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Two Economists' Musings on  
the Stability of Locus of Control

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# **Two Economists' Musings on the Stability of Locus of Control\***

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## **Abstract**

Empirical studies of the role of non-cognitive skills in driving economic behavior often rely heavily on the assumption that these skills are stable over the relevant time frame. We analyze the change in a specific non-cognitive skill, i.e. locus of control, in order to directly assess the validity of this assumption. We find that short- and medium-run changes in locus of control are rather modest on average, are concentrated among the young or very old, do not appear to be related to the demographic, labor market, and health events that individuals experience, and are unlikely to be economically meaningful. Still, there is no evidence that locus of control is truly time-invariant implying that the use of lagged measures results in an errors-in-variables problem that could downward bias the estimated wage return to locus of control by as much as 50 percent. Those researchers wishing to analyze the economic consequences of non-cognitive skills should consider (i) restricting their analysis to the working-age population for whom there is little evidence of systematic change in skill levels and (ii) accounting for error in the skill measures they employ.

**JEL classification:** J24, C18

**Keywords:** Non-cognitive skills, locus of control, stability, measurement error, endogeneity, life events

## 1 Introduction

Increasingly, economists are pushing the boundaries of human capital theory to accommodate the role of non-cognitive skills in driving economic behavior.<sup>1</sup> 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 behaviors including schooling choices, work choices, and risky behavior. Finally, non-cognitive-skill endowments themselves are increasingly being modelled as resulting from educational attainment, parental investments, and policy interventions (see 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 Borghans et al., 2008; Heckman et al., 2006, for an overview).

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 (Heineck and Anger, 2010; Cebi, 2007; Semykina and Linz, 2007; Goldsmith et al., 1997; Andrisani, 1977). This assumption is convenient because it implies that non-cognitive skills are exogenous and are not themselves a function of the specific educational or labor 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. An assumption that non-cognitive skills are time-invariant allows the use of lead or lagged measures of these

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<sup>1</sup>The range of traits considered is often quite broad, but generally includes psycho-social traits like personality, self-efficacy, locus of control, risk preferences, self-esteem, emotional intelligence, etc. Economists typically refer to these traits as “non-cognitive skills” to distinguish them from other productivity-related characteristics (e.g. ability, experience, education, etc.) 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.

skills, a strategy commonly chosen in the empirical literature (e.g. Heineck and Anger, 2010; Schurer, 2011; Cebi, 2007; Osborne Groves, 2005).<sup>2</sup>

Unfortunately, empirical analyzes 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, unemployment history, etc.). 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 by 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 analyzing the change in a specific non-cognitive skill, i.e. locus of control, over both the short (one year) and medium run (four years). “Locus of control” is a psychological concept capturing “a generalized attitude, belief, or expectancy regarding the nature of the causal relationship between one’s own behavior 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 (Heineck and Anger, 2010; Semykina and Linz, 2007; Osborne Groves, 2005; Goldsmith et al., 1997; Duncan and Dunifon, 1998; Andrisani, 1981, 1977), educational attainment (Barón and Cobb-Clark, 2010; Coleman and Deleire, 2003; Coleman, 1966), and health (Chiteji, 2010) as well as the ability to cope with unanticipated life-events such as health shocks (Schurer, 2011) or unemployment (Caliendo et al., 2010). 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

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<sup>2</sup>For instance, in the German Socio-Economic Panel (GSEOP), locus of control and the Big Five personality traits are measured in 2005, more than 20 years after the first wave of data was collected. A similar issue arises with the British Household Panel Survey (BHPS).

individuals’ locus of control over time? Are any changes in individuals’ locus of control effectively exogenous or do they appear to be related to labor 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 incorporating non-cognitive skills like locus of control into empirical analyzes of economic behavior?

In answering these questions, we take advantage of high-quality, longitudinal data from the Household, Income and Labor Dynamics in Australia (HILDA) Survey. These data are unique in providing measures 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.<sup>3</sup> 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 rather modest on average, are concentrated among the young or very old, do not appear to be related to the demographic, labor market, and health events that individuals experience, and are unlikely to be economically meaningful. At the same time, there is no evidence that locus of control is truly time-invariant implying that the use of lagged measures results in an errors-in-variables problem. Our analysis indicates that the associated attenuation bias is large leading the estimated wage return to locus of control to understate the true return by as much as 50 percent. Those researchers wishing to analyze the economic consequences of non-cognitive skills should consider (i) restricting their analysis to the working-age population for whom there is little evidence of systematic change in skill levels and (ii) accounting for error in the skill measures they employ.

