THE ECONOMIC JOURNAL

The Economic Journal, **123** (*August*), F358–F400. Doi: 10.1111/ecoj.12069 © 2013 The Author(s). The Economic Journal © 2013 Royal Economic Society. Published by John Wiley & Sons, 9600 Garsington Road, Oxford OX4 2DQ, UK and 350 Main Street, Malden, MA 02148, USA.

TWO ECONOMISTS' MUSINGS ON THE STABILITY OF LOCUS OF CONTROL*

Deborah A. Cobb-Clark and Stefanie Schurer

Empirical studies of non-cognitive skills often rely on the assumption that these skills are stable over time. We analyse the change in a specific non-cognitive skill, that is locus of control, to assess the validity of this assumption directly. We find that short- and medium-run changes in locus of control are modest on average, are concentrated among the young or very old, are unlikely to be economically meaningful and are not related to demographic, labour market and health events. Still, there is no evidence that locus of control is truly time-invariant and the use of lagged measures could result in a substantial attenuation bias.

Increasingly, economists are pushing the boundaries of human capital theory to accommodate the role of non-cognitive skills in driving economic behaviour.[1] The explicit consideration of individuals' non-cognitive skills as a form of productive human capital has required economists to rethink – and overhaul – the theoretical and empirical models they use to understand economic relationships. Almlund *et al.* (2011), for example incorporate psychological characteristics into an economic model of decision making by allowing personality to directly affect individuals' preferences and expectations as well as the constraints they face. Similarly, Heckman *et al.* (2006) model the interaction of latent cognitive and non-cognitive skills in explaining a large array of diverse behaviours including schooling choices, work choices and risky behaviour. Finally, non-cognitive-skill endowments themselves are increasingly being modelled as resulting from educational attainment, parental investments and policy interventions (Almlund *et al.*, 2011). In this emerging literature, non-cognitive skills, once formed, are typically seen as being relatively stable and as important as cognitive ability in explaining economically relevant outcomes; see Heckman *et al.* (2006) and Borghans *et al.* (2008), for an overview.

* Corresponding author: Stefanie Schurer, RMIT University, School of Economics, Finance, and Marketing, Melbourne 3001, Australia. Email: stefanie.schurer@rmit.edu.au.

The authors are grateful for helpful comments from Angela Duckworth, Shelly Lundberg, Steven Stillman, and participants of the 2010 IZA/SOLE Transatlantic Meeting, of the 2011 Labour Econometrics Workshop, of the 2012 Society of Labor Economists' meeting, and of a brown-bag seminar at the Positive Psychology Centre, University of Pennsylvania (2012), as well as for financial support from an Australian Research Council Discovery Programme Grant (DP110103456). This article uses unit record data from the Household, Income and Labour Dynamics in Australia (HILDA) Survey, which is a project initiated and funded by the Australian Government Department of Families, Housing, Community Services and Indigenous Affairs (FaHCSIA) and is managed by the Melbourne Institute of Applied Economic and Social Research. The findings and views reported in this article, however, are those of the authors and should not be attributed to either FaHCSIA or the Melbourne Institute.

[1] The range of traits considered is often quite broad but generally includes psycho-social traits such as personality, self-efficacy, locus of control, risk preferences, self-esteem or emotional intelligence. Economists typically refer to these traits as 'non-cognitive skills' to distinguish them from other productivity-related characteristics (e.g. ability, experience or education), which are generally seen as more 'cognitive' (Kuhn and Weinberger, 2005). We follow that convention here although there is no clear distinction between what is best considered cognitive *versus* non-cognitive.

Empirical studies of the importance of non-cognitive skills for economic outcomes often go a step further and assume that these skills are not only stable but are fixed over the relevant time frame (Andrisani, 1977; Goldsmith *et al.*, 1997; Cebi, 2007; Semykina and Linz, 2007; Heineck and Anger, 2010). This assumption is convenient because it implies that non-cognitive skills are exogenous and are not themselves a function of the specific educational or labour market outcomes under consideration. Moreover, this assumption resolves the problems associated with having data on non-cognitive skills only at a single point in time and is particularly useful when the measurement of these non-cognitive skills occurs *ex post* or years before the main outcome of interest. The assumption that non-cognitive skills are time-invariant allows the use of lead or lagged measures of these skills, a common strategy in the empirical literature (Osborne Groves, 2005; Cebi, 2007; Heineck and Anger, 2010; Schurer, 2011).

Unfortunately, empirical analyses relying upon this assumption are likely to be biased if non-cognitive skills are in fact not fixed over the analysis period. Of most concern is the possibility that non-cognitive skills – rather than being exogenous – are driven by or determined jointly with contemporaneous and/or past values of the outcome of interest (e.g. income or unemployment history). In this case, the endogeneity of non-cognitive skills implies that the classical assumptions of standard regression models no longer hold resulting in an estimation bias of unclear sign and magnitude. Occasionally, researchers attempt to eliminate any bias resulting from reverse causality or simultaneity using lagged measures of non-cognitive skills. However, the inclusion of lagged skills measures – even when available – results in an errors-in-variables problem if non-cognitive skills do in fact change over the relevant time frame (Almlund *et al.*, 2011).

We make an important contribution to this emerging literature by carefully analysing the change in a specific non-cognitive skill, that is locus of control, over both the short (one year) and medium run (four years). 'Locus of control' is a psychological concept capturing 'a generalised attitude, belief or expectancy regarding the nature of the causal relationship between one's own behaviour and its consequences' (Rotter, 1966). Those believing that life's outcomes are due to their own efforts have an internal locus (sense) of control, while those believing that outcomes are due to external factors (e.g. luck) have an external locus (sense) of control (Gatz and Karel, 1993).

It is not surprising then that locus of control has been shown to have a substantial influence on key economic outcomes including earnings (Andrisani, 1977; Goldsmith *et al.*, 1997; Duncan and Dunifon, 1998; Osborne Groves, 2005; Semykina and Linz, 2007; Heineck and Anger, 2010), unemployment (Becker *et al.*, 2012), educational attainment (Coleman, 1966; Coleman and Deleire, 2003; Barón and Cobb-Clark, 2010; Piatek and Pinger, 2010), life satisfaction (Becker *et al.*, 2012) and health investments (Chiteji, 2010; Cobb-Clark *et al.*, 2012) as well as the ability to cope with unanticipated life events such as health shocks (Schurer, 2011) or unemployment (Caliendo *et al.*, 2010). In conjunction with self-esteem, it has also been shown to affect a battery of adulthood outcomes and appears to be equally strong in its effects as cognitive ability (Heckman *et al.*, 2006). Locus of control captures beliefs that are distinct from – but complementary to – key economic preferences for example risk, time and social preferences (Becker *et al.*, 2012) but that correlate with other non-cognitive skills such as self-esteem or neuroticism (Judge *et al.*, 2002). Moreover, there is increasing evidence that education, policy interventions and parental investments that enhance personality traits like locus of control can lead to more successful outcomes in adulthood (Almlund *et al.*, 2011; Heckman and Kautz, 2012). Our comprehensive, in-depth analysis of the stability of locus of control provides important insights into the stability of non-cognitive skills more generally.

We are particularly interested in addressing the following questions. How stable is individuals' locus of control over time? Are any changes in individuals' locus of control effectively exogenous or do they appear to be related to labour market, health or demographic events? Are these changes economically meaningful? What is the likely magnitude of the errors-in-variables problem? What estimation strategies should be adopted when analysing non-cognitive skills like locus of control?

In answering these questions, we take advantage of high-quality, longitudinal data from the household, income and labour dynamics in Australia (HILDA) Survey. These data are unique in providing the same measure of locus of control at three separate points in time. This allows us to quantify the magnitude of the errors-in-variables problem associated with using lead or lagged non-cognitive skills measures. In addition, the HILDA data contain annual measures of a number of positive (e.g. promoted at work) and negative (e.g. unemployment) life events. These life-events data are particularly useful given that they are likely to drive what psychologists refer to as 'non-normative' changes in personality more generally.[2] Moreover, many of these events are outside individuals' control (e.g. death of a spouse) and thus can be used to capture the important, exogenous shocks that Seligman (1975) suggests may cause helplessness. We use these life-events data to gain important insights into the determinants of individuals' locus of control.

We find that short and medium-run changes in locus of control are modest on average, are concentrated among the young or very old, are unlikely to be economically meaningful, and are not related to demographic, labour market and health events. Still, there is no evidence that locus of control is truly time-invariant and the use of lagged measures could result in a substantial attenuation bias. Researchers wishing to analyse non-cognitive skills should consider: restricting analysis to the working-age population for whom there is little evidence of systematic change in skill levels; accounting for error in the skill measures they employ.

The remainder of the article is as follows. Section 1 reviews the psychological and economic evidence on the stability of non-cognitive skills including personality traits and locus of control. Section 2 outlines the econometric problems that arise when the assumption that non-cognitive skills are fixed is violated, while Section 3 describes the HILDA data and the specific measures we analyse. In Section 4, we present evidence on

[2] Psychologists use the term 'normative' differently from economists. Psychologists view normative change as occurring when most people change in the same way during a specific period of the life course (McCrae *et al.*, 2000).

the stability of locus of control, the relationship between life events and change in locus of control, the economic significance of locus-of-control changes and the magnitude of the attenuation bias resulting from the errors-in-variables problem. Section 5 concludes by discussing the strategies that applied economists should consider when analysing non-cognitive skills.

1. Psychology and the Stability of Non-cognitive Skills

Economists' standard assumption that non-cognitive skills are stable (or time-invariant) is not simply driven by convenience but also rests on the early work of psychologists who argued that a variety of personality traits develop before or during adolescence and then remain relatively stable from the age of 30 onwards (Costa and McCrae, 1988; McCrae and Costa, 2006). This psychological evidence is important because economists view personality traits as key non-cognitive skills. The extent to which personality can be considered stable is more contested today, with some psychologists suggesting that personality changes may occur up until the age of 50 (Roberts *et al.*, 2000).

It is important for economists wishing to rely on this psychological evidence to note that psychologists typically focus on several alternative concepts of consistency – all of which are considered important for understanding the stability of personality traits. Rank-order consistency is defined as the relative placement of an individual within a group over time and is usually assessed via test-retest stability coefficients. On the other hand, mean-level consistency reflects whether groups of individuals increase or decrease on trait dimensions over time (Roberts and DelVecchio, 2000). Mean-level consistency is often equated with the normative changes in personality that result when the maturational, social or historical forces facing a population lead the personalities of most individuals to change in much the same way (McCrae *et al.*, 2000). Rank-order and mean-level consistency pertain to populations of individuals. In contrast, intra-individual consistency focuses on how the personality traits of each individual change with time (Roberts and DelVecchio, 2000).

Psychologists have studied the rank-order and mean-level consistency of personality traits extensively. Meta-analyses of this research generally conclude that: personality traits are consistent across time and age; the greatest mean-level change in personality traits occurs not during adolescence, but during young adulthood; rank-order stability increases steadily over the life course (Roberts and DelVecchio, 2000; Roberts *et al.*, 2000). Psychologists know less about intra-individual consistency in personality traits, however. Although several longitudinal studies have focused on personality development in young people, the ability to generalise has been limited by unrepresentative sampling, low power and limited trait coverage (Roberts *et al.*, 2000).

What should economists interested in analysing non-cognitive skills take away from this psychological literature? First, it is important to note that one form of consistency does not imply any other. Rank-order and mean-level consistency are best thought of as orthogonal concepts, while the existence of rank-order or mean-level consistency does not rule out the presence of intra-individual changes (Roberts and DelVecchio, 2000; Roberts *et al.*, 2000). In particular, even when mean-level changes in personality traits are zero, there may still be substantial intra-individual change. Some individuals within a population may simply be increasing in a particular trait dimension while others are decreasing, thus producing offsetting changes and zero mean-level change (Roberts, 1997; Roberts *et al.*, 2001). Second, mean-level and intra-individual consistency are much more relevant than rank-order consistency for most economic analyses, and it is important to carefully consider what these forms of consistency do and do not imply for our models. Mean-level consistency, for example implies not that personality traits do not change at all, but rather that personality changes occur in systematic, non-idiosyncratic ways that apply to most people. For this reason, economists need to account carefully for the effects of these normative changes in any empirical analysis.[3] Third, it is the concept of intra-individual consistency that underpins economists' standard treatment of non-cognitive skills in their econometric analysis. Yet, the psychological evidence on the existence of intra-individual consistency is relatively weak. Moreover, evidence is mounting that genetics, environmental influences, education, parental investments and policy interventions can all influence personality change suggesting that intra-individual consistency in personality traits cannot necessarily be assumed (see Almlund *et al.*, 2011, for an overview). Finally, consistency is about stability – not time invariance. We can find no evidence from the psychological literature that personality traits are truly time-invariant.

Thus far, our discussion has focused on the psychological evidence for the consistency of personality traits. This is sensible given the preponderance of the literature on this issue and the fact that applied economists often use personality traits – in particular, the Big Five – as measures of non-cognitive skills. However, since the degree of trait consistency depends on the specific trait considered (Roberts *et al.*, 2000), it is important to also explicitly consider the evidence on the consistency of locus of control.

Like the Big Five measures of personality traits, indicators of locus of control are often included in large-scale, representative panel data sets. This has resulted in a growing literature which assesses the link between individuals' sense of control over their lives and the outcomes they achieve. Although not formally included in the Big Five taxonomy, locus of control is related to the Big Five factors of neuroticism and emotional stability (Almlund *et al.*, 2011).

Psychologists have devoted a great deal of effort to understanding the development of locus-of-control tendencies, especially during childhood. Locus of control is thought to develop during childhood and stabilise during adolescence (Kulas, 1996). Children are more likely to develop internal control tendencies if their parents provide both emotional support and a nurturing home environment, free of stressful and disruptive life events (Carton and Nowicki, 1994). Moreover, there appears to be a link between socio-economic status and locus of control. Stephens and Delys

[3] Heineck and Anger (2010), for example account for normative personality changes by adjusting their lead personality measures for age implicitly assuming that there are no individual-specific changes in personality. Osborne Groves (2005) purges a lagged measure of childhood locus of control of the age effect for similar reasons.

(1973), for example, argue that by the age of four, children from economically disadvantaged backgrounds already exhibit less internal control tendencies than children from more advantaged families. Stressful life events are also related to a tendency to have a more external locus of control and although the empirical evidence is inconclusive, locus of control appears to evolve over the life cycle as physical and mental health changes.[4]

Little in-depth analysis exists on the stability of locus of control in adulthood. Doherty and Baldwin (1985) analyse changes in control tendencies over the 1970s for both young and mature men and women using National Longitudinal Survey of Labour Market Experiences (NLS) data. The authors find that men's control tendencies remained relatively stable, whereas women became somewhat more external. However, the change in women's locus of control was modest (averaging just under a one standard deviation change between 1969 and 1978) and could not be explained by demographic factors (i.e. marital status, race or occupation).

It is not clear, however, whether adults' locus of control responds to the economic, social and demographic events that they experience or whether the reverse is true. The potential simultaneity between locus of control and labour market outcomes poses enormous econometric challenges and renders much of the applied literature in this area rather unconvincing. An important exception is the work of Gottschalk (2005) who finds that exogenous increases in work hours induced by an experimental tax credit resulted in increased internal control tendencies among welfare recipients.

