estimation methods are adopted, future studies should bear this in mind. Even with a rich set of control variables the estimates in the existing literature are still likely to be biased.

First, it is virtually impossible to control for all genetic and family background factors using observables. An example is Fletcher's study (2013) in which controls for a rich set of variables, including demographic characteristics, family background information and cognitive skills, are progressively added to test for the effect of personality on wages. Absent sibling fixed effects the estimates change slightly across specification. However, once sibling fixed effects, which capture some omitted genetic and family background, are included, the estimated coefficients of personality change dramatically, in terms of both size and significance level. For example, Fletcher finds that the estimated coefficient of conscientiousness becomes statistically insignificant and smaller in magnitude when sibling fixed effects are included. But conscientiousness is significantly correlated with earnings in Fletcher's other specifications (and also typically in other studies) where sibling fixed effects are not included. This indicates that even controlling for a rich tapestry of control variables is unlikely to account for all genetic and family background effects.

Second, as a replication exercise we explore how the estimates change once we control for more covariates using the HILDA data. As mentioned earlier, the first two columns in Table 7 present the OLS estimates using essentially the same specifications as our prior analysis. We add more covariates in Column 3 of Table 7. Specifically, we include the Big-Five personality measures and state dummies for all outcomes and include number of children for non-education outcomes. We also include weekly hours worked, occupation and industry fixed effects for health measures and income outcome of the employed sample. Additionally, we include a quadratic in tenure for the income outcome of the employed sample. Comparing the three columns of Table 7, the results suggest that inclusion of more covariates causes only a slight drop in coefficient size for most outcomes, and more importantly, the estimates in Column 3 are still larger than the MZ twin FE results in Table 3. [32] Once again this suggests that controlling for more covariates is unlikely to solve the omitted variable bias. Thus, absence of genetics and family background information remains a potential cause for concern in the existing literature.

7. Concluding remarks

In this paper, we estimate the relationship between locus of control and a set of adulthood outcomes using a sample of Australian female twins. The OLS estimates for both DZ and MZ twins and the twin FE estimates for DZ twins suggest that (internal) locus of control has a positive and significant association with education level, income, likelihood of employment and higher occupational status as well as more frequent exercise. This result is consistent with previous findings in the literature. However, our MZ twin FE estimates are small in size and statistically insignificant for many outcomes. Two important exceptions are occupational rank and exercise habit. The MZ FE locus of control estimates for these two outcome variables remain statistically significant and economically sizeable, i.e. even after controlling for omitted variables.

One interpretation of the discrepancy between OLS and the MZ twin FE estimates is that OLS suffers from omitted variable bias. Two alternative explanations are: (i) attenuation bias associated with measurement error and (ii) a within family externality in the twin FE estimation. Our prior analysis suggests that neither is likely to be the main reason underlying the small and insignificant MZ twin FE estimates.

In general, our OLS results are large and significant but MZ twin FE are much smaller and insignificant. As noted earlier there are two key exceptions, where significance is maintained in MZ FE estimates. Unfortunately, we do not have a plausible explanation as to why the discrepancy holds for education, income, employment and most health habits but at the same time not for occupational status and exercise outcomes. This discrepancy is left for future research. Future estimates of the effect of locus of control should further examine the potential importance of omitted variables and shed further light on their importance across socio-economic behaviours.

A final caveat is that our results refer to a limited set of adulthood outcomes and a particular population – Australian females. The existing literature suggests that the relationship between locus of control and outcome variables may differ by gender (e.g. Hansemark, 2003; Semykina and Linz, 2007). Whether our results may be generalised to other outcome variables and other populations requires further exploration.

Declaration of Competing Interest

None.

[32] In column 3 the estimate for the smoking outcome becomes insignificant. This is mainly caused by the different samples used in columns 1 and 2 and column 3. If we use the same specification as column 2 but use the same sample as column 3, then the estimate coefficient is only 0.015, which is similar to the current estimated coefficient in column 3.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jebo.2020.09.018.