The remainder of the paper is as follows: Section 2 reviews the psychological and eco-

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<sup>3</sup>Psychologists use the term “normative” differently than do economists. Psychologists view normative change as occurring when most people change in the same way during a specific period of the life course (see McCrae et al., 2000).

economic evidence on the stability of non-cognitive skills including personality traits and locus of control. Section 3 outlines the econometric problems that arise when the assumption that non-cognitive skills are fixed is violated, while Section 4 describes the HILDA data and the specific measures we analyze. In Section 5, we present evidence on 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 6 concludes by discussing the empirical strategies that applied economists should consider when estimating the returns to non-cognitive skills.

## **2 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 age 30 onwards (e.g. McCrae and Costa, 2006; Costa and McCrae, 1988). 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, depending on which specific personality trait is considered (e.g. 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 to be 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 or not groups of individuals increase or decrease on trait dimensions over time (see 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 (e.g. 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).<sup>4</sup>

Psychologists have studied the rank-order and mean-level consistency of personality traits extensively. Meta-analyses of this research generally conclude that: 1) personality traits are consistent across time and age; 2) the greatest mean-level change in personality traits occurs not during adolescence, but during young adulthood; and 3) rank-order stability increases steadily over the life course (Roberts et al., 2000; Roberts and DelVecchio, 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 generalize has been limited by unrepresentative sampling, low power, and limited trait coverage (Roberts et al., 2000).

What should economists interested in analyzing 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 et al., 2001; Roberts, 1997). 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 carefully account for the effects of these normative changes in any empirical analysis.<sup>5</sup> Third, it is the concept of intra-individual consistency that underpins economists' standard treatment of non-cognitive

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<sup>4</sup>Psychologists also occasionally examine the relative salience of attributes within an individual over time (Roberts and DelVecchio, 2000).

<sup>5</sup>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 off the age effect for similar reasons.



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 psychological evidence 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 (e.g. Roberts et al., 2000), it is important for us to also explicitly consider the evidence on the consistency in and determinants of individuals’ 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 stabilize during adolescence. In particular, cross-sectional studies usually find a linear, negative relationship between age and external control tendencies (see Weisz and Stipek, 1982, for a review). On the other hand, a limited number of studies using longitudinal data typically find a curvilinear relationship with children first increasing in internal control tendencies from age 8 or so and then reversing again during adolescence (see Sherman, 1984; Kulas, 1996). Overall, however, these changes are generally small suggesting that locus of control in adolescence is relatively stable (Kulas, 1996).<sup>6</sup>

Children are more likely to develop internal control tendencies if their parents provide

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<sup>6</sup>Both Sherman (1984) and Kulas (1996) use small samples of 97 and 84 children, respectively.

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 (1973), for example, argue that by age 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.<sup>7</sup>

Only a handful of studies have investigated the stability of locus of control in adulthood. Doherty and Baldwin (1985) analyze changes in control tendencies over the 1970s for both young and mature men and women using National Longitudinal Survey of Labor Market Experiences (NLS) data. The authors find that men’s control tendencies remained relatively stable, while women became somewhat more external. However, the change in women’s locus of control is modest (averaging just under a one standard deviation change between 1969 and 1978) and cannot be explained by demographic factors (i.e. marital status, race, occupation, etc.). Similarly, Schurer (2011) analyzes data from the German Socio-Economic Panel (GSOEP) and concludes that substantial intra-individual and mean-level changes in locus of control tendencies are rare among working-age adults.

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 labor 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 an exogenous increases in work hours induced by an experimental tax credit resulted in increased internal control tendencies among welfare recipients.

Taken together, 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 the applied economists studying these issues 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, self-esteem, etc.) generally available in the large-scale, general

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<sup>7</sup>See Gatz and Karel (1993) and Coleman and Deleire (2003) for particularly helpful reviews.

population samples that we are analyzing. The psychological literature provides us with some guidance, but no absolutes.