Overall, the psychological literature provides important insights into the nature of non-cognitive-skill change over the life cycle. However, it is perhaps less helpful to applied economists than is commonly thought. What we really need to understand when specifying our econometric models is the degree of exogeneity and intra-individual consistency in the self-reported non-cognitive skill measures (Big Five, locus of control or self-esteem) generally available in the large, general population samples that we are analysing. The psychological literature provides us with some guidance but no absolutes.

2. The Econometric Problem

Economists increasingly recognise that non-cognitive skills may represent an important source of unobserved heterogeneity in economic behaviour. Wooldridge (2009, p. 282), for example motivates the importance of panel-data econometrics by arguing that individual differences in motivation or cognitive ability, two possible manifestations of personality, may generate unobserved, time-invariant heterogeneity. In the absence of data on individuals' non-cognitive skills, researchers are limited to using fixed-effect, panel-data models to purge their estimates of these confounding factors. This approach is sensible, however, only to the extent that the unobserved skills under consideration are truly time-invariant. The increasing availability of individual-specific

[4] See Gatz and Karel (1993) and Coleman and Deleire (2003) for particularly helpful reviews.

data on personality traits, including locus of control, has been very powerful in allowing economists to account for the effects of non-cognitive skills in standard econometric models explicitly. This has dramatically expanded the range of models that can be considered.

In the remainder of this Section, we briefly review some econometric issues that arise if non-cognitive skills, rather than being time-invariant, are instead time-varying. We begin with an illustration. Let us assume that we are interested in the effects of locus of control (L_{it}) on wages (Y_{it}):

$$Y_{it} = \alpha + \gamma L_{it} + \varepsilon_{it}, \tag{1}$$

where α is a common intercept and ε_{it} are idiosyncratic, time-varying shocks. For simplicity, we will assume that L_{it} captures all relevant individual-specific heterogeneity and we ignore the influence of any other independent variables. An ordinary least squares (OLS) estimate of γ is unbiased as long as the error term ε_{it} is mean zero and independent of L_{it}.

The assumption that locus of control is independent of the error term in (1) is uncontroversial if locus of control is a fixed trait like gender or race and if there are no omitted variables that correlate with locus of control. Then, $L_{it} = L_i$ and $\mathrm{Cov}(L_{it}, \varepsilon_{it}) = 0$. In effect, locus of control would be pre-determined permitting the use of standard regression techniques. The review of the psychological evidence in Section 1, however, suggests that this assumption is unlikely to hold in reality. What implications does the violation of this assumption have for the estimated wage returns to locus of control? In what follows, we consider two important cases.

2.1. *Case 1: The Errors-in-variables Problem*

Let us assume that information about current locus of control (L_{it}) is unavailable, but that we do observe individuals' locus of control as measured in a previous period $t-k$. In this case, lagged locus of control (L_{it-k}) can be used as a proxy for current ('true') locus of control (L_{it}) plus some measurement error (υ_{it-k}) that is assumed to have a mean-zero distribution:

$$L_{it-k} = L_{it} + \upsilon_{it-k}. \tag{2}$$

In (2), $\upsilon_{it-k} = L_{it-k} - L_{it}$ reflects the change in individuals' locus of control between $t-k$ and t. Many studies that investigate the returns to non-cognitive skills using lagged measures (Osborne Groves, 2005; Cebi, 2007) or the determinants of changes in non-cognitive skills (Lucas and Donnellan, 2011; Specht *et al.*, 2011; Cobb-Clark and Schurer, 2012) implicitly adopt this framework. Using (2) implies that (1) can be re-written as follows:

$$Y_{it} = \alpha + \gamma L_{it-k} + (\varepsilon_{it} - \gamma \upsilon_{it-k}). \tag{3}$$

If the measurement error fits the classical case, it will be uncorrelated with the contemporaneous measure of locus of control, that is $\mathrm{Cov}(L_{it}, \upsilon_{it-k}) = 0$. Then by construction, the correlation between the measurement error and the lagged measure of locus of control must be non-zero, that is $\mathrm{Cov}(L_{it-k}, \upsilon_{it-k}) \neq 0$.[5] OLS regression of (3) would then yield biased and inconsistent estimates of γ because our proxy measure of locus of control would be correlated with the error term in the wage equation.[6] This results in an attenuation bias in the estimated wage returns to locus of control:

$$\mathrm{plim}(\hat{\gamma}) = \gamma \frac{\sigma^2_{L_t}}{\sigma^2_{L_t} + \sigma^2_{\upsilon}} = \gamma\lambda. \tag{4}$$

In the limit, $\hat{\gamma}$ is biased towards zero and the extent of the attenuation bias depends on the variance of the measurement error (σ^2_{υ}) and the variance of the contemporaneous locus of control measure ($\sigma^2_{L_t}$). The greater the variation in the measurement error (i.e. the noise) relative to the variation in the contemporaneous locus of control measure (i.e. the signal), the greater is the bias. In the literature, λ is often interpreted as a reliability parameter with higher values of λ indicating less bias (Bound and Krueger, 1991).

If we are unwilling to make the strong assumption that the measurement error is uncorrelated with the contemporaneous measure of locus of control and we allow $\mathrm{Cov}(L_{it}, \upsilon_{it-k}) \neq 0$, the reliability parameter λ is constructed as follows:

$$\lambda = \frac{\mathrm{Cov}(L_{it}, L_{it-k})}{\mathrm{Var}(L_{it-k})}. \tag{5}$$

In this case, λ is simply the slope coefficient from an OLS regression of the contemporaneous measure of locus of control L_{it} on its lagged (proxy) value L_{it-k}. In an application presented in subsection 4.4, we quantify the measurement error in locus of control and compare our estimates of the reliability parameter to estimates presented in Bound and Krueger (1991) and Kapteyn and Ypma (2007).

In our simple example, the attenuation bias that results from using lagged values of locus of control as proxies for contemporaneous locus of control leads the wage returns to locus of control to be underestimated. However, it is also important to note that the errors-in-variables problem becomes much more complex if we have multiple independent variables. In that case – even if locus of control is the only variable measured with error – the ensuing bias will also depend in a not so straightforward way on the correlation between the locus of control measure and the other explanatory variables. In particular, the attenuation bias is aggravated the more collinear the true locus of control is with all other explanatory variables (Wooldridge, 2009, p. 81).

Moreover, it is important to note that estimates of reliability, as in for example (4), are dependent on the structure of measurement error being postulated (Thompson and Vacha-Haase, 2000). There are clearly alternative models that could be considered. For example, it is possible that changes in recorded locus of control are observed not because of changes in the underlying trait itself but because of

[5] The assumption of non-independence between lagged values of locus of control and the measurement error implies that the change in locus of control between $t-k$ and t depends on the value of locus of control in period $t-k$ and not on the value of locus of control in period t. We believe that this is a reasonable assumption.

[6] This is given in the following: $\mathrm{Cov}(L_{it-k}, \varepsilon_{it} - \gamma\upsilon_{it-k}) = -\gamma\,\mathrm{Cov}(L_{it-k}, \upsilon_{it-k}) \neq 0$.

changes in the way that individuals answer survey questions about these traits.[7] Specifically, let us assume that locus of control is a latent trait (L_i^*) that is stable over time but which is measured with error (η_{it}) in each time period, where η_{it} is assumed to have a mean-zero distribution:

$$L_{it} = L_i^* + \eta_{it}, \tag{6}$$

$$L_{it-k} = L_i^* + \eta_{it-k}. \tag{7}$$

In this model specification, the measurement error expressed in (2) is interpreted as the change in the measurement error between the two proxies of the latent factor ($\upsilon_{it} = \eta_{it-k} - \eta_{it}$). If we assume classical measurement error, that is there is no correlation between the measurement error and the latent trait, there will be an attenuation bias when using either (6) or (7) to estimate (1). The magnitude of the attenuation bias in time period t and $t - k$ depends on the size of $\sigma^2_{\eta_t}$ and $\sigma^2_{\eta_{t-k}}$, as the reliability parameters are as follows:

$$\lambda^t = \frac{\sigma^2_{L^*}}{\sigma^2_{L^*} + \sigma^2_{\eta_t}}, \tag{8}$$

$$\lambda^{t-k} = \frac{\sigma^2_{L^*}}{\sigma^2_{L^*} + \sigma^2_{\eta_{t-k}}}. \tag{9}$$

It can further be shown that the attenuation bias in (9) is larger than in (8) if $\sigma^2_{\eta_{t-k}} > \sigma^2_{\eta_t}$, that is if the variance of the measurement error in past locus of control proxies is greater than the variance of the measurement error in contemporaneous proxies.

Theoretically, the attenuation biases in (8) and (9) cannot be quantified since L_i^* is not observed and therefore $\sigma^2_{L^*}$, $\sigma^2_{\eta_t}$ or $\sigma^2_{\eta_{t-k}}$ cannot be calculated. Nevertheless, an approximation can be calculated using the estimated measurement error variances obtained from a latent factor model (Bollen, 1989). We do this in subsection 4.4. In addition, we compare the estimated wage effects of locus of control between OLS and linear latent factor structural equation modelling (SEM), where the latter is a simplified version of the models proposed in, for example Cunha and Heckman (2008) to account for measurement error as outlined in (8) and (9).

2.2. *Case 2: The Simultaneity and Reverse Causality Problem*

Rather than being exogenous, individuals' locus of control may either be determined with or result from individuals' previous labour market outcomes. Locus of control and wages, for example may be simultaneously determined if the cognitive and

[7] For example, Cunha and Heckman (2008) and Cunha *et al.* (2010) emphasise the importance of measurement error in non-cognitive skills in their analysis of the determinants and the evolution of non-cognitive skills in early childhood and adolescence. To this end, they develop a dynamic latent factor structural equation model to deal both with the potential simultaneity in outcome and latent factors, and the measurement error in those latent factors. Identification is achieved through maintained assumptions regarding: the production function; the variance-covariance matrix for the individual items in the measurement model.

non-cognitive skills that underpin labour market success are jointly determined through the same process, say education or parents' investments in their children. Alternatively, individuals' locus of control may respond directly to their earnings capacity, unemployment history or occupational status, leading to reverse causality. Our review of the psychological evidence regarding the stability of non-cognitive skills points to many channels through which these links might occur.

To illustrate the consequences of reverse causality using a simple case, let us assume that locus of control is simultaneously determined by wages and an exogenous background variable X_{it}, where ω and δ in (10) measure the impact of wages and the background variable, respectively, on locus of control.

$$L_{it} = \omega Y_{it} + \delta X_{it} + v_{it}. \tag{10}$$

The error term v_{it} is assumed to be distributed independently of X_{it} with zero mean and variance σ_v^2. The covariance $\sigma_{\varepsilon v}$ measures the relationship between the two error terms v_{it} and ε_{it}. Inserting (10) into (1) (and *vice versa*) and solving for Y_{it} and L_{it} results in the following:

$$\begin{aligned} Y_{it} &= \frac{\alpha}{1-\gamma\omega} + \frac{\gamma\delta}{1-\gamma\omega} X_{it} + \frac{1}{1-\gamma\omega}\varepsilon_{it} + \frac{\gamma}{1-\gamma\omega} v_{it} \\ L_{it} &= \frac{\alpha\omega}{1-\gamma\omega} + \frac{\delta}{1-\gamma\omega} X_{it} + \frac{\omega}{1-\gamma\omega}\varepsilon_{it} + \frac{1}{1-\gamma\omega} v_{it} \end{aligned}. \tag{11}$$

It follows from (11) that the covariance between L_{it} and ε_{it} in (1) is non-zero. Specifically,

$$\mathrm{Cov}(L_{it}, \varepsilon_{it}) = \frac{1}{1-\gamma\omega}(\omega\sigma_\varepsilon^2 + \sigma_{\varepsilon v}), \tag{12}$$

and

$$\mathrm{Var}(L_{it}) = \left(\frac{1}{1-\gamma\omega}\right)^2 (\delta^2\sigma_X^2 + \omega^2\sigma_\varepsilon^2 + \sigma_v^2 + 2\omega\sigma_{\varepsilon v}). \tag{13}$$

Thus, the bias in $\hat{\gamma}$ which results from estimating (1) without considering the simultaneity as expressed in (10) is given in the following:

$$\mathrm{plim}(\hat{\gamma}) = \gamma + \frac{\mathrm{Cov}(L_{it}, \varepsilon_{it})}{\mathrm{Var}(L_{it})} = \gamma + (1-\gamma\omega)\frac{\omega\sigma_\varepsilon^2 + \sigma_{\varepsilon v}}{\delta^2\sigma_X^2 + \omega^2\sigma_\varepsilon^2 + \sigma_v^2 + 2\omega\sigma_{\varepsilon v}}. \tag{14}$$

The simple errors-in-variables problem given in (2), (6) or (7) results in a clear prediction that our estimates will be biased towards zero. In contrast, the direction of bias in the case of simultaneity or reverse causality will depend on: the sign of γ and ω; the variation in the error one makes in specifying the wage equation (σ_ε^2); the relationship between the errors in the wage and the locus of control equation ($\sigma_{\varepsilon v}$); the noise-to-signal ratio, that is the proportion of error in the wage equation. The bias in $\hat{\gamma}$ will be negligible only for very small values of the noise-to-signal ratio. This will be the case either when: there is substantial variation in $X_{it}(\sigma_X^2)$; the effect of X_{it} on locus of control is very strong (δ) and/or; the variation in the error in wages (σ_ε^2) is small.[8]

[8] See Cobb-Clark and Schurer (2011) for a detailed discussion of the direction of the bias.

Simultaneity and reverse causality problems can be addressed by finding suitable proxy variables that affect locus of control but do not influence wages other than through locus of control. Many researchers in this situation turn to lagged locus-of-control measures. Unfortunately, however, if locus of control is not a fixed trait, lagged locus of control proxies contemporaneous locus of control only with error resulting in the attenuation bias discussed above. Alternatively, lagged values of locus of control may be used as an instrumental variable in a two-stage least square approach. However, this requires multiple measures of locus of control and to date is uncommon in the applied literature. See Osborne Groves (2005) for an exception.

3. Data: Household, Income and Labour Dynamics in Australia Survey

Our data come from the HILDA Survey, which collects longitudinal information from a large nationally representative sample of Australian households through both face-to-face interviews and self-completion questionnaires for all household members aged 15 years and older. A total of 13,969 individuals in 7,682 households were interviewed in wave 1 (Summerfield, 2010). The HILDA Survey is a general-purpose, panel survey designed to obtain detail information about the dynamics of household structure and formation, income and economic well-being, as well as employment and labour force participation (Wooden and Watson, 2007). The HILDA data are ideally suited for our purposes. In addition to standard demographic and labour market information, measures of several key non-cognitive skills (in particular locus of control and the Big Five) are available in multiple waves.

3.1. *Estimation Sample*

We rely on individual-level HILDA data from waves 3–7 spanning the years 2003–7. From the original 12,728 individuals interviewed in 2003, 11,501 answered the locus-of-control items (90.4%).[9] Of these 11,501, 9,728 (8,351) also answered the locus of control items in 2004 (2007) and so the base sample for the descriptive analysis consists of 4,554 men and 5,174 women for short-run changes, and 3,883 men and 4,468 women for medium-run changes in locus of control. Our final estimation sample used in investigating the medium-run changes in locus of control is further reduced by about 0.5% to 3,859 men and 4,437 women due to missing data on some of the life events and health conditions.[10]

[9] Locus-of-control data are collected in a self-completion questionnaire (SCQ) that is left with the interviewee who is asked to return it by mail. Response rates in 2003, 2004 and 2007 when locus of control was collected were 92.3%, 91.9% and 89.0% respectively (Summerfield, 2010).