References

Ahn, T., 2015. Locus of control and job turnover. Econ. Inq. 53 (2), 1350–1365.
Abay, K.A., Blalock, G., Berhane, G., 2017. Locus of control and technology adoption in developing country agriculture: evidence from Ethiopia. J. Econ. Behav. Organ. 143, 98–115.
Andrisani, P.J., 1977. "Internal-external attitudes, personal initiative, and the labor market experience of black and white men. J. Hum. Resour. 12 (3), 308–328.
Ashenfelter, Orley, Krueger, Alan, 1994. Estimates of the economic return to schooling from a new sample of twins. Am. Econ. Rev. 84 (5), 1157–1173.
Ashenfelter, O., Rouse, C., 1998. Income, schooling, and ability: evidence from a new sample of identical twins. Q. J. Econ. 113 (1), 253–284.
Avtgis, T.A., 1998. Locus of control and persuasion, social influence, and conformity: a meta-analytic review. Psychol. Rep. 83 (3), 899–903.
Ahlin, E.M., Antunes, M.J.L., 2015. 'Locus of control orientation: parents, peers, and place. J. Youth Adolesc. 44 (9), 1803–1818.
Arbet, J., McGue, M., Basu, S., 2018. 'A robust and unified framework for estimating heritability in twin studies using generalized estimating equations', *working paper*.
Beauchamp, J.P., Cesarini, D., Johannesson, M., van der Loos, M.J.H.M., Koellinger, Ph.D., Groenen, P.J.F, Fowler, J.H, Rosenquist, J.N., Thurik, A.R., Christakis, N.A., 2011. Molecular genetics and economics. J. Econ. Perspect. 25, 57–82.
Behrman, J.R., Rosenzweig, M.R., 2004. Returns to birthweight. Rev. Econ. Stat. 86 (2), 586–601.
Berger, E.M., Haywood, L., 2016. Locus of control and mothers. return to employment. J. Hum. Cap. 10 (4), 442–481.
Bound, J., Solon, G., 1999. Double trouble: on the value of twins-based estimation of the return to schooling. Econ. Educ. Rev. 18 (2), 169–182.
Caliendo, M., Cobb-Clark, D.A., Uhlendorff, A., 2015. Locus of control and job search strategies. Rev. Econ. Stat. 97 (1), 88–103.
Chew, S.H., Yi, J., Zhang, J., Zhong, S., 2018. Risk aversion and son preference: experimental evidence from Chinese twin parents. Manag. Sci. 64 (8), 3896–3910.
Coleman, M., DeLeire, T., 2003. An economic model of locus of control and the human capital investment decision. J. Hum. Resour. 38 (3), 701–721.
Cederlöf, R., Friberg, L., Jonsson, E., Kaij, L., 1961. Studies on similarity diagnosis in twins with the aid of mailed questionnaires. Acta Genet. Stat. Med. 11 (4), 338–362.
Cloninger, C.R., Przybeck, T.R., Svrakic, D.M., 1991. The tridimensional personality questionnaire: U.S. normative data. Psychol. Rep. 63 (3 Pt 1), 1047–1057.
Cebi, M., 2007. Locus of control and human capital investment revisited. J. Hum. Resour. 42 (4), 919–932.
Cobb-Clark, D.A., 2015. Locus of control and the labor market. IZA J. Labor Econ. 4 (1), 3.
Cobb-Clark, D.A., Schurer, S., 2013. Two economists' musings on the stability of locus of control. Econ. J. 123 (570), F358–F400.
Cobb-Clark, D.A., Kassenboehmer, S.C., Schurer, S., 2014. Healthy habits: the connection between diet, exercise, and locus of control. J. Econ. Behav. Organ. 98, 1–28.
Cobb-Clark, D.A., Kassenboehmer, S.C., Sinning, M.G., 2016. Locus of control and savings. J. Bank. Financ. 73, 113–130.
Elkins, R., Kassenboehmer, S., Schurer, S., 2017. The stability of personality traits during adolescence and young adulthood. J. Econ. Psychol. 60, 37–52.
Elkins, R., Schurer, S., 2020. 'Exploring the role of parental engagement in non-cognitive skill development over the lifecourse. J. Popul. Econ. 33 (3).
Fletcher, J.M., 2013. The effects of personality traits on adult labor market outcomes: evidence from siblings. J. Econ. Behav. Organ. 89, 122–135.
Fletcher, J., Schurer, S., 2017. Origins of adulthood personality: the role of adverse childhood experiences. BE J. Econ. Anal. Policy 17 (2).
Flossmann, A.L., Piatek, R., Wichert, L., 2007. 'Going beyond returns to education: the role of noncognitive skills on wages in Germany. In: Proceedings of the European Meeting of the Econometric Society. Budapest.
Gensowski, M., 2018. Personality, IQ, and lifetime earnings. Labour Econ. 51, 170–183.
Groves, M.O., 2005. How important is your personality? Labor market returns to personality for women in the US and UK. J. Econ. Psychol. 26 (6), 827–841.
Gillen, B., Snowberg, E., Yariv, L., 2019. 'Experimenting with measurement error: techniques with applications to the Caltech Cohort Study. J. Polit. Econ. 127 (4), 1826–1863.
Hansemark, O.C., 2003. Need for achievement, locus of control and the prediction of business start-ups: a longitudinal study. J. Econ. Psychol. 24 (3), 301–319.
Heckman, J.J., Rubinstein, Y., 2001. The importance of noncognitive skills: lessons from the GED testing program. Am. Econ. Rev. 91 (2), 145–149.
Heckman, J.J., Stixrud, J., Urzua, S., 2006. The effects of cognitive and noncognitive abilities on labor market outcomes and social behavior. J. Labor Econ. 24 (3), 411–482.
Heineck, G., Anger, S., 2010. The returns to cognitive abilities and personality traits in Germany. Labour Econ. 17 (3), 535–546.
Lundborg, P., 2013. The health returns to schooling – What can we learn from twins? J. Popul. Econ. 26, 673–701.
Lekfuangfu, W.N., Powdthavee, N., Warrinnier, N., Cornaglia, F., 2018. Locus of control and its intergenerational implications for early childhood skill formation. Econ. J. 128 (608), 298–329.
Li, H., Liu, P.W., Zhang, J., Ma, N., 2007. Economic returns to communist party membership: evidence from urban Chinese twins. Econ. J. 117 (523), 1504–1520.
Mor, N., 2010. Eysenck personality questionnaire. Corsini Encyclopedia Psychol. 1–2.
McGee, A.D., 2015. How the perception of control influences unemployed job search. ILR Rev. 68 (1), 184–211.
McGee, A., McGee, P., 2016. Search, effort, and locus of control. J. Econ. Behav. Organ. 126, 89–101.
Magnus, P., Berg, K., Nance, W., 1983. 'Predicting zygosity in Norwegian twin pairs born 1915–1960. Clin. Genet. 24 (2), 103–112.
Martin, N., Martin, P., 1975. 'The inheritance of scholastic abilities in a sample of twins I. Ascertainment of the sample and diagnosis of zygosity. Ann. Hum. Genet. 39 (2), 213–218.
Miller, P., Mulvey, C., Martin, N., 1995. What do twins studies reveal about the economic returns to education? A comparison of Australian and US findings. Am. Econ. Rev. 85 (3), 586–599.
Miller, J.Z., Rose, R.J., 1982. 'Familial resemblance in locus of control: a twin-family study of the internal-external scale. J. Pers. Soc. Psychol. 42 (3), 535–540.
Miller, P., Mulvey, C., Martin, N., 2001. Genetic and environmental contributions to educational attainment in Australia. Econ. Educ. Rev. 20 (3), 211–224.
Mueller, G., Plug, E., 2006. Estimating the effect of personality on male and female earnings. ILR Rev. 60 (1), 3–22.
Mosing, M.A., Pedersen, N.L., Cesarini, D., Johannesson, M., Magnusson, P.K.E., Nakamura, J., Madison, G., Ullén, F., 2012. "Genetic and environmental influences on the relationship between flow proneness, locus of control and behavioral inhibition. PLoS ONE 7 (11), e47958.
Neumark, D., 1999. Biases in twin estimates of the return to schooling. Econ. Educ. Rev. 18 (2), 143–148.
Nyhus, E.K., Pons, E., 2005. The effects of personality on earnings. J. Econ. Psychol. 26 (3), 363–384.
Posner, S., Baker, L., Heath, A., Martin, N., 1996. 'Social contact, social attitudes, and twin similarity. Behav. Genet. 26 (2), 123–133.
Pearlin, L.I., Schooler, C., 1978. The structure of coping. J. Health Soc. Behav. 19 (1), 2–21.
Pedersen, N.L., Gatz, M., Plomin, R., Nesselroade, J.R., McClearn, G.E., 1989. Individual differences in locus of control during the second half of the life span for identical and fraternal twins reared apart and reared together. J. Gerontol.: Psychol. Sci. 44 (4), 100–105.
Piatek, R., Pinger, P., 2016. Maintaining (locus of) control? Data combination for the identification and inference of factor structure models. J. Appl. Econometr. 31 (4), 734–755.
Plug, E., Webbink, D., Martin, N., 2014. Sexual orientation, prejudice, and segregation. J. Labor Econ. 32 (1), 123–159.