### 3 The econometric problem

Economists increasingly recognize that non-cognitive skills may represent an important source of unobserved heterogeneity in economic behavior. Wooldridge (2002), for example, motivates the importance of panel-data econometrics by arguing that individual differences in motivation or time preferences, two possible manifestations of personality, may generate unobserved, time-invariant heterogeneity (p. 248). Similarly, Boyce (2010) concludes that up to 20 percent of the time-invariant fixed effect in a longitudinal model of life satisfaction can be explained by individuals' personality traits. 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.<sup>8</sup> The increasing availability of individual-specific data on personality traits, including locus of control, has been very powerful in allowing economists to explicitly account for the effects of non-cognitive skills in standard econometric models. 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 from the inclusion of non-cognitive skill measures in empirical analyzes. We pay particular attention to the problems 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  $\alpha$  is a common intercept and  $\varepsilon_{it}$  are idiosyncratic, time-varying shocks. For simplicity, we will assume that  $L_{it}$  captures all relevant individual-specific heterogeneity and we

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<sup>8</sup>Some studies have questioned this assumption. Frijters et al. (2010) allow for unobserved, individual-specific health shocks which vary over the life cycle in a mixed proportional hazard model. Jones and Schurer (2009) have shown that the individual-specific effects estimated from non-linear models that seek to explain health status do vary by age-groups.

ignore the influence of any other independent variables. An OLS estimate of  $\gamma$  is unbiased as long as the error term  $\varepsilon_{it}$  is mean zero and independent of  $L_{it}$ .

The assumption that locus of control is independent of the error term in eq. (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  $\text{Cov}(L_{it}, \varepsilon_{it}) = 0$ . In effect, locus of control would be pre-determined permitting the use of standard regression techniques. The review of the psychological evidence in Section 2, 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.

Case 1: The errors-in-variables problem: Let us assume that individuals' true locus of control is not observed and that we observe a proxy instead. For example, it may be the case that while information about current locus of control ( $L_{it}$ ) is unavailable, we do observe individuals' locus of control as measured in a previous period  $t - k$ . In this case, lagged locus of control ( $L_{it-k}$ ) becomes a proxy measure of the true locus of control ( $L_{it}$ ) plus some measurement error ( $v_{it}$ ) that is assumed to have a mean-zero distribution:

$$L_{it-k} = L_{it} + v_{it}. \quad (2)$$

This implies that eq. (1) can be re-written as:

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

If the measurement error fits the classical case, it will be uncorrelated with the true measure of locus of control, i.e.  $\text{Cov}(L_{it}, v_{it}) = 0$ . Then by construction the correlation between the measurement error and the proxy (lagged) measure of locus of control must be non-zero, i.e.  $\text{Cov}(L_{it-k}, v_{it}) \neq 0$ .<sup>9</sup> OLS regression of eq. (3) would then yield biased and inconsistent estimates of  $\gamma$  because our proxy measure of locus of control would be correlated with the error term in the wage equation.<sup>10</sup> This results in an attenuation bias

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<sup>9</sup>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 this is a reasonable assumption.

<sup>10</sup>This is:  $\text{Cov}(L_{it-k}, \varepsilon_{it} - \gamma v_{it}) = -\gamma \text{Cov}(L_{it-k}, \varepsilon_{it}) \neq 0$ .

in the estimated wage returns to locus of control. More specifically,

$$plim(\hat{\gamma}) = \gamma \frac{\sigma_{L_{it}}^2}{\sigma_{L_{it}}^2 + \sigma_v^2} = \gamma\lambda, \quad (4)$$

In the limit,  $\hat{\gamma}$  is biased towards zero and the extent of the attenuation bias depends on the variance of the measurement error ( $\sigma_v^2$ ) and the variance of the true locus of control measure ( $\sigma_{L_{it}}^2$ ). The greater the variation in the measurement error (i.e. the noise) relative to the variation in the true locus of control measure (i.e. the signal) the greater is the bias (Greene, 2002, p.437). In the literature,  $\lambda$  is often interpreted as a reliability parameter with higher values of  $\lambda$  indicating less bias (Bound and Krueger, 1991).

If we are unwilling to make the strong assumption that the measurement error is uncorrelated with the true measure of locus of control and we allow  $\text{Cov}(L_{it}, v_{it}) \neq 0$ , the reliability parameter  $\lambda$  is constructed as follows:

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

In this case,  $\lambda$  is simply the slope coefficient from an OLS regression of the contemporaneous (true) measure of locus of control  $L_{it}$  on its lagged (proxy) value  $L_{it-k}$ . In an application presented in Section 5.4, 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 true locus of control is with all other explanatory variables (see Wooldridge, 2002, p. 75).