[10] We investigated the potential for bias due to selective attrition by comparing the average short-run (2003–4) change in locus of control for those who do (3,635 women, 3,383 men) and do not (24,335 women, 20,555 men) drop out of the sample before 2007. We find no statistical difference for women. Men who left the sample had on average no change in locus of control between 2003 and 2004, while those who remained become slightly more internal.

3.2. *Parameterising Locus of Control*

Our objective is to understand the stability of individuals' locus of control over time. In 2003, 2004 and 2007 respondents were asked supplemental personality questions. These included, among other things, all seven of the original items from the Psychological Coping Resources component of the Mastery Module developed by Pearlin and Schooler (1978). Mastery refers to beliefs about the extent to which life's outcomes are under one's own control. Those with an internal locus of control generally believe that life's outcomes are due to their own efforts, while those with an external locus of control believe that outcomes are mainly due to external factors (Gatz and Karel, 1993). Mastery, that is self-efficacy, has been linked to many aspects of human development including cognitive, health, clinical, athletic and organisational functioning (Bandura, 1997).[11]

Specifically, HILDA Survey respondents were asked about the extent to which they agree that a particular personality trait refers to them. Possible responses range from 1 (strongly disagree) to 7 (strongly agree). Table 1 documents the wording of the seven locus of control items. A preliminary factor analysis reveals that items (*a*) to (*e*) unambiguously load on one factor, while items (*f*) and (*g*) load on another one. These two factors can be interpreted as external and internal control tendencies respectively (Pearlin and Schooler, 1978). A test of internal consistency yields a Cronbach's α reliability statistic of 0.82 when including all seven items in the index which is usually accepted in the literature as highly reliable (Cronbach, 1951).

We create a combined locus of control index (LOC_{it}) by summing responses to the five external items (*a–e*), subtracting the sum of responses to the two internal items (*f–g*) and adding 16. Specifically,

$$LOC_{it} = \sum_{j=a}^{e} ELOC_{it,j} - \sum_{j=f}^{g} ILOC_{it,j} + 16. \tag{15}$$

This index is therefore increasing in external control tendencies and is bounded between 7 (internal) and 49 (external). A similar index has been used in Andrisani (1977), Pearlin and Schooler (1978), Semykina and Linz (2007) and Caliendo *et al.* (2010).[12] The advantage of this approach is that the magnitude of changes in the index is easily interpreted. The disadvantage is that each individual item is assumed to contribute equally to the overall index. We investigated the sensitivity of our results to this equal weighting assumption by re-estimating our models using a locus of control index derived from the first predicted (latent) factor as in Piatek and Pinger (2010) and Cobb-Clark *et al.* (2012). The results are virtually identical across the two measures. Sensitivity results using this alternative measure of locus of control are presented in Table 4.

[11] Strictly speaking, coping efficacy is not identical to the concept of locus of control as developed by Rotter (1966). There is, however, significant overlap in the indicators used to identify the two concepts. Moreover, Judge *et al.* (2002) argues that measures of locus of control and generalised self-efficacy are markers of the same higher order concept. This supports conceiving the various concepts of efficacy and locus of control as being similar.

[12] Alternatively, Gottschalk (2005) uses four binary indicators, whereas Coleman and Deleire (2003) use the average response to six locus of control items.

Table 1

Dimensions of Locus of Control: Number of Observations (%)

	Categories							
Question N = 33,749	Strongly disagree	2	3	4	5	6	Strongly agree	Mean (SD)
(*a*) I have little control over the things that happen to me	7,701	10,204	5,423	4,765	2,958	1,679	1,019	2.83
	(22.82)	(30.23)	(16.07)	(14.12)	(8.76)	(4.97)	(3.02)	(1.61)
(*b*) There is really no way I can solve some of the problems I have	9,214	11,343	4,718	3,297	2,359	1,649	1,169	2.64
	(27.30)	(33.61)	(13.98)	(9.77)	(6.99)	(4.89)	(3.46)	(1.63)
(*c*) There is little I can do to change many of the important things in my life	8,876	11,139	4,922	3,684	2,439	1,633	1,056	2.67
	(26.30)	(33.01)	(14.58)	(10.92)	(7.23)	(4.84)	(3.13	(1.61)
(*d*) I often feel helpless in dealing with the problems of life	9,662	10,897	4,704	3,629	2,397	1,585	875	2.60
	(28.63)	(32.29)	(13.94)	(10.75)	(7.10)	(4.70)	(2.59)	(1.59)
(*e*) Sometimes I feel that I'm being pushed around in life	9,777	9,992	4,768	3,840	2,812	1,640	920	2.66
	(28.97)	(29.61)	(14.13)	(11.38)	(8.33)	(4.86)	(2.73)	(1.63)
(*f*) What happens to me in the future mostly depends on me	1,229	1,313	1,447	2,895	4,903	11,111	10,851	5.54
	(3.64)	(3.89)	(4.29)	(8.58)	(14.53)	(32.92)	(32.15)	(1.59)
(*g*) I can do just about anything I really set my mind to do	925	1,238	1,934	4,508	7,012	10,026	8,106	5.31
	(2.74)	(3.67)	(5.73)	(13.36)	(20.78)	(29.71)	(24.02)	(1.51)

Source. HILDA 2003, 2004, 2007. Self-completion Questionnaire, Question B10.

4. Results

Our interest is in analysing the change over time in individuals' locus-of-control tendencies. In this Section, we provide empirical evidence on: the degree of short and medium-run stability in locus of control; the degree to which locus of control appears to respond to individuals' life experiences; the extent to which changes in locus of control are economically meaningful; the potential magnitude of the attenuation bias resulting from the errors-in-variables problem.

4.1. *Is Locus of Control Stable?*

We begin by calculating the short-run (2003–4) and medium-run (2003–7) change in locus of control for those individuals providing locus-of-control data in multiple years. A positive result is interpreted as an increase in external control tendencies, whereas a negative result indicates an increase in internal control tendencies. The distributions of short and medium-run changes in locus of control are graphically depicted in Figures 1(*a*) and (*b*) separately by gender.

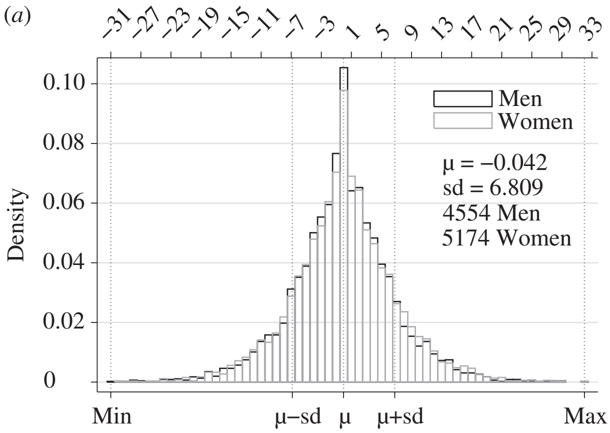
Theoretically, the change in our locus-of-control index ranges from −42 to +42. The most extreme change would imply that an individual is completely internally controlled in one year ($LOC_{it} = 7$) and completely externally controlled in another year ($LOC_{ik} = 49, t \neq k$) or *vice versa*. We can find no evidence that such dramatic changes happen in reality. On average, the mean and median locus-of-control change among the individuals in our sample is 0 for women and nearly 0 for men. Moreover, the standard deviation of the change in locus of control is only 7.5 points in the medium run. A change of 7.5 implies that, on average, individuals change their response to each of the seven locus-of-control items (*a*)–(*g*) (range from 1 to 7) by approximately one point. Short-run changes in individuals' locus-of-control indexes are, not surprisingly, even smaller. Thus, complete reversals in control tendencies over the short or medium run do not occur.

Moreover, it is important to note that approximately 9.3% of men and 8.3% of women do not change their locus-of-control index at all between 2003 and 2007. In fact, only 25.0% of men and 27.5% of women change their locus-of-control index by more than one standard deviation over the medium run and less than 1% change by three standard deviations or more. The vast majority of men and women either do not change their internal–external control tendencies or change them very little. Finally, the distribution of locus-of-control changes does not differ for men and women in the short run ($p = 0.386$); however, in the medium run, women become somewhat more external relative to men ($p < 0.001$).

The psychological literature reviewed in Section 1 suggests that as people age, normative changes in personality may occur as the result of social forces or indeed the ageing process itself. Consequently, it is important to carefully consider how changes in locus-of-control tendencies may vary over the life cycle. Figure 2 presents non-parametric bivariate regression estimates of the change in locus of control by age.[13] Results are presented separately by gender for both the short

[13] We use bivariate kernel regression with a bandwidth of 2 to estimate mean levels of locus of control as a function of age. Figures also include a 95% confidence interval (Wand and Jones, 1995).

(*a*)



(*b*)

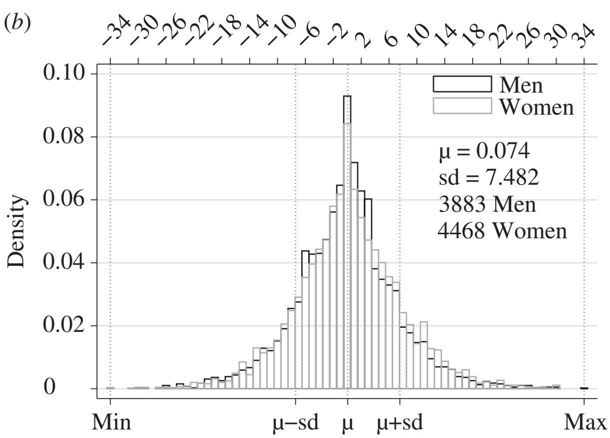


Fig. 1. *Distribution of Changes in Locus of Control by Gender*
Notes. (*a*) Short-run (2003–4), (*b*) Medium-run (2003–7) Kolmogorov–Smirnov equal distribution test: (*a*) $p = 0.386$, (*b*) $p < 0.001$.

(Figures 2(*a*) and (*b*)) and medium run (Figures 2(*c*) and (*d*)) and for the working-age population (ages 25–60) as a whole (Figures 2(*e*) and (*f*)). These results indicate that although the degree of change in locus of control varies somewhat across the life cycle, on average locus-of-control changes are quite small especially over the short run. Even in the medium-run, average changes in individuals' locus-of-control indexes typically range from −2 to +2 points. Only among the old (aged 70+) is there evidence of a substantial increase in external control tendencies, although given our small sample sizes these changes are imprecisely estimated and not always significant. We test for the equality of locus-of-control changes across age groups and reject the null hypothesis only for men in the medium run ($p = 0.053$). In all other cases, we cannot reject the hypothesis that changes over time in individuals' locus of control are the same irrespective of their age.

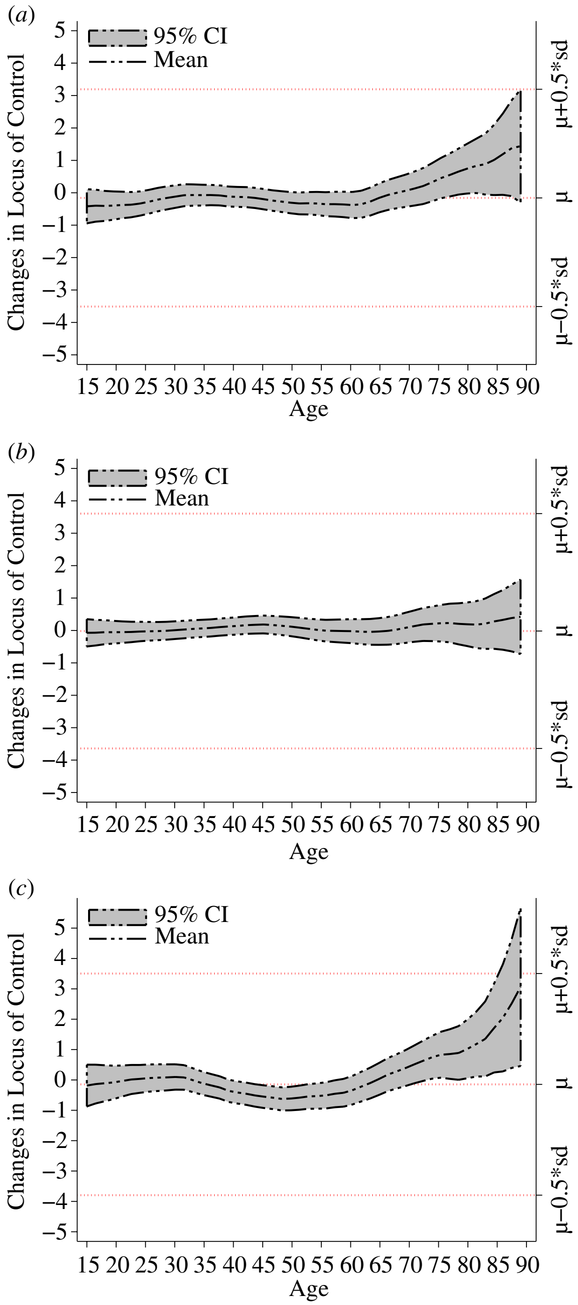


Fig. 2. *Changes in Locus of Control Over the Life Cycle: Short and Medium Run*

Notes. (*a*) Men 2003–4: F-test of no difference across age-groups: p = 0.361. (*b*) Women 2003–4: F-test of no difference across age-groups: p = 0.354. (*c*) Men 2003–7: F-test of no difference across age-groups: p = 0.053. (*d*) Women 2003–7: F–test on no differences across positive life-events: p = 0.012. (*e*) Men and women 2003–4: F-test of no difference across age-groups: p = 0.414. (*f*) Men and women 2003–7: F-test of no difference across age-groups: p = 0.354.