Stipek, D., 1980. ‘A causal analysis of the relationship between locus of control and academic achievement in first grade’, Contemp. Educ. Psychol., vol. 5, pp. 90–99.
Sandewall, Ö., Cesarini, D., Johannesson, M., 2014. The co-twin methodology and returns to schooling—Testing a critical assumption. Labour Econ. 26, 1–10.
Schnitzlein, D.D., Stephani, J., 2016. Locus of control and low-wage mobility. J. Econ. Psychol. 53, 164–177.
Schurer, S., 2017. Bouncing back from health shocks: locus of control and labor supply. J. Econ. Behav. Organ. 133, 1–20.
Semykina, A., Linz, S.J., 2007. Gender differences in personality and earnings: evidence from Russia. J. Econ. Psychol. 28 (3), 387–410.
Specht, J., Egloff, B., Schmukle, S.C., 2013. Everything under control? The effects of age, gender, and education on trajectories of perceived control in a nationally representative German sample. Dev. Psychol. 49 (2), 353.
Webbink, D., Martin, N.G., Visscher, P.M., 2008. Does teenage childbearing increase smoking, drinking and body size? J. Health Econ. 27 (4), 888–903.
Webbink, D., Martin, N.G., Visscher, P.M., 2010. Does education reduce the probability of being overweight? J. Health Econ. 29 (1), 29–38.
Webbink, D., Martin, N.G., Visscher, P.M., 2011. Does teenage childbearing reduce investment in human capital? J. Popul. Econ. 24 (2), 701–730.
Wooldridge, J.M., 2010. Econometric Analysis of Cross Section and Panel Data. MIT press.