Case 2: The simultaneity and reverse causality problem: Rather than being exogenous, individuals' locus of control may either (i) be determined with or (ii) result from individ-

uals' previous labor market outcomes. Locus of control and wages, for example, may be simultaneously determined if the cognitive and non-cognitive skills that underpin labor 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, occupational status, etc. 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  $\omega$  and  $\delta$  in eq. (6) measure the impact of wages and the background variable, respectively, on locus of control.

$$L_{it} = \omega Y_{it} + \delta X_{it} + \nu_{it}. \quad (6)$$

The error term  $\nu_{it}$  is assumed to be distributed independently of  $X_{it}$  with zero mean and variance  $\sigma_\nu^2$ . The covariance  $\sigma_{\varepsilon\nu}$  measures the relationship between the two error terms  $\nu_{it}$  and  $\varepsilon_{it}$ . Inserting eq. (6) into eq. (1) (and vice versa) and solving for  $Y_{it}$  and  $L_{it}$  results in:

$$\begin{aligned} Y_{it} &= \frac{\alpha}{1 - \gamma\omega} + \frac{\gamma\delta}{1 - \gamma\omega} X_{it} + \frac{1}{1 - \gamma\omega} \varepsilon_{it} + \frac{\gamma}{1 - \gamma\omega} \nu_{it} \\ L_{it} &= \frac{\alpha\omega}{1 - \gamma\omega} + \frac{\delta}{1 - \gamma\omega} X_{it} + \frac{\omega}{1 - \gamma\omega} \varepsilon_{it} + \frac{1}{1 - \gamma\omega} \nu_{it} \end{aligned} \quad (7)$$

It follows from eq. (7) that the covariance between  $L_{it}$  and  $\varepsilon_{it}$  in eq. (1) is non-zero. Specifically,

$$Cov(L_{it}, \varepsilon_{it}) = \frac{1}{1 - \gamma\omega} (\omega\sigma_\varepsilon^2 + \sigma_{\varepsilon\nu}). \quad (8)$$

and

$$Var(L_{it}) = \left(\frac{1}{1 - \gamma\omega}\right)^2 (\delta^2\sigma_X^2 + \omega^2\sigma_\varepsilon^2 + \sigma_\nu^2 + 2\omega\sigma_{\varepsilon\nu}). \quad (9)$$

Thus, the bias in  $\hat{\gamma}$  which results from estimating eq. (1) without considering the

simultaneity as expressed in eq. (6) is:

$$plim(\hat{\gamma}) = \gamma + \frac{Cov(L_{it}, \varepsilon_{it})}{Var(L_{it})} = \gamma + (1 - \gamma\omega) \frac{\omega\sigma_{\varepsilon}^2 + \sigma_{\varepsilon\nu}}{\delta^2\sigma_X^2 + \omega^2\sigma_{\varepsilon}^2 + \sigma_{\nu}^2 + 2\omega\sigma_{\varepsilon\nu}}. \quad (10)$$

Unlike the simple errors-in-variables problem which results in a clear prediction that our estimates will be biased towards zero, the direction of bias in the case of simultaneity or reverse causality will depend on (i) the sign of  $\gamma$  and  $\omega$ ; (ii) the variation in the error one makes in specifying the wage equation ( $\sigma_{\varepsilon}^2$ ); (iii) the relationship between the errors in the wage and the locus of control equation ( $\sigma_{\varepsilon\nu}$ ); and (iv) the Noise-to-Signal ratio, i.e. the proportion of error in the wage equation and the relationship between both error terms in the overall variance  $\left(\frac{\omega\sigma_{\varepsilon}^2 + \sigma_{\varepsilon\nu}}{\delta^2\sigma_X^2 + \omega^2\sigma_{\varepsilon}^2 + \sigma_{\nu}^2 + 2\omega\sigma_{\varepsilon\nu}}\right)$ .

The three graphs in Figure 1 illustrate the deviation of  $\hat{\gamma}$  from  $\gamma$  for three different values of the Noise-to-Signal ratio (.1, .5, and .9) and five possible values of  $\omega$  (ranging from -1 to 1) over a wide range of positive and negative values of  $\gamma$  (ranging from -1 to 1). We assume that  $\sigma_{\varepsilon\nu} = 0$  to simplify the derivations.