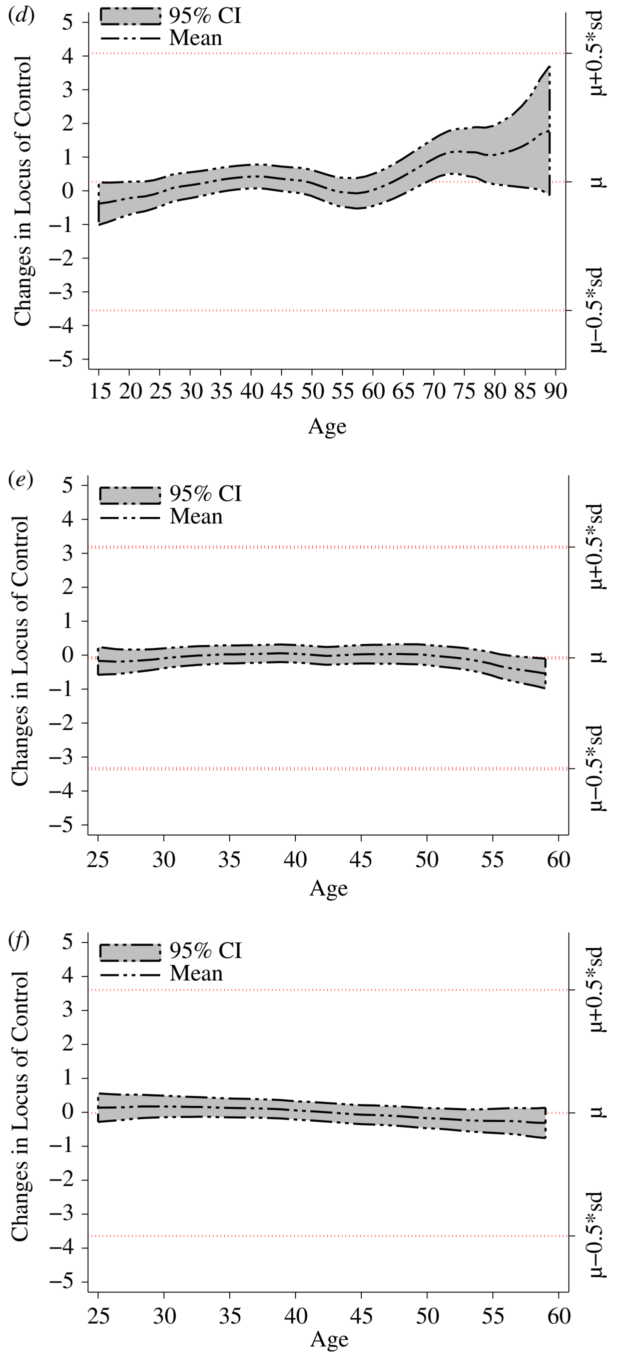


Fig. 2. *(Continued)*

Among working-age men and women aged 25–59, changes in locus of control are even smaller (between −1 and +1) and the differences in changes across age groups are not statistically significant in either the short ($p = 0.414$) or medium run ($p = 0.354$) (see Figures 2(*e*) and (*f*)). These results are particularly important given that much of the applied economics literature focuses on assessing the labour market consequences of non-cognitive skills for working-age men and women.

Finally, we can also gain insight into the stability of individuals' locus of control by calculating the period-to-period correlation in control tendencies. We find that the one-year correlation in locus of control is 0.610 on average, while the correlation over four years is 0.533.[14] The strength of these correlations varies significantly across age-groups both in the short and medium run ($p < 0.05$). In particular, the medium-run correlation in locus of control is the smallest for the very young (younger than 20) and the elderly (80+) and is the largest for individuals between 25–59 and 40–59 years.

Taken together, these results indicate that there is a great deal of stability in individuals' locus of control over both the short and medium run. The changes in locus of control that do occur tend to be rather modest on average and concentrated among the young or very old.

4.2. *Does Locus of Control Respond to Important Life Events?*

The most difficult econometric challenge facing applied economists arises from the possibility that – rather than being exogenous – locus of control in fact is determined simultaneously with, or results from, educational, health or labour market outcomes. As discussed in Section 2, if we do not account for the nature of simultaneity or reverse causality in our estimation model, the resulting estimates will be biased in ways that are difficult to understand. Unfortunately, there are many reasons to expect that locus of control, like other non-cognitive skills, may not be truly exogenous and may instead respond to individuals' life experiences. Moreover, the nature of these experiences is likely to matter. Seligman (1975) notes, for example that the more uncontrollable an event is perceived to be, the more likely it will lead to a sense of helplessness and loss of control. Similarly, Goldsmith *et al.* (1996) argue that those individuals who are constantly shocked by (unanticipated) life events are more likely to adjust their beliefs about how much control they exert over their own lives.

We shed light on these issues by investigating the extent to which the change in individuals' locus-of-control tendencies appears to be linked to the events they experience. To this end, we take advantage of HILDA data on a range of both positive and negative life events that individuals may experience. While some of these events are under individuals' control, others are not (see Table 2). As these events are uncommon in the short run, we restrict this analysis to medium-run changes in locus of control.

[14] Correlation coefficients are obtained from an OLS regression of locus of control measured in 2004 (2007) on locus of control measured in 2003 and locus of control interacted with age-group indicators while controlling for gender and age-groups. Each variable is standardised to mean 0 and standard deviation of 1.

Table 2

Negative and Positive Life Events

Questions
Negative life events
Serious personal illness or injury
Serious personal illness to family member
Death of spouse or child
Death of close family member or relative
Death of a close friend
Victim of physical violence
Victim of property crime
Detained in jail (dropped due to insufficient number of observations)
Family member detained in jail
Fired or made redundant
Major worsening of finances
Positive life events
Got married
Got back together with spouse
Pregnancy
Birth or adoption of new child
Promoted at work
Major improvement of finances
Retired from the workforce
Changed jobs

Note. Life events are part of a self-completion questionnaire of HILDA; Life-event data is available from Wave 2 (2002) onwards.

4.2.1. *Descriptive analysis*

We begin by calculating the total number of times an individual reports experiencing any of the 11 negative life events listed in the upper panel of Table 2 between 2004 and 2007. A similar total is created for the eight positive life events listed in the lower panel of Table 2. In our sample, the total number of negative life events reported for men between 2004 and 2007 is bounded between 0 and 17 and has a mean of 2.2, while total positive life events are bounded between 0 and 11 and have a mean of 1.4 (see Appendix Table A1). Over 60% of our sample did not report any positive events at all, whereas only 25% failed to report any negative event. Although the average number of events experienced differs by gender (see Table A1), there is no systematic difference in the overall distribution of the life events experienced by men *versus* women.[15]

Figures 3(*a*) and (*b*) plot the estimates (and 95% confidence intervals) from a bivariate kernel regression of the change in locus-of-control tendencies on the total number of negative life events reported by men and women respectively. There are two issues. The first is whether negative life events are associated with a tendency for individuals on average to develop a more external locus of control. The second is whether the relationship between the change in locus of control and negative life events varies with the number of negative life events reported.

[15] The p-values of a Kolmogorov–Smirnov test of equal distributions are $p = 0.96$ for positive life events and 0.160 for negative life events. These results are available upon request.

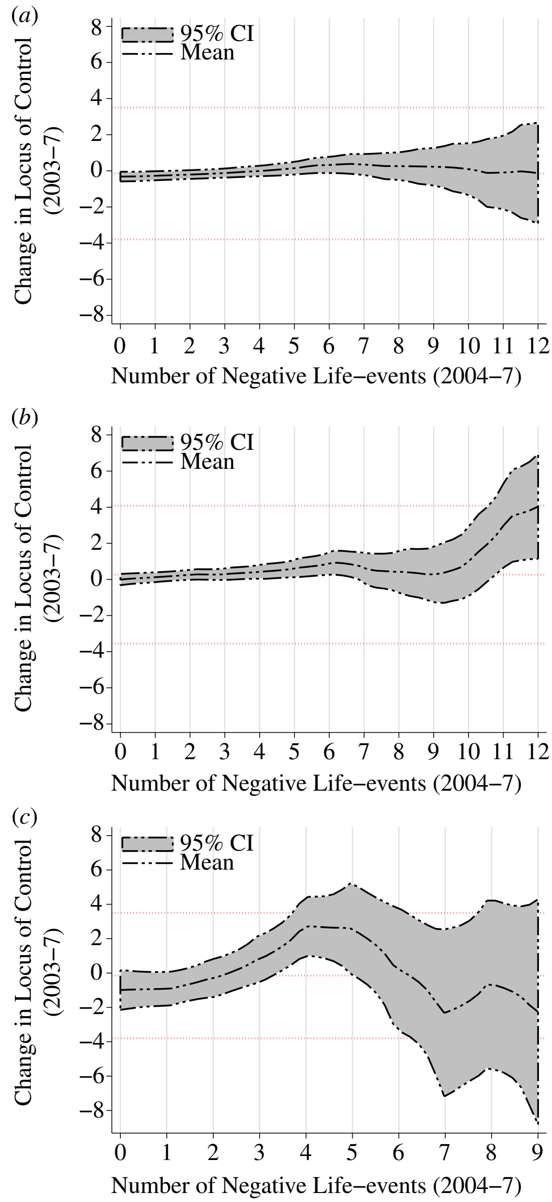


Fig. 3. *Association Between Negative Life Events and Changes in Locus of Control (2003–7)*

Notes. (*a*) Men: F–test on no differences across all shocks: p = 0.601 (across 0–9 shocks: p = 0.342). (*b*) Women: F–Test on no differences across all shocks: p = 0.081 (across 0–9 shocks: p = 0.224). (*c*) Men 15–24: F–Test on no differences across shocks: p = 0.055. (*d*) Women 15–24: F–Test on no differences across shocks: p = 0.276. (*e*) Men 25–59: F–test on no differences across shocks: p = 0.372. (*f*) Women 25–59: F–test on no differences across shocks: p = 0.61. (*g*) Men 60+: F–Test on no differences across shocks: p = 0.98. (*h*) Women 60+: F–Test on no differences across shocks: p = 0.047.

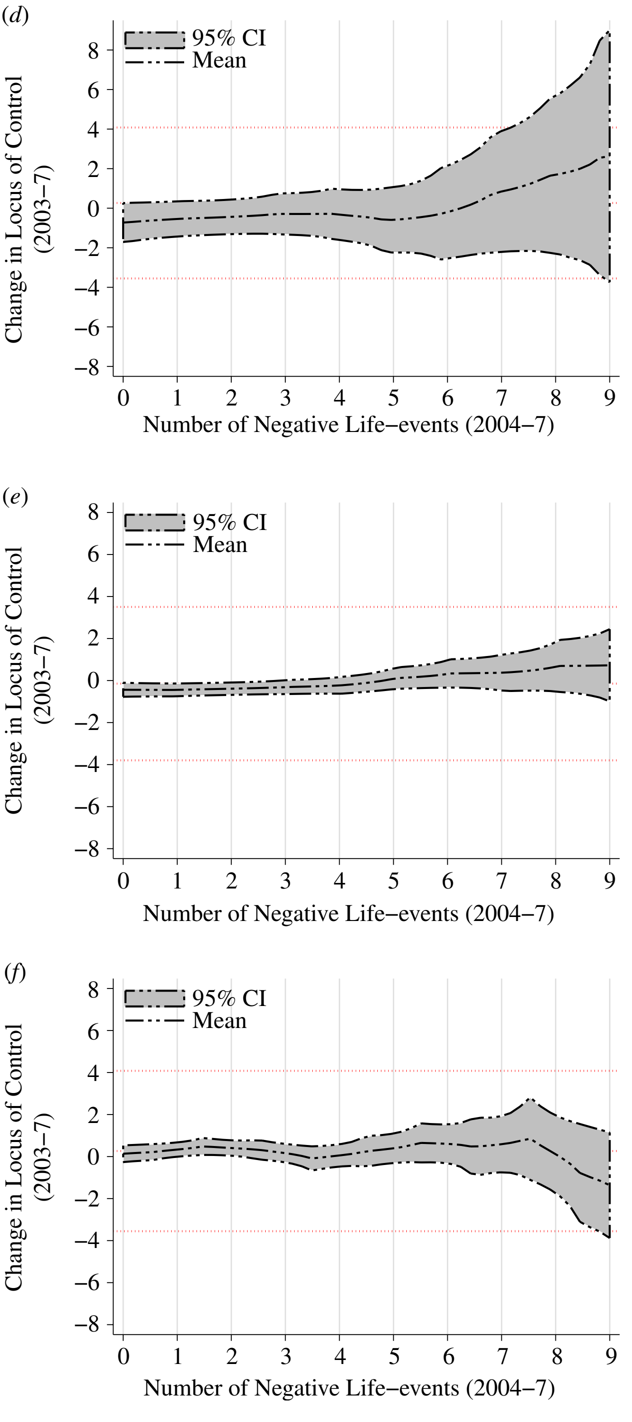
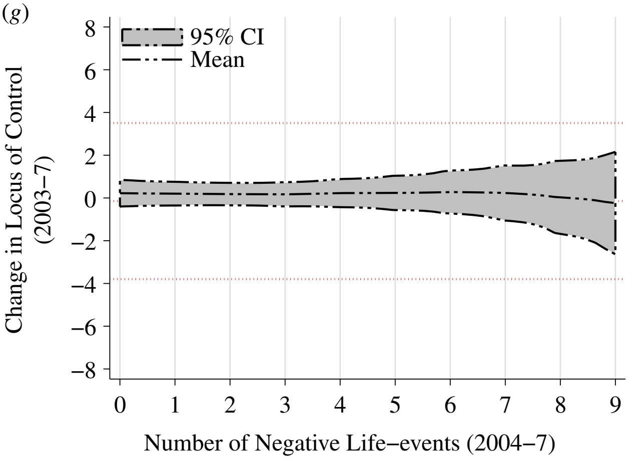


Fig. 3. *(Continued)*



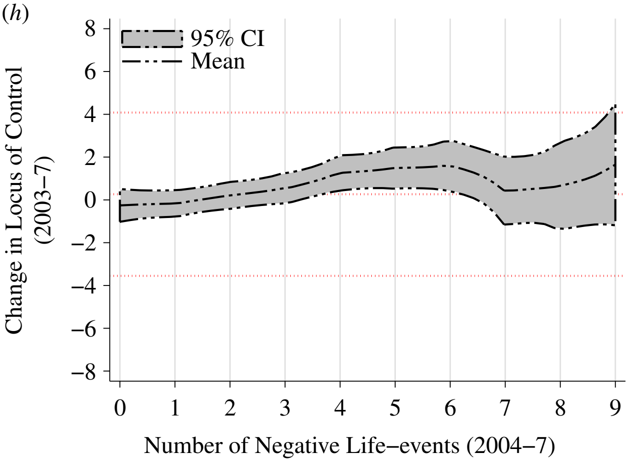


Fig. 3. *(Continued)*

We find that the average change in locus-of-control tendencies between 2003 and 2007 is essentially 0 for all individuals experiencing nine or fewer negative life events between 2004 and 2007. Due to small sample sizes, the results become less precisely estimated (i.e. confidence intervals become wider) for individuals reporting 10 or more negative life events. However in almost all cases, we cannot reject the hypothesis that the mean medium-run change in locus-of-control tendencies is zero irrespective of the number of negative life events reported. The single exception is that the small number of women ($n = 13$) experiencing 12 or more negative life events in this four-year period become significantly more external in their control tendencies.

Given our interest in normative changes in non-cognitive skills as people age, we repeat the above exercise for different age-groups. Specifically, Figures 3(*c*) to (*h*) present bivariate kernel regression estimates of the link between locus-of-control change and negative life events for individuals: less than age 25; age 25–59; age 60+.

Due to small sample sizes, we restrict the analysis to those individuals reporting nine or fewer negative life events. Our results indicate that negative life events are associated with external control tendencies only for young men aged less than 25 ($p = 0.055$) and for older women aged 60+ ($p = 0.047$). For these groups, experiencing between four and five negative events in a four-year period is associated with a significant increase in external control tendencies. In contrast, for working-age men and women, there is no relationship between the change in locus of control and the number of life events reported.

Finally, we consider whether there is any evidence that positive life events are associated with the development of more internal control tendencies. In particular, Figures 4(*a*) and (*b*) show the relationship between the average, medium-run change in locus of control and cumulative positive life events. We find that the association between locus-of-control change and positive life events varies with the number of positive life events reported for both men ($p = 0.022$) and women ($p = 0.012$). For women, the accumulation of positive life events is more likely to be associated with increases in internal control tendencies. This is particularly true for working-age women aged 25–59 who are most likely to experience such events as marriage, childbirth or promotions at the work place (see Figure 4(*f*)).[16] At the same time, these changes are not statistically significant, except for those young women (age 15–24) reporting one to three positive life events.