**[Insert Figure 1 here]**

Moving from Figure 1(a) to 1(c) shows that there is no bias if  $\omega = 0$ , but in all other cases  $\hat{\gamma}$  increasingly deviates from  $\gamma$  (i.e. deviates from the 45° line) as the value of the Noise-to-Signal ratio grows larger. Moreover, if  $\gamma$  and  $\omega$  have the same sign then  $|\hat{\gamma}|$  will be an over-estimate of the true  $\gamma$ , especially as  $\gamma$  approaches 0 and/or  $|\omega|$  approaches 1. The bias is more problematic if  $\omega$  and  $\gamma$  have opposite signs. In this case, the sign of  $\gamma$  will be incorrectly estimated as  $|\omega|$  approaches 1 and/or  $\gamma$  approaches 0. Moreover, if  $\omega$  approaches 0 and/or  $|\gamma|$  approaches 1 then  $|\hat{\gamma}|$  will be an under-estimate of the true  $\gamma$  if  $\gamma$  and  $\omega$  are of opposite sign. The signs of  $\omega$  and  $\gamma$  will of course depend on the application of interest.

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 (i) there is a lot of variation in  $X_{it}$  ( $\sigma_X^2$ ); (ii) the effect of  $X_{it}$  on locus of control is very strong ( $\delta$ ); and/or (iii) the variation in the error in wages ( $\sigma_{\varepsilon}^2$ ) is small.

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.

## 4 Data: Household, Income and Labour Dynamics in Australia Survey

Our data come from the Household, Income and Labour Dynamics in Australia (HILDA) Survey. The HILDA Survey 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 (Wooden and Watson, 2007; Summerfield, 2010). A total of 13,969 individuals in 7,682 households were interviewed in wave 1 of the HILDA survey.<sup>11</sup> The HILDA Survey is a broad, general-purpose, panel survey designed to obtain detailed information about the dynamics of household structure and formation, income and economic well-being, as well as employment and labor force participation. The HILDA data are ideally suited for our purposes because, in addition to standard demographic and labor market information, measures of several key non-cognitive skills (in particular locus of control and the Big Five) are available at multiple points in time.

### 4.1 Estimation sample

We rely on individual-level HILDA data from waves 3 - 7 spanning the years 2003 - 2007. From the original 12,728 individuals interviewed in 2003, 11,501 filled out the locus-of-control questionnaire (90.4 percent).<sup>12</sup> Of these 11,501, 9,728 (8,351) also filled out the locus of control questionnaire 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

<sup>11</sup>A more detailed description of the HILDA data can be found in the various HILDA Annual Reports available from [www.melbourneinstitute.com](http://www.melbourneinstitute.com).

<sup>12</sup>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 to these SCQs in the years 2003, 2004, and 2007, when locus of control was collected, were 92.3, 91.9, and 89.0 percent, respectively (Summerfield, 2010).



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 percent to 3,859 men and 4,437 due to missing data on some of the life-events and health conditions.

## 4.2 Parameterizing locus of control

Our primary objective is to understand the stability of individuals' locus of control over time. Fortunately, in 2003, 2004, and 2007 HILDA Survey respondents were asked a range of 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 a personal belief about the extent to which life's outcomes are under one's own control as opposed to being fatalistically determined. 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, i.e. self-efficacy, has been linked to many aspects of human development including cognitive, health, clinical, athletic and organizational functioning (see Bandura, 1997, for an overview).

More 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 principal component 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  $\alpha$  reliability statistic of 0.82 when including all seven questions in the index (Cronbach, 1951), which is usually accepted in the literature as highly reliable.

**[Insert Table 1 here]**

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,

$$LOC_{it} = \sum_{j=a}^e ELOC_{it,j} - \sum_{j=f}^g ILOC_{it,j} + 16. \quad (11)$$

This index is therefore increasing in external control tendencies and is bounded between 7 (internal) and 49 (external).

## 5 Results

Our interest is in carefully analyzing the change over time in individuals' locus-of-control tendencies and in shedding light on the potential biases that may result if standard econometric models are used to estimate the return to locus of control. Specifically, in this section, we provide empirical evidence on (i) the degree of short- and medium-run stability in locus of control; (ii) the degree to which locus of control appears to respond to individuals' life experiences; (iii) the extent to which changes in locus of control are economically meaningful; and (iv) the potential magnitude of the attenuation bias resulting from the errors-in-variables problem.