4.2.2. *Regression analysis*

Our descriptive analysis has been useful in demonstrating that mean short and medium-run changes in locus of control are quite small and, with few exceptions, are not significantly related to the total number of negative or positive life events that individuals report (see subsections 4.1 and 4.2.1). In what follows, we use regression analysis to investigate in more detail the relationship between the type of life events that individuals experience and the changes in their locus of control. Specifically, we address three questions. First, are there certain life events (e.g. death of a family member) that have particularly large effects on individuals' locus of control? Second, does the intensity of related events matter? Finally, do persistent events (e.g. recurring health shocks or consecutive years of unemployment) matter more than one-time shocks?

In answering these questions, we estimate variations of the following equation:

$$\triangle LOC^{j}_{i,07/03} = \boldsymbol{X}^{j}_{i,03}\boldsymbol{\beta}^{j} + S^{j}_{i,07/04}\gamma^{j} + \varepsilon^{j}_{i}, \tag{16}$$

where j indexes life events and $\triangle LOC^{j}_{i,07/03}$ is the change in locus of control between the years 2003 and 2007 with positive changes indicating an increase in external control tendencies. The vector $\boldsymbol{X}^{j}_{i,03}$ comprises control variables (indicators for age-groups, marital status, immigrant status, employment status and educational qualifications as well as household income) measured in 2003.[17] Moreover, $S^{j}_{i,07/04}$ is an

[16] Unfortunately, we cannot estimate these relationships for the older population (age 60+) as they experience very few of the positive life events considered.

[17] Household income is measured in natural logarithm. The omitted categories for the indicator variables are: < 30 years old, single, native-born, unemployed or out of the labour force, and completed Year 11 or less, respectively. Complete regression results are available upon request.

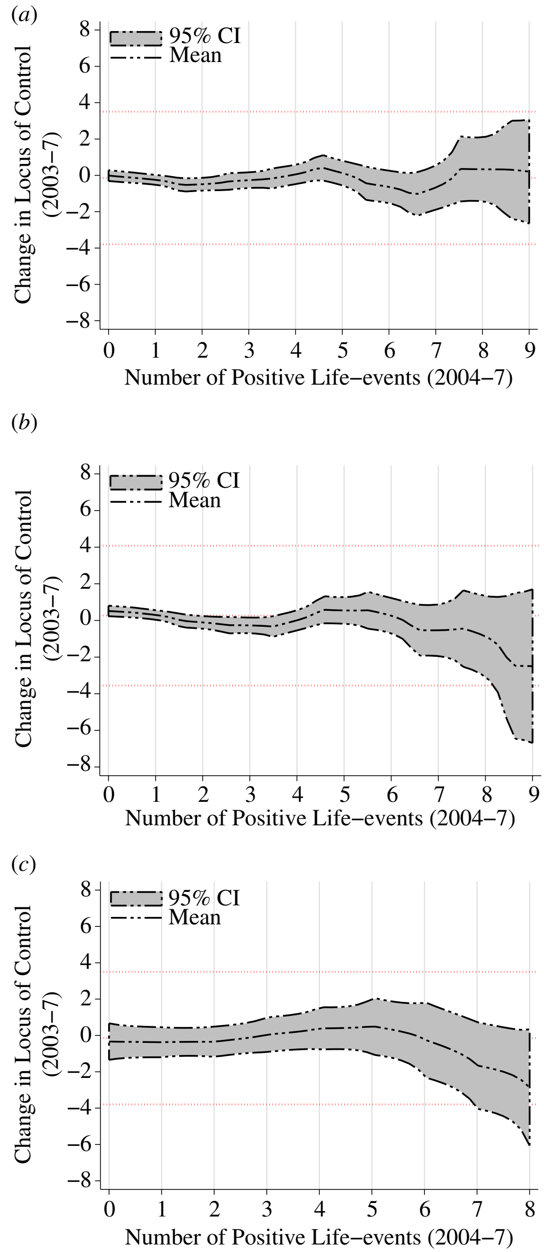
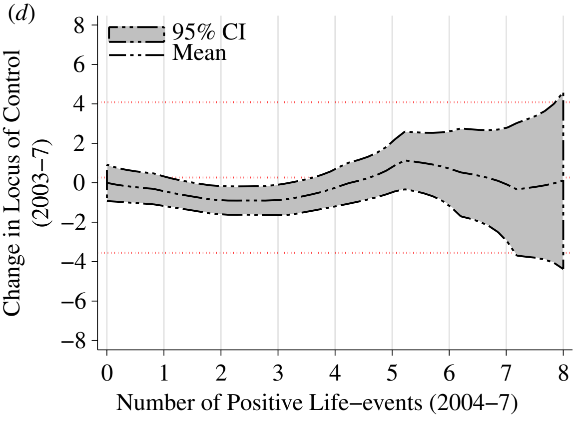
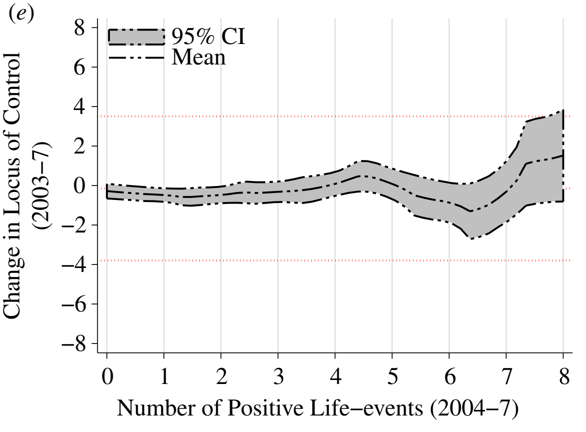


Fig. 4. *Association Between Positive Life Events and Changes in Locus of Control (2003–7)*

Notes. (*a*) Men: F–test on no differences across positive life-events: p = 0.022. (*b*) Women: F-test of no difference across age-groups: p = 0.188. (*c*) Men ages 15–24: F–Test on no differences across positive life-events: p = 0.478. (*d*) Women ages 15–24: F–test on no differences across positive life-events: p = 0.093. (*e*) Men ages 25–59: F–test on no differences across positive life-events: p = 0.054. (*f*) Women ages 25–59: F–test on no differences across positive life-events: p = 0.042.





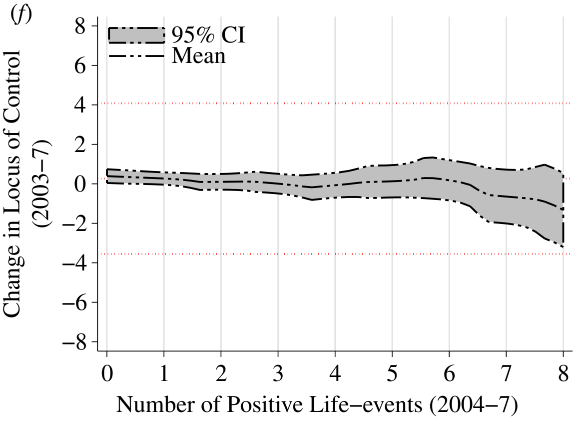


Fig. 4. *(Continued)*

indicator variable that takes the value 1 if an individual reports experiencing life event j at any point between 2004 and 2007, and 0 otherwise. We estimate (16) separately for each of 11 negative and eight positive life events listed in Table 2 because many of these events are closely related (e.g. unemployment and worsening of finances), and we would like to generate an upper-bound estimate of the relationship between life experiences and locus-of-control changes. Figures 5(*a*) (men) and 5(*b*) (women) graphically display the results (OLS coefficients and 95% confidence intervals) from these regressions. Although changes in locus of control are bounded between -34 and 34 for men and between -34 and 30 for women, we standardise our change measure to have mean = 0 and standard deviation = 1. Therefore, the effect of each individual life event is expressed in terms of standard-deviation changes in locus-of-control tendencies.[18]

We find that men who experience the birth of a child, a serious illness of a family member, or a worsening in their finances become significantly more external in their control tendencies, while men who change jobs or experience a significant improvement in their finances become more internal. Like men, women also become significantly more external in their outlook if they give birth or experience a major worsening of their finances and become more internal if they are promoted or experience a significant improvement in their finances. Women also become more external if they experience a serious personal injury. Interestingly, while the death of a friend is linked to women becoming more external, women who experience the death of a relative become more internal.[19]

Overall, it is important to note several things about the results in Figure 5. First, the events that individuals experience have little predictive power in explaining the changes in their locus of control. There is no evidence of a significant effect of life events in general on changes in locus of control, particularly when we consider the large number of hypotheses being tested. Many important life events (e.g. death of a spouse, retirement, being a crime victim) appear to have no significant effect at all. Moreover, our model explains very little of the variation in locus-of-control changes. In particular, regressing changes in locus of control on life events and control variables such as age, labour force status, education and marital status results in an adjusted R^2 of little more than 0.005 irrespective of the event considered. Second, those life events that do matter have effects that are quite intuitive. Negative life events are related to individuals becoming more external, whereas positive life events (with the exception of pregnancy and childbirth) are linked to individuals becoming more internal. Third, we do not find evidence for Seligman's (1975) hypothesis that the more uncontrollable an event is perceived to be, the more likely it will lead to a sense of helplessness and loss of control. In contrast, events which are arguably more uncontrollable, for example the

[18] We tested for normality, heteroscedasticity, omitted variable bias (RESET test) and functional form (Hosmer–Lemeshow test). Each model passed all tests except for a test for homoscedasticity. Thus, we use White-robust standard errors in the analysis. As a robustness check, we also estimated zero-inflated negative binomial models which account for the count nature of our data. Our substantive conclusions were unchanged and we report linear OLS regression results for simplicity.

[19] The following life events are (almost) significant at the 10% level: 'birth/adoption of a new child' ($p = 0.060$) and a 'Serious illness to a family member' ($p = 0.104$) for men, and 'birth/adoption of a new child' ($p = 0.106$) and 'death of a friend' ($p = 0.059$) for women.

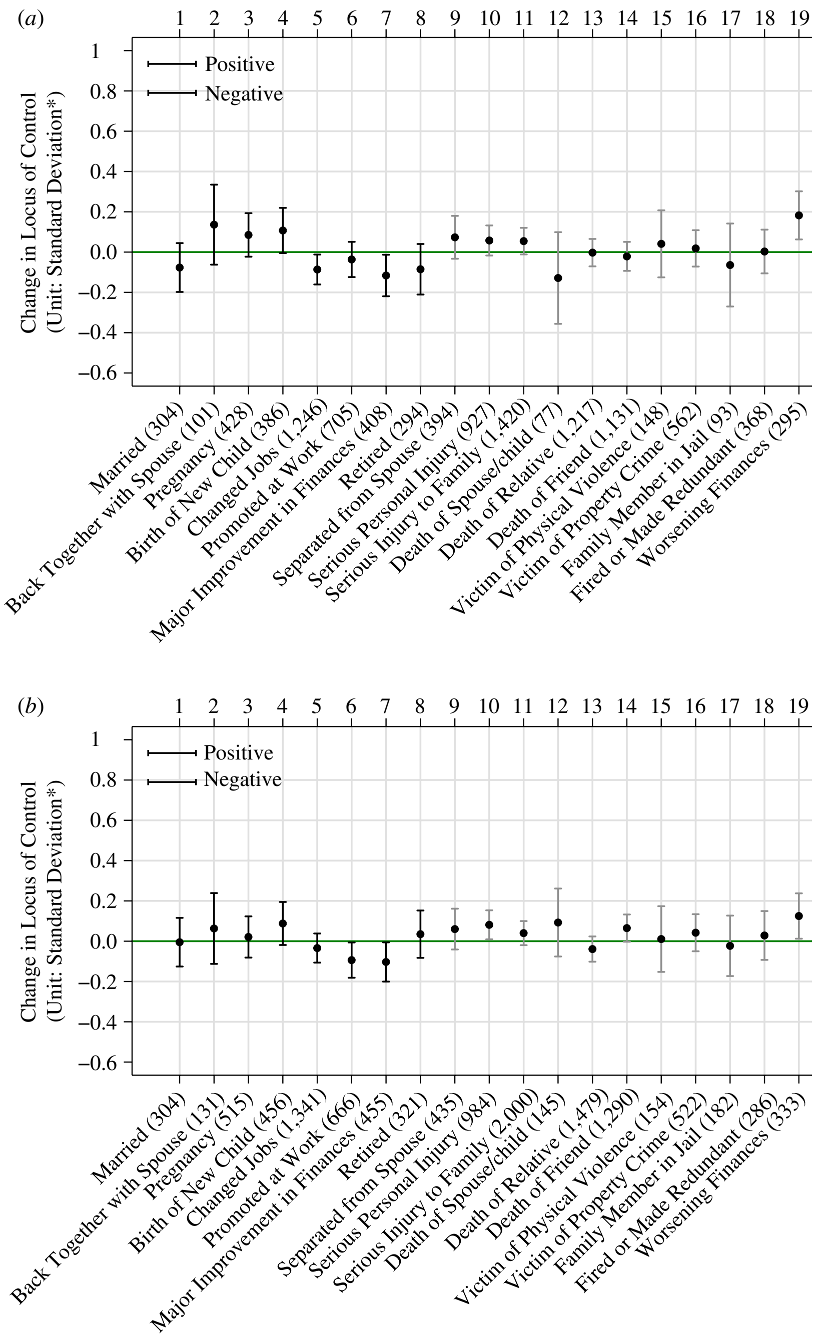


Fig. 5. *Effect of Individual Life Events on Changes in External Control Tendencies*

Notes. (*a*) Men: Estimated coefficients obtained from OLS; average R^2: 0.005; n = 3,859; observations for life-event = 1 in parentheses; *1 SD change in locus of control is equal to 7.3 units on a scale ranging from −34 to 34. (*b*) Women: Estimated coefficients obtained from OLS; average R^2: 0.002; n = 4,437; observations for life-event = 1 in parentheses; *1 SD change in locus of control is equal to 7.6 units on a scale ranging from −34 to 30.

death of a family member or becoming a crime victim, appear to have smaller effects on locus of control than events that are notionally under individuals' control, for example pregnancy, childbirth and one's financial situation. Most importantly, the life events we consider all lead to surprisingly small changes in individuals' locus of control – at most 0.2 standard deviations. Women who experience a severe illness or injury between 2004 and 2007, for example increase their external control tendencies by only 0.08 of a standard deviation which represents less than a one-unit change on a scale ranging from −34 to 30. For men, a worsening of finances is associated with a change of 0.18 of a standard deviation, that is only 1.5 units on a −34 to 34 scale.

Are negative life events which are more intense or more persistent associated with larger changes in individuals' external locus of control tendencies? We investigate the intensity of negative life events by summing the total number of negative events that individuals report between 2004 and 2007 in three separate domains: family-related (death of a spouse, child, relative or friend; being a victim of property crime); employment/income-related (worsening of finances, retiring, being fired or episodes of unemployment); health-related (serious illness or injury, being a victim of physical violence and new health conditions that were not yet present in 2003). We then create nine separate indicator variables – three for each domain – that each take the value of 1 for individuals whose reported number of domain-specific events is more than one, two or three sample standard deviations, respectively, and 0 otherwise. Equation (16) is re-estimated sequentially using these nine indicator variables as a measure of $S^j_{i,07/04}$, where $j \in \{1,\ldots,9\}$. The results are graphically displayed Figure 6(*a*).