### 5.1 Is locus of control stable?

We begin by calculating the short-run (2003 - 2004) and medium-run (2003 - 2007) 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 2(a) and 2(b) separately by gender.

**[Insert Figures 2(a) and 2(b) here]**

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) by approximately one point. Short-run changes in individuals' locus-of-control indexes are, not surprisingly, even smaller. Thus, complete reversals in individuals' control tendencies over the short or medium run do not appear to occur.

Moreover, it is important to note that approximately 9.3 percent of men and 8.3 percent of women do not change their locus-of-control index at all between 2003 and 2007. In fact, only 25.0 percent of men and 27.5 percent of women change their locus-of-control index by more than one standard deviation over the medium run and less than one percent 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 2 suggests that, as people age, normative changes in personality may occur as the result of social forces or indeed the aging process itself. Consequently, it is important to carefully consider how changes in locus-of-control tendencies may vary over the life cycle. Figure 3 presents nonparametric bivariate regression estimates of the change in locus of control by age.<sup>13</sup> Results are presented separately by gender for both the short (Figures 3(a) and 3(b)) and medium run (Figures 3(c) and 3(d)) and for the working-age population (ages 25 - 60) as a whole (Figures 3(e) and 3(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 amongst 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 tested for the equality of locus-of-control changes across age groups and rejected 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

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<sup>13</sup>We use bivariate kernel regression methods with a bandwidth of 2 to estimate mean levels of locus of control as a function of age and plot these profiles including a 95 percent confidence interval (CI) (Wand and Jones, 1995).

the same irrespective of their age.

**[Insert Figures 3(a) to 3(f) here]**

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 ( $p=0.354$ ) or medium run ( $p=0.414$ ) (see Figures 3(e) and 3(f)). These results are particularly important given that much of the applied economics literature focuses on assessing the labor 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. Table 2 documents the correlation in short- and medium-run locus of control for the sample as a whole and for specific age groups (see column 1).<sup>14</sup> We find that the one-year correlation in locus of control is 0.605 on average, while the correlation over four years is 0.517. The strength of these correlations varies significantly across age groups both in the short and medium run ( $p<0.001$ ). 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 40 - 59 years.

**[Insert Table 2 here]**

To place these results into context, Table 2 also presents information about the correlation in individuals' income, life satisfaction, self-assessed health, Big-Five personality traits and religious affiliation (i.e. being Catholic) over the same period. Interestingly, the correlation in locus-of-control tendencies over time resembles those in self-reported health, especially for the younger and middle-aged groups (up to age 50). It is larger than the period-to-period correlation in life satisfaction, but smaller than that in household income and substantially smaller than the correlation in religious affiliation.<sup>15</sup> We also

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<sup>14</sup>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.

<sup>15</sup>Results are presented for having a Catholic affiliation, however similar results are obtained for both Islamic and Jewish affiliations.

find particularly high medium-run correlations for three of the five Big-Five personality traits (extraversion, conscientiousness, and openness to experience) suggesting that these traits may exhibit even greater stability over time than does locus of control.

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.

## **5.2 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 labor market outcomes. As discussed in Section 3, 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 (see eq. (10)). 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 (see Section 2). 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 (e.g. major improvement of finances) and negative (e.g. death of a family member) life events that individuals may experience. While some of these events are under individuals' control, others are not (see Table 3). As these events are uncommon in the short run, we restrict this analysis to medium-run changes in locus of control.

**[Insert Table 3 here]**

### 5.2.1 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 3 between 2004 and 2007. A similar total is created for the eight positive life events listed in the lower panel of Table 3. 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 A.1). Over 60 percent of our sample did not report any positive events at all, whereas only 25 percent failed to report any negative event. Although the average number of events experienced differs by gender (see p-values from tests of equal means reported in Table A1), there is no systematic difference in the overall distribution of the life events experienced by men versus women.<sup>16</sup>

Figures 4(a) and 4(b) plot the estimates (and 95 percent 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.

**[Insert Figure 4 here]**

We find that the average change in locus-of-control tendencies between 2004 and 2007 is essentially 0 for all individuals experiencing nine or fewer negative life events. Due to small sample sizes, the results become less precisely estimated (i.e. the 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 0 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.