The intensity of negative health, employment or family-related life events is not associated with changes in men's and women's control tendencies. Changes in locus of control are remarkably small – and much the same size – irrespective of the number of domain-specific events that individuals report. The only exception is that women who experience more than 4.8 negative, employment-related events (i.e. more than three standard deviations) within four years become significantly more external. In particular, they increase their locus-of-control index by almost three points (0.39 standard deviations) on a scale of −34 to 30. Note, however, that this effect is rather modest. It implies a change in the answers to the seven questions on the locus of control instrument of one point on three out of seven questions. Moreover, it is rare to experience such intense labour market disadvantage: only 23 women (0.5% of women in our estimation sample) experience such a sequence of events.

Finally, we investigate the importance of the persistence of negative life events by creating five separate indicator variables which each take the value 1 if individuals report the following sequence of events between 2004 and 2007 (and 0 otherwise):

(*i*) unemployment for at least three years;
(*ii*) chronic pain in all years;
(*iii*) a serious illness or injury in at least two years;
(*iv*) the death of at least two very close family members (spouse or child);
(*v*) a health shock, losing a partner or a child, and being fired from the workplace (or experiencing a major worsening of finances).

We again re-estimate (16) sequentially using these five indicator variables as a measure of $S^j_{i,07/04}$. Figure 6(*b*) presents the results for both men and women.

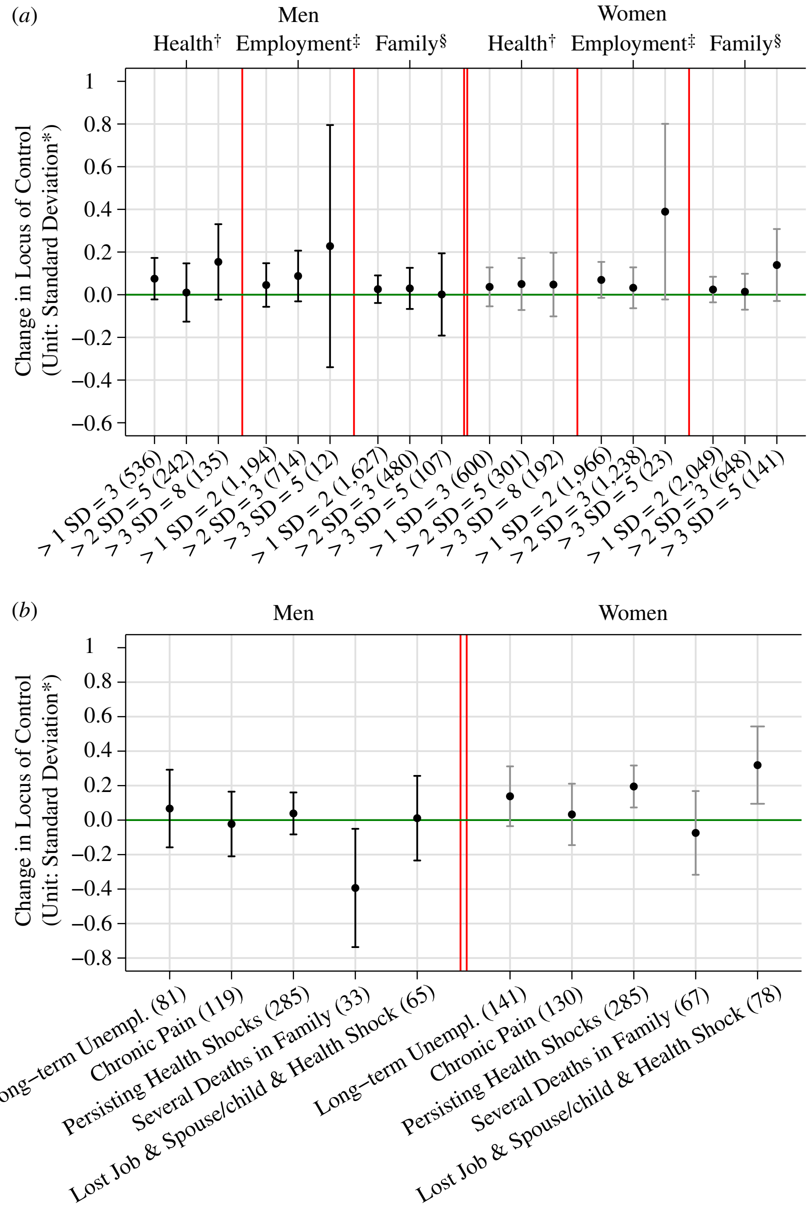


Fig. 6. *Relationship Between Intensity of Shocks and Changes in External Control Tendencies*

Notes. (*a*) Domain-specific shocks: Estimated coefficients obtained from OLS; average $R^2 = 0.003$; *n* men = 3,859, *n* women = 4,437, *1 SD = 7.3 (range −34 to 34) men *1 SD = 7.6 (range −34 to 30) women, †health-related = 1 if number of health shocks > 1–3 SD, ‡employment-related = 1 if number of employment shocks > 1–3 SD, §family-related = 1 if number of family shocks > 1–3 SD. Observations domain shock = 1 in parentheses. (*b*) Chronic shocks: Estimated coefficients obtained from OLS; average $R^2 = 0.004$; *n* men = 3,859, *n* women = 4,437 *1 SD = 7.3 (range −34 to 34) for men, *1 SD = 7.6 (range −34 to 30) for women, observations for shocks = 1 in parentheses.

Overall, we find little evidence that persistent negative life events have large effects on individuals' propensity to believe that life is outside of their control. None of the persistent events we considered is associated with an increase in men's external control tendencies, though oddly, the small (n = 33) number of men reporting several deaths in their families had a significant increase in their internal control tendencies by almost three points (0.39 standard deviations). Long-term unemployment, chronic pain and family deaths are also not related to an increase in women's external control tendencies. For them, it is a sequence of health shocks and a combination of employment, family and health-related shocks that matters most. Women who lost their job, lost a spouse or child, and experienced a serious illness/injury between 2004 and 2007, increased their external locus-of-control index by 2.3 points (0.32 standard deviations). Similarly, women who experienced at least two health shocks within four years increased their external tendencies by 1.4 points (0.20 standard deviations).

In addition, we find that the predictive power of severe life events in explaining changes in locus of control is exceptionally modest. It may be true that some life events are a good predictor of extreme changes of locus of control[20] but the group of individuals who experience persistent life events and increase their external control tendencies by more than three standard deviations is extremely small, that is less than 1% of our sample.

4.3. *Are Changes in Locus of Control Economically Meaningful?*

Economists studying the role of non-cognitive skills in economic decision making are interested in more than simple statistical significance. They also need to understand which relationships are economically meaningful. We shed light on this issue by expressing these changes in terms of the wage returns to locus of control that have been identified in the empirical literature. This is of course not the only metric for gauging economic significance; however, it is a particularly sensible benchmark given the preponderance of such estimates in the literature and the fact that wage rates typically summarise a multitude of labour market processes.

Table 3 summarises the results of five of the most frequently cited studies of the wage returns to locus of control. Overall, the largest estimates are obtained by Heineck and Anger (2010) for both men (7%) and women (up to 10%). In Table 4, we use these upper-bound estimates to quantify the potential wage loss (or wage gain) associated with those sequences of life events that appear to have the strongest link with changes in locus of control. We investigate the sensitivity of our calculated wage returns to changes in locus of control to alternative methods of parameterising locus of control. Specifically, we also report in Table 4 wage equivalents calculated from a regression that uses an alternative locus of control index derived from the first predicted factor in a factor analysis; see Piatek and Pinger (2010); Cobb-Clark *et al.* (2012), for details. The conclusions remain unchanged.

The largest wage penalties are found for women who experience a series of employment shocks that are greater than three sample standard deviations. These

[20] We find that the probability of being in the extreme tail of the locus-of-control changes distribution is significantly related to some life events. These results are provided upon request.

Table 3

Estimated Wage Effects of Locus of Control

Study	Data	Wage effect	Locus of control measured
Heineck and Anger (2010)	GSOEP*	Men: 7% Women: 4%–10%	In 2005 Earnings in 1991–2005
Cebi (2007)	NLSY†	Men: 2.1%	In 1979, earnings in 1979–82
Osborne Grooves (2005)	NLSYW‡	Women 5%–7%	In 1970/1988, earnings in 1991–3
Andrisani (1977)	NLS§	Young men: 7.5% Middle-aged men: 5%	In same year as earnings
Semykina and Linz (2007)	Three surveys on Russian employees	Women: 6.4% Men: 4.6%	In same year as earnings

Notes. *German Socio-economic Panel. †National Longitudinal Survey of Youth. ‡National Longitudinal Survey of Youth Women sample. §National Longitudinal Survey.

Table 4

Wage Equivalent of Changes in External Control Tendencies

Men	Worsen finances	Health shocks > 3 SD	Employ. shocks > 3 SD	Multiple deaths in family
Benchmark model: summed index				
Changes in locus of control (Proportion of SD)	0.18	0.15	0.23	−0.39
Percentage change*	−1.26	−1.08	−1.61	+2.73
Implied change in wage (in €)†	−0.49	−0.42	−0.62	+1.05
Robustness check: first predicted factor				
Changes in locus of control (Proportion of SD)	0.15	0.30	0.27	−0.43
Percentage change*	−1.00	−2.10	−1.90	+3.0
Implied change in wage (in €)†	−0.39	−0.81	−0.72	+1.16
N	295	135	12	33
Women	**Worsen finances**	**Persisting health shocks ≥2**	**Employ. shocks > 3 SD**	**Death + Health + Fired**
Benchmark model: summed index				
Changes in locus of control (Proportion of SD)	0.13	0.20	0.39	0.32
Percentage change‡	−1.3	−2.0	−3.9	−3.2
Implied change in wage (in €)§	−0.39	−0.60	−1.17	−0.96
Robustness check: first predicted factor				
Changes in locus of control (Proportion of SD)	0.08	0.16	0.13	0.33
Percentage change‡	−0.88	−1.60	−1.30	−3.30
Implied change in wage (in €)§	−0.25	−0.48	−0.40	−0.99
N	333	285	23	78

Notes. *Wage elasticity from Heineck and Anger (2010) is 7%. †Average hourly wage (>0) in GSOEP in 2010: €38.5. ‡Wage elasticity from Heineck and Anger (2010) is 10%. §Average hourly wage (>0) in GSOEP in 2010: €30.1.

series of shocks increase external control tendencies by an equivalent of a 3.9% loss in average hourly wages (approximately €1.17). This wage penalty is only 1.3% when using the alternative index of locus of control. The largest wage effect for men is induced by the experience of losing at least two immediate family members between 2004 and 2007. It is associated with a decrease in external control tendencies – rather than an increase – equivalent to a 2.7% increase in average hourly wages (approximately €1).[21] This surprising latter result is not sensitive to the measure of locus of control chosen and it cannot be easily explained by the previous psychological evidence. It is important to note that such sequences of events are a rare phenomenon as only 33 men and 23 women are observed to experience so many family or employment-related shocks. In contrast, more common life events, such as a worsening of finances, are associated with an increase in external control tendencies that is equivalent to a decrease in average hourly wages of 1.3%. This translates into a fall in hourly wages of less than €0.50 for both men and women, and of less than €0.40 when using the alternative index of locus of control.

4.4. *What is the Magnitude of the Attenuation Bias?*

Economists often use lagged (and occasionally lead) measures of non-cognitive skills as a proxy for current skill endowments. This results in an errors-in-variables problem if non-cognitive skills do in fact change over time (see Section 2). The extent of the attenuation bias depends on what is assumed about the structure of measurement error (Thompson and Vacha-Haase, 2000). In this section, we investigate two important cases.

4.4.1. *Case 1: Current measure is reliable*

We begin by estimating the reliability parameter λ given the maintained assumption that current-period locus of control is a reliable measure of true locus of control, while a lagged locus-of-control measure captures true locus of control only with error (see (2)).[22] The measurement error (υ_{it-k}) is then given by $\upsilon_{it-k} = L_{it-k} - L_{it}$. The subscript t refers to locus of control measured in the current year (2007), and $t - k$ refers to a previous period (2003). Figure 1 shows the distribution of the measurement error in our data.

The direction of the attenuation bias can only be calculated without ambiguity in bivariate models. However, we can control for other relevant demographic and human capital variables by estimating the hourly wage returns to locus of control separately by gender, university degree status and age-groups (25–39, 40–49, 50–59). Each sample is further restricted to those individuals who are currently employed at the time of the interview and who had no missing values for the variables of interest.[23]

In columns (1) and (2) of Table 5, we present the estimated reliability statistic ($\hat{\lambda}_1$) and its standard error under the assumption that our measurement error is classical

[21] Average hourly wages for men in GSOEP in 2010 were €38.50 and for women €31.10.

[22] The same analysis using lead data as proxy for contemporaneous locus of control leads to almost identical results because the formula used to calculate the bias is based on the variance of a difference which will always be positive.

[23] We use a bootstrap with 200 iterations to obtain standard errors for $\hat{\lambda}$ (Mooney and Duval, 1993).

Table 5

Estimated Reliability Parameters and Wage Effects

	Measurement error				Wage effects*		
	Classical		Non-classical		*LOC* in 2003		
	$\hat{\lambda}_1$	SE	$\hat{\lambda}_2$	SE	$\hat{\gamma}^{03}$	SE	*N*
Men							
Full sample	0.524	0.012	0.547	0.021	−0.064	0.011	1,565
Less than university degree							
Age 25–39	0.496	0.022	0.490	0.042	−0.058	0.018	440
Age 40–49	0.525	0.025	0.545	0.042	0.017	0.029	393
Age 50–59	0.545	0.028	0.578	0.048	−0.052	0.022	285
University degree							
Age 25–39	0.536	0.037	0.567	0.059	−0.061	0.034	194
Age 40–49	0.549	0.048	0.595	0.072	−0.085	0.025	128
Age 50–59	0.568	0.053	0.613	0.071	−0.070	0.047	125
Women							
Full sample	0.513	0.012	0.523	0.021	−0.052	0.011	1,685
Less than university degree							
Age 25–39	0.503	0.024	0.502	0.045	−0.045	0.022	376
Age 40–49	0.493	0.024	0.483	0.044	−0.055	0.028	401
Age 50–59	0.511	0.029	0.519	0.048	−0.023	0.017	322
University degree							
Age 25–39	0.465	0.024	0.419	0.057	−0.033	0.029	258
Age 40–49	0.611	0.033	0.676	0.053	−0.048	0.028	195
Age 50–59	0.539	0.045	0.566	0.072	−0.035	0.033	133

Notes. $\hat{\lambda}_1$ measures the reliability parameter estimate under classical measurement error. $\hat{\lambda}_2$ measures the reliability parameter estimate under non-classical measurement error. *Wage effects measured in percentage change due to a 1 SD increase in external locus of control. Hourly wages are measured in 2007, locus of control measured in 2003. Standard errors of reliability parameters are bootstrapped with 200 repetitions.