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<sup>16</sup>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 provided upon request.

Given our interest in normative changes in non-cognitive skills as people age, we repeat the above exercise for different age groups. Specifically, Figures 4(c) to 4(h) present bivariate kernel regression estimates of the link between locus-of-control change and negative life events for individuals (i) less than age 25; (ii) age 25 - 59; and (iii) age 60+. Due to small sample sizes, we restrict the analysis to those individuals reporting 9 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 approximately 4 - 5 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 5(a) and 5(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, child-birth, or promotions at the work place (see Figure 5(f)).<sup>17</sup> 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.<sup>18</sup>

**[Insert Figure 5 here]**

### 5.2.2 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

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<sup>17</sup>Unfortunately, we cannot estimate these relationships for the older population (age 60+) as they experience very few of the positive life events considered.

<sup>18</sup>We performed a similar descriptive analysis for changes between 2005 and 2009 in the Big-Five personality traits and obtained similar results.

(see Sections 5.1 and 5.2.1). 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:

$$\Delta LOC_{i,07/03}^j = X_{i,03}^j \beta^j + S_{i,07/04}^j \gamma^j + \varepsilon_i^j, \quad (12)$$

where  $j$  indexes life events and  $\Delta LOC_{i,07/03}^j$  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  $X_{i,03}^j$  comprises control variables (indicators for age-groups, marital status, immigrant status, employment status, and educational qualifications as well as household income) measured in 2003.<sup>19</sup> Moreover,  $S_{i,07/04}^j$  is an 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 eq. (12) separately for each of 11 negative and eight positive life events listed in Table 3 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 6(a) (men) and 6(b) (women) graphically display the results (OLS coefficients and 95 percent 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 standardize 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.<sup>20</sup>

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<sup>19</sup>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 labor force, and completed Year 11 or less, respectively. Complete regression results are available upon request.

<sup>20</sup>We tested our estimation models for normality, heteroskedasticity, omitted variable bias (RESET test) and functional form (Hosmer-Lemeshow-Test). Each model passed all tests except for a test for homoskedasticity. 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 so we report the results from a linear OLS regression for simplicity.



[Insert Figure 6 here]

We find that men who experience the birth of a child, the 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.<sup>21</sup>

Overall, it is important to note several things about the results in Figure 6. First, the events that individuals experience have little predictive power in explaining the changes in their locus of control. Many important life events (e.g. death of a spouse, retirement, being a crime victim) appear to have no significant effect at all and 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, labor 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. In particular, negative life events are related to individuals becoming more external, while positive life events (with the exception of pregnancy and child birth) 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, e.g. the 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, e.g., pregnancy, child birth, and ones 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

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<sup>21</sup>The following life events are (almost) significant at the 10 percent 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.

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, i.e. 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: (i) Family-related life events (death of a spouse, child, relative, or friend; being a victim of property crime); (ii) Employment/income-related life events (worsening of finances; retiring; being fired; or episodes of unemployment); and (iii) Health-related life events (serious illness or injury; being a victim of physical violence; 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 (12) is re-estimated sequentially using these nine indicator variables as a measure of  $S_{i,07/04}^j$ , where  $j \in \{1, \dots, 9\}$ . The results (OLS coefficients and 95 percent confidence intervals) are graphically displayed Figure 7(a).

**[Insert Figures 7(a) and 7(b) here]**

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 their outlook. In particular, they increase their locus-of-control index by almost 3 points (0.39 standard deviations) on a scale of -34 to 30. It is important to note, however, that this effect is rather modest. Moreover, it is rare to experience such intense labor market disadvantage: only 23 women (0.5 percent 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); and (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 equation (12) sequentially using these five indicator variables as a measure of  $S_{i,07/04}^j$ . Figure 7(b) presents the results for both men and women.

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 are 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 3 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,<sup>22</sup> but the group of individuals who experience persistent life events and increase their external control tendencies by more than 3 SD is extremely small, i.e. less than one percent of our estimation sample.

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<sup>22</sup>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.

### 5.3 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. Are the changes in individuals' locus of control identified above economically meaningful? We shed light on this question 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 summarize a multitude of labor market processes.

Table 4 summarizes 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 percent) and women (up to 10 percent). In Table 5 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.

**[Insert