(see (4)). The corresponding reliability statistic ($\hat{\lambda}_2$) and standard error for the case of general measurement error (see (5)) are presented in columns (3) and (4). Finally, columns (5) and (6) report the log hourly wage (in 2007) penalty resulting from a one standard deviation increase in external locus-of-control tendencies (in 2003). The true wage effect in the absence of the attenuation bias is the quotient of the wage effect obtained from using lagged locus of control and $\hat{\lambda}_1$ or $\hat{\lambda}_2$, depending on the underlying assumption about the nature of the measurement error. Thus, the closer $\hat{\lambda}_1$ and $\hat{\lambda}_2$ are to 1, the smaller is the bias.

When we assume that our measurement error is classical, we find that the reliability of lagged locus of control as a proxy of 'true' (contemporaneous) locus of control is below 0.55 for both men and women. Reliability appears to be slightly higher for both genders if we allow for general measurement error (and the possibility of reversion to the mean).[24] Overall, our results imply that the 'true' wage return to locus of control is almost twice as high as estimated by the lagged measure of locus of control.

[24] Moreover, the reliability parameters are slightly greater for both men and women when considering shorter time spans (i.e. between 2003 and 2004) between the 'true' and 'proxied' measure of locus of control. These results are available upon request.

4.4.2. *Case 2: All measures contain error*

We now consider the case in which locus of control is a stable, latent variable that is measured with error in all periods (see (6) and (7)). Estimated wage returns to locus of control are generated using

(*i*) OLS which ignores the presence of measurement error, and
(*ii*) Linear Latent factor SEM which controls for the measurement error in both contemporaneous and lagged indicators of locus of control (Bollen, 1989).

The difference between OLS and SEM estimates provides one indicator for the extent of attenuation bias due to measurement error. We also calculate an approximation of the theoretically derived reliability parameter as outlined in (8) and (9). We do this by obtaining an approximation for the variance of true, but latent locus of control and the measurement error in its proxies from a latent factor model consisting of seven measurement equations. Each equation models one of the seven items listed in Table 1 as a function of true latent locus of control and a measurement error. To identify the system, we assume that all covariances between the measurement errors of each equation are zero and standardise the variance of the latent factor to be equal to one such that all estimated variances of each measurement error are anchored against the latent factor variance.[25] The variance of the overall measurement error is approximated by the average over all seven item variances.

Results are reported in Table 6. Columns (1) to (4) report the standardised coefficients, standardised standard errors (SE), and the resulting 95% confidence intervals of the various models for men and women separately. The results presented stem from a regression of log hourly wages on locus of control only. Our conclusions are not sensitive to the inclusion of controls for age, education, marital status, children and the Big Five personality traits (results available upon request). Column (5) presents the reliability parameter calculated by dividing the estimated OLS coefficient by the estimated SEM coefficient. Finally, Column (6) presents the theoretical reliability parameter.

We find that the theoretical reliability parameter is approximately 0.87 for both men and women, which implies an attenuation bias of the estimated wage effect of about 13%. The variances of the measurement errors are almost the same in the two time periods considered implying that the attenuation bias is not aggravated when using a lagged measure of locus of control. These results are broadly consistent with differences in the OLS and SEM estimated wage returns to locus of control. Estimated wage returns are somewhat larger in the SEM models that control for measurement error, independent of whether we use a contemporaneous or a lagged measure of locus of control. The reliability parameters obtained by dividing the OLS estimates by the SEM estimates are slightly larger, however, than the theoretically derived estimates. It is important to note, however, that the differences in the OLS and SEM estimates of the wage returns to locus of control of about 5% to 9% are not statistically significant. All 95% confidence intervals of the OLS and SEM estimates are overlapping.

[25] Such assumptions for identification are common in latent factor structural equation models as outlined in, for example Cunha and Heckman (2008).

Table 6

*Wage Effects of Locus of Control: OLS and SEM**

	Std coef	Std SE	95% CI Min	95% CI Max	Reliability parameter $\hat{\beta}_{OLS}/\hat{\beta}_{SEM}$	Reliability parameter Approx.†
Men (N= 1,565)						
Wages 2007, Locus of control 2007						
OLS	−0.1285	0.0251	−0.1777	−0.0793		
SEM	−0.1352	0.0266	−0.1874	−0.0831	0.950	0.874
Wages 2007, Locus of control 2003						
OLS	−0.1396	0.0248	−0.1883	−0.0910		
SEM	−0.1533	0.0267	−0.2057	−0.1009	0.911	0.868
Women (N=1,685)						
Wages 2007, Locus of control 2007						
OLS	−0.1049	0.0242	−0.1524	−0.0574		
SEM	−0.1152	0.0257	−0.1656	−0.0647	0.911	0.872
Wages 2007, Locus of control 2003						
OLS	−0.1128	0.0243	−0.1604	−0.0651		
SEM	−0.1199	0.0255	−0.1699	−0.0698	0.941	0.873

Notes. Results reported are the standardised beta coefficients and standard errors, which are obtained from multiplying the regression coefficients and SE by the sample standard deviation of locus of control and dividing by the sample standard deviation of log wages. *SEM refers to structural equation model. In the SEM, all seven locus of control items are used as inputs in the measurement equation to predict the latent factor of locus of control (either from 2003 or 2007). The SEM model controls for measurement error while simultaneously estimating both latent factor and wages. It assumes multivariate normality and zero covariances between all error equations. †The reliability parameter refers to $\sigma^2_{L*}/(\sigma^2_{L*} + \sigma^2_{\eta_{t-k}})$ and $\sigma^2_{L^*}/(\sigma^2_{L^*} + \sigma^2_{\eta_t})$. Proxies for both the variance of the latent factor L_i^* and the measurement errors η_t and η_{t-k} are obtained from a linear latent factor measurement model (estimated using the – SEM – command in STATA MP 12.0.). We estimated seven measurement equations, one for each item of the seven locus of control items. The variance of the latent factor is assumed equal to one, and the variance of the measurement error is approximated by the average variance across all seven equations. Covariances of measurement errors across equations are assumed to be zero, which is standard.

4.4.3. *Summary*

Taken together, these results suggest that measurement error leads to an attenuation bias in the estimated wage returns to locus of control of 13% to 50%. These results can be put into context by considering similar research which attempts to assess the reliability of survey data as a proxy for the earnings, income or tax information captured in administrative data sources. In particular, the reliability of CPS data as a proxy for social security earnings data is around 0.80 for men (Bound and Krueger, 1991, Table 6). Comparing Swedish survey and administrative data on earnings, taxes and pension incomes (Kapteyn and Ypma, 2007) find the reliability of the survey data as a proxy for administrative earnings (taxes) to be 0.7 (0.735). However, survey data on pension payments appear to be less reliable (0.363) resulting in large potential biases (Kapteyn and Ypma, 2007, Table 5).

5. Conclusions

The increasing availability of standard psychological items in the large-scale, nationally-representative panel surveys that economists often analyse has allowed us to make tremendous progress in understanding the links between non-cognitive skills and economic behaviour. Still, the conclusions we draw from our econometric modelling rest heavily on us correctly accounting for the ways that these skills evolve over the life cycle as demographic, labour market and health events unfold.

On balance, the news for applied researchers is positive. Our results indicate that locus of control is surprisingly stable even over a four-year period. The vast majority of individuals – particularly those of working age – experience no change in their control tendencies at all or experience change that is best described as modest and not economically meaningful. Moreover, changes in control tendencies are generally unrelated to the demographic, labour market and health events that individuals experience. Many important life events (e.g. death of a spouse, being a crime victim, serious personal injury) are not significantly related to changes in locus of control at all. There is also little evidence that intense or persistent negative life events have large effects on individuals' propensity to believe that life is outside their control. In particular, we find no evidence to support Seligman's (1975) hypothesis that it is uncontrollable events which lead to a sense of helplessness and loss of control. When we do find significant effects, they are very small and require a sequence of major life events that are associated with less than half a standard deviation change in locus of control over a four-year period.

Still, the news is not all good. We can find nothing in our review of the psychological literature or in our analysis of HILDA data to suggest that locus of control is truly time-invariant. While many individuals do not change their control tendencies, many others do. Moreover, these changes are concentrated among the young and the old. This lends support to the view that normative changes in non-cognitive skills like personality and locus of control occur over the life cycle as a consequence of the ageing process and the maturational, social and historical forces facing a population. Finally, we find evidence that the errors-in-variables problem has the potential to result in substantial attenuation bias when estimating the wage returns to locus of control. The bias is greatest when changes in locus of control reflect true changes in perceived control rather than changes in the way individuals report their control tendencies. Measurement error due to differences in reporting control tendencies appears to be negligible.

What estimation strategies should be adopted then when incorporating non-cognitive skills like locus of control into empirical analyses of economic behaviour? First, the fact that locus of control appears to be stable – but not time-invariant – implies that researchers will not be able to rely solely upon fixed-effects estimation to purge their estimates of its effects. It is critical, therefore, to observe individuals' non-cognitive skills so that these skills can be incorporated directly into our empirical models. Second, researchers need to account for the changes in non-cognitive skills that may occur as a result of the ageing process itself. Non-cognitive skill measures should be appropriately adjusted for age (Heineck and Anger, 2010), and it may be useful to restrict analyses to the working-age population for whom changes in non-cognitive skills are particularly small. Finally, and perhaps most importantly, researchers need to think carefully about the nature of the error in the skill measures they use and adopt the appropriate estimation strategies to account for that error.

We can only speculate about the extent to which these results for locus of control can be generalised. Nonetheless, there is evidence that other cognitive and non-cognitive skills are also remarkably stable. In particular, the Big Five personality traits appear to be as stable, if not more so, as locus of control and they cannot be linked to major life events either (Lucas and Donnellan, 2011; Specht *et al.*, 2011; Cobb-Clark and Schurer, 2012).

Cognitive ability is also very stable increasing slightly in early adulthood and remaining stable until old age when cognitive functioning begins to decline (Hertzog and Schaie, 1988). At least 50% of the variance in cognitive test performance later in life is accounted for by childhood cognitive ability (Gow *et al.*, 2011; Deary *et al.*, 2012). Correlations between age 11 and 77 cognitive ability are estimated to be as high as 0.73 (Deary *et al.*, 2000). Moreover, it is clear that measurement error has implications for the analysis of cognitive and non-cognitive skills more generally. Its effects, however, are difficult to quantify – and compare – because estimates of test reliability are dependent on the structure of measurement error being postulated (Thompson, 1981). In addition, cognitive skills tests in particular require effort. Thus, the endowment of effort or the rewards to effort will all contaminate the measurement of the underlying trait (Almlund *et al.*, 2011; Heckman and Kautz, 2012). Finally, we use a simple wage example to provide a benchmark for the economic (as opposed to statistical) significance of our results and to investigate the extent of attenuation bias. It would be useful to extend these results to other contexts, for example educational attainment, occupational choice and cognitive skill development, to more fully understand the extent to which we can generalise.

The expansion of standard human capital theory to explicitly include non-cognitive as well as cognitive skills – and the interactions between them – seems certain to dramatically improve our understanding of economic decision making. It is important that we develop the understanding necessary to sensibly estimate the nature of those relationships.

Appendix

Table A1

*Descriptive Statistics of Variables Used in Analysis for Estimation Samples**

Variable	Sample of men					Sample of women					Difference p-value†
	Mean	SD	Min	Max	N	Mean	SD	Min	Max	N	
Full index locus of control	18.28	7.55	7	49	3,859	18.52	7.76	7	49	4,435	0.148
Change in locus of control score (2003–4)	−0.26	6.61	−30	32	3,586	0.02	6.86	−30	29	4,152	0.075
Change in locus of control score (2003–7)	−0.13	7.29	−34	34	3,859	0.26	7.64	−34	30	4,435	0.017
Life events that occurred between 2004–7											
Got married	0.03	0.16	0	1	3,827	0.02	0.15	0	1	4,406	0.323
Separated from spouse	0.04	0.19	0	1	3,820	0.04	0.2	0	1	4,388	0.208
Got back together with spouse	0.01	0.1	0	1	3,823	0.01	0.11	0	1	4,391	0.449
Pregnancy	0.05	0.22	0	1	3,826	0.06	0.23	0	1	4,398	0.178
Birth/adoption of new child	0.04	0.19	0	1	3,822	0.04	0.19	0	1	4,394	0.924
Serious personal injury/illness	0.09	0.28	0	1	3,827	0.08	0.27	0	1	4,395	0.073
Serious injury/illness to family member	0.16	0.37	0	1	3,822	0.2	0.4	0	1	4,396	0.000
Death of spouse or child	0.01	0.08	0	1	3,824	0.01	0.1	0	1	4,393	0.031
Death of close relative/family member	0.1	0.31	0	1	3,825	0.11	0.31	0	1	4,393	0.873
Death of a close friend	0.1	0.31	0	1	3,824	0.11	0.31	0	1	4,392	0.290
Victim of physical violence	0.02	0.13	0	1	3,821	0.02	0.13	0	1	4,395	0.451
Victim of a property crime	0.07	0.25	0	1	3,826	0.06	0.23	0	1	4,401	0.071
Detained in jail	0	0.04	0	1	3,827	0	0.02	0	1	4,399	0.060
Close family member detained in jail	0.01	0.09	0	1	3,826	0.02	0.12	0	1	4,401	0.001
Retired from the workforce	0.03	0.17	0	1	3,825	0.02	0.15	0	1	4,403	0.163
Fired or made redundant	0.04	0.19	0	1	3,823	0.02	0.15	0	1	4,399	0.000
Changed jobs	0.15	0.35	0	1	3,822	0.12	0.32	0	1	4,397	0.000
Promoted at work	0.07	0.26	0	1	3,819	0.05	0.22	0	1	4,386	0.000
Major improvement in finances	0.04	0.19	0	1	3,827	0.04	0.19	0	1	4,397	0.886

Table A1
(*Continued*)

Variable	Sample of men					Sample of women					Difference p-value†
	Mean	SD	Min	Max	N	Mean	SD	Min	Max	N	
Major worsening in finances	0.03	0.17	0	1	3,826	0.03	0.18	0	1	4,401	0.809
Sum of all negative shocks	2.19	2.1	0	17	3,859	2.32	2.2	0	19	4,435	0.007
Sum of all positive shocks	1.4	1.77	0	11	3,859	1.31	1.65	0	10	4,435	0.016
Total number of new health conditions or health shocks	1.14	2.48	0	30	3,859	1.16	2.66	0	26	4,435	0.711
Total number of income-related shocks between	1.2	1.62	0	7	3,858	1.68	1.75	0	7	4,435	0.000
Total number of shocks regarding family life	1.56	1.62	0	12	3,856	1.73	1.71	0	13	4,434	0.000
Health-related shock > 3 SD	0.03	0.18	0	1	3,859	0.04	0.2	0	1	4,435	0.066
Employment-related shock > 3 SD	0	0.06	0	1	3,859	0	0.07	0	1	4,435	0.241
Family-related shock > 3 SD	0.03	0.16	0	1	3,859	0.03	0.17	0	1	4,435	0.333
Health-related shock > 3 SD	0.06	0.24	0	1	3,859	0.07	0.25	0	1	4,435	0.387
Employment-related shock > 3 SD	0.19	0.39	0	1	3,859	0.28	0.45	0	1	4,435	0.000
Family-related shock > 2 SD	0.12	0.33	0	1	3,859	0.15	0.35	0	1	4,435	0.005
Health-related shock > 1 SD	0.14	0.35	0	1	3,859	0.13	0.34	0	1	4,435	0.591
Employment-related shock > 1 SD	0.31	0.46	0	1	3,859	0.44	0.5	0	1	4,435	0.000
Family-related shock > 1 SD	0.42	0.49	0	1	3,859	0.46	0.5	0	1	4,435	0.000
At least three times unemployed	0.02	0.14	0	1	3,826	0.03	0.18	0	1	4,401	0.002
In chronic pain in all years	0.03	0.17	0	1	3,859	0.03	0.17	0	1	4,435	0.685
At least two health shocks	0.01	0.11	0	1	3,859	0.01	0.12	0	1	4,435	0.553
At least two deaths in family	0.07	0.26	0	1	3,827	0.06	0.25	0	1	4,395	0.087
Lost spouse/child and health shock and lost job	0.01	0.09	0	1	3,859	0.02	0.12	0	1	4,435	0.006

Table A1

(*Continued*)

Variable	Sample of men					Sample of women					Difference
	Mean	SD	Min	Max	*N*	Mean	SD	Min	Max	*N*	p-value†
Other control variables measured in 2003											
Age-group 15–19	0.08	0.27	0	1	3,859	0.07	0.26	0	1	4,435	0.369
Age-group 20–24	0.06	0.24	0	1	3,859	0.06	0.23	0	1	4,435	0.387
Age-group 25–29	0.07	0.25	0	1	3,859	0.08	0.27	0	1	4,435	0.058
Age-group 30–39	0.19	0.39	0	1	3,859	0.2	0.4	0	1	4,435	0.525
Age-group 40–49	0.22	0.42	0	1	3,859	0.22	0.42	0	1	4,435	0.793
Age-group 50–59	0.17	0.38	0	1	3,859	0.17	0.37	0	1	4,435	0.406
Age-group 60–69	0.12	0.33	0	1	3,859	0.11	0.32	0	1	4,435	0.174
Age-group 70–79	0.07	0.26	0	1	3,859	0.07	0.26	0	1	4,435	0.998
Age-group 80 and older	0.01	0.1	0	1	3,859	0.02	0.13	0	1	4,435	0.006
Married or de facto	0.57	0.49	0	1	3,859	0.54	0.5	0	1	4,435	0.001
Separated or divorced	0.03	0.16	0	1	3,859	0.03	0.18	0	1	4,435	0.056
Foreigner	0.22	0.41	0	1	3,859	0.21	0.4	0	1	4,435	0.246
Full or part-time employed	0.72	0.45	0	1	3,859	0.58	0.49	0	1	4,435	0.000
Household income (ln)	10.75	0.67	5.3	13.02	3,859	10.67	0.70	5.23	13.02	4,435	0.000
Postgrad-masters or doctorate	0.04	0.19	0	1	3,859	0.03	0.16	0	1	4,435	0.002
Grad diploma, grad certificate	0.05	0.21	0	1	3,859	0.06	0.23	0	1	4,435	0.019
Bachelor or honours	0.12	0.32	0	1	3,859	0.13	0.34	0	1	4,435	0.033
Adv diploma, diploma	0.09	0.29	0	1	3,859	0.09	0.28	0	1	4,435	0.159
Any certificate	0.28	0.45	0	1	3,859	0.14	0.34	0	1	4,435	0.000
Year 12	0.13	0.33	0	1	3,859	0.15	0.36	0	1	4,435	0.001
Year 11 and below	0.3	0.46	0	1	3,859	0.41	0.49	0	1	4,435	0.000

Notes. *Number of observations vary between the regression models. Numbers presented here refer to samples from Figures 6(*a*) and 6(b). †p-value refers to a t-test of differences in mean between men and women.

Melbourne Institute of Applied Economic and Social Research, The University of Melbourne, and Institute for the Study of Labor (IZA)
School of Economics and Finance, Victoria University of Wellington, and Institute for the Study of Labor (IZA)

Submitted: 6 June 2011
Accepted: 18 October 2012

References

Almlund, M., Lee Duckworth, A., Heckman, J.J. and Kautz, T. (2011). 'Personality psychology and economics', in (E.A. Hanushek, S. Machin and L. Woessmann, eds.), *Handbook of the Economics of Education*, vol. 4, pp. 1–181, Amsterdam: North-Holland.

Andrisani, P. (1977). 'Internal-external attitudes, personal initiative, and the labor market experience of white and black men', *Journal of Human Resources*, vol. 12(3), pp. 308–28.

Bandura, A. (1997). *Self-efficacy: The Exercise of Control*, New York: Worth Publishers.

Barón, J.A. and Cobb-Clark, D. (2010). 'Are young people's educational outcomes linked to their sense of control?', IZA Discussion Paper, vol. 4907.

Becker, A., Deckers, T., Dohmen, T.J., Falk, A. and Kosse, F. (2012). 'The relationship between economic preferences and psychological personality measures', mimeo, Institute for the Study of Labor (IZA).

Bollen, K.A. (1989). *Structural Equations with Latent Variables*, New York: Wiley.

Borghans, L., Duckworth, A., Heckman, J. and ter Weel, B. (2008). 'The economics and psychology of personality traits', *Journal of Human Resources*, vol. 43(4), pp. 972–1059.

Bound, J. and Krueger, A.B. (1991). 'The extent of measurement error in longitudinal earnings data: do two wrongs make a right?', *Journal of Labour Economics*, vol. 9(1), pp. 1–24.

Caliendo, M., Cobb-Clark, D. and Uhlendorff, A. (2010). 'Locus of control and job search strategies', mimeo, Institute for the Study of Labor (IZA).

Carton, J. and Nowicki, S. (1994). 'Antecedents of individual differences in locus of control of reinforcement-A critical review', *Genetic Social and General Psychology*, vol. 120(1), pp. 31–81.

Cebi, M. (2007). 'Locus of control and human capital investment revisted', *Journal of Human Resources*, vol. 17 (4), pp. 919–32.

Chiteji, N. (2010). 'Time preference, noncognitive skills and well being across the life course: do noncognitive skills encourage healthy behavior?', *American Economic Review: Papers & Proceedings*, vol. 100 (2), pp. 200–4.

Cobb-Clark, D., Kassenboehmer, S. and Schurer, S. (2012). 'Healthy lifestyle choices: the connection between diet, exercise, and locus of control', mimeo, Institute for the Study of Labor (IZA).

Cobb-Clark, D. and Schurer, S. (2011). 'Two economists' musings on the stability of locus of control', mimeo, Institute for the Study of Labor (IZA).

Cobb-Clark, D. and Schurer, S. (2012). 'The stability of Big-Five personality traits', *Economics Letters*, vol. 115 (1), pp. 11–5.

Coleman, J. (1966). *Equality and Educational Opportunity/United States Office of Education*, Washington, DC: GPO.

Coleman, M. and Deleire, T. (2003). 'An economic model of locus of control and the human capital investment decision', *Journal of Human Resources*, vol. 38(3), pp. 701–21.

Costa, P. and McCrae, R. (1988). 'Personality in adulthood: a six-year longitudinal study of self-reports and spouse ratings on the NEO personality inventory', *Journal of Personality and Social Psychology*, vol. 54(5), pp. 853–63.

Cronbach, L.J. (1951). 'Coefficient alpha and the internal structure of tests', *Psychometrika*, vol. 16(3), pp. 297–334.

Cunha, F. and Heckman, J.J. (2008). 'Formulating, identifying and estimating the technology of cognitive and noncognitive skill formation', *Journal of Human Resources*, vol. 43(4), pp. 738–82.

Cunha, F., Heckman, J.J. and Schennach, S.M. (2010). 'Estimating the technology of cognitive and noncognitive skill formation', *Econometrica*, vol. 78(3), pp. 883–931.

Deary, I., Whalley, L., Crawford, H.L.J. and Starr, J. (2000). 'The stability of individual differences in mental ability from childhood to old age: follow-up of the 1932 Scottish Mental Survey', *Intelligence*, vol. 28(1), pp. 49–55.

Deary, I.J., Yang, J., Davies, G., Harris, S.E., Tenesa, A. and Liewald, D. (2012). 'Genetic contributions to stability and change in intelligence from childhood to old age', *Nature*, vol. 482(7384), pp. 212–5.

Doherty, W.J. and Baldwin, C. (1985). 'Shifts and stability in locus of control during the 1970s: divergence of the sexes', *Journal of Personality and Social Psychology*, vol. 48(4), pp. 1048–53.

Duncan, G. and Dunifon, R. (1998). 'Soft skills and long run labor market success', in (S. Polochek, ed.), *Research in Labor Economics*, pp. 123–9, Stamford, CN: JAI Press.

Gatz, M. and Karel, J. (1993). 'Individual change in perceived control over 20 years', *International Journal of Behavioral Development*, vol. 16(2), pp. 305–22.

Goldsmith, A., Veum, J. and Darity, W. (1997). 'The impact of psychological and human capital on wages', *Economic Inquiry*, vol. 35(4), pp. 815–29.

Goldsmith, A., Veum, J.R. and Darity, W. (1996). 'The psychological impact of unemployment and joblessness', *Journal of Socio-Economics*, vol. 25(3), pp. 333–58.

Gottschalk, P. (2005). 'Can work alter welfare recipients' beliefs?', *Journal of Policy Analysis and Management*, vol. 24(3), pp. 485–98.

Gow, A., Johnson, W., Pattie, A., Brett, C., Roberts, B., Starr, J. and Deary, I. (2011). 'Stability and change in intelligence fromage 11 to ages 70, 79, and 87: the Lothian Birth Cohorts of 1921 and 1936', *Psychological Aging*, vol. 26, pp. 232–40.

Heckman, J.J. and Kautz, T. (2012). 'Hard evidence on soft skills', mimeo, Institute for the Study of Labor (IZA).

Heckman, J., Stixrud, J. and Urzua, S. (2006). 'The effects of cognitive and noncognitive abilities on labor market outcomes and social behavior', *Journal of Labour Economics*, vol. 24(3), pp. 411–82.

Heineck, G. and Anger, S. (2010). 'The returns to cognitive abilities and personality traits in Germany', *Labour Economics*, vol. 17(3), pp. 535–46.

Hertzog, C. and Schaie, K.W. (1988). 'Stability and change in adult intelligence: II. simultaneous analysis of longitudinal means and covariance structures', *Psychology and Aging*, vol. 3(2), pp. 122–30.

Judge, T.A., Erez, A., Thoresen, C.J. and Bono, J.E. (2002). 'Are measures of self-esteem, neuroticism, locus of control, and generalized self-efficacy indicators of a common core construct?', *Journal of Personality and Social Psychology*, vol. 83(3), pp. 693–710.

Kapteyn, A. and Ypma, J.Y. (2007). 'Measurement error and misclassification: a comparison of survey and administrative data', *Journal of Labour Economics*, vol. 25(3), pp. 513–51.

Kuhn, P. and Weinberger, C. (2005). 'Leadership skills and wages', *Journal of Labour Economics*, vol. 23(3), pp. 395–436.

Kulas, H. (1996). 'Locus of control in adolescence: a longitudinal study', *Adolescence*, vol. 31(123), pp. 721–9.

Lucas, R.E. and Donnellan, M.B. (2011). 'Personality development across the life span: longitudinal analyses with a national sample from Germany', *Journal of Personality and Social Psychology*, vol. 101(4), pp. 847–61.

McCrae, R. and Costa, P. (1994). 'The stability of personality: observation and evaluations', *Current Directions in Psychological Science*, vol. 3(6), pp. 73–5.

McCrae, R.R., Costa, Jr., P., Ostendorf, F., Angleitner, A., Hrebickova, M., Avia, M., Sanz, J., Sánchez-Bernardos, M.L., Kusdil, M.E., Woodfield, R., Saunders, P.R. and Smith, P.B. (2000). 'Nature over nurture: temperament, personality, and life span development', *Journal of Personality and Social Psychology*, vol. 78(1), pp. 173–86.

Mooney, C.Z. and Duval, R.D. (1993). *Bootstrapping: A Nonparametric Approach to Statistical Inference*, Newbury Park, CA: Sage.

Osborne Groves, M. (2005). 'How important is your personality? Labor market returns to personality for women in the US and UK', *Journal of Economic Psychology*, vol. 26(6), pp. 827–41.

Pearlin, L. and Schooler, C. (1978). 'The structure of coping', *Journal of Health and Social Behavior*, vol. 19(1), pp. 2–21.

Piatek, R. and Pinger, P. (2010). 'Maintaining (locus of) control? Assessing the impact of locus of control on education decisions and wags', mimeo, Institute for the Study of Labor (IZA).

Roberts, B., Caspi, A. and Moffitt, T. (2001). 'The kids are alright: growth and stability in personality development from adolescence to adulthood', *Journal of Personality and Social Psychology*, vol. 81(4), pp. 670–83.

Roberts, B.W. (1997). 'Plaster or plasticity: are adult work experiences associated with personality changes in women?', *Journal of Personality*, vol. 65(4), pp. 205–32.

Roberts, B.W. and DelVecchio, W.F. (2000). 'The rank-order consistency of personality traits from childhood to old age: a quantitative review of longitudinal studies', *Psychological Bulletin*, vol. 126(1), pp. 3–25.

Roberts, B.W., Walton, K.E. and Viechtenbauer, W. (2000). 'Patterns of mean-level change in personality traits across the life course: a meta-analysis of longitudinal studies', *Psychological Bulletin*, vol. 126(1), pp. 3–25.

Rotter, J. (1966). 'Generalized expectancies of internal versus external control of reinforcements', *Psychological Monographs*, vol. 80(1), pp. 1–28.

Schurer, S. (2011). 'How do your beliefs of control affect the relationship between health and labor supply?', mimeo, Victoria University of Wellington.

Seligman, M.E.P. (1975). *Helplessness: On Depression, Development and Death*, San Francisco, CA: W. H. Freeman.

Semykina, A. and Linz, S.J. (2007). 'Gender differences in personality and earnings: evidence from Russia', *Journal of Economic Psychology*, vol. 28(3), pp. 387–410.

Specht, J., Egloff, B. and Schmukle, S.C. (2011). 'Stability and change of personality across the life course: the impact of age and major life events on mean-level and rank-order stability of the Big Five', *Journal of Personality and Social Psychology*, vol. 101(4), pp. 862–82.

Stephens, M.W. and Delys, P. (1973). 'External control expectancies among disadvantaged children at preschool age', *Child Development*, vol. 44(3), pp. 670–4.

Summerfield, M. (2010). *User Manual HILDA Release 9*, Melbourne: Melbourne Institute of Applied Economic and Social Research – The University of Melbourne.

Thompson, B. and Vacha-Haase, T. (2000). 'Psychometrics is datametrics: the test is not reliable', *Educational and Psychological Measurement*, vol. 60(2), pp. 174–95.

Thompson, S. (1981). 'Will it hurt less if I can control it? A complex answer to a simple question', *Psychological Bulletin*, vol. 90(1), pp. 89–101.

Wand, M.P. and Jones, M.C. (1995). *Kernel Smoothing, Monographs on Statistics and Applied Probability*, Boca Raton, FL: Chapman & Hall.

Wooden, M. and Watson, N. (2007). 'The HILDA survey and its contribution to economic and social research (so far)', *Economic Record*, vol. 83(261), pp. 208–31.

Wooldridge, J. (2009). *Econometric Analysis of Cross Section and Panel Data*, Cambridge, MA: The MIT Press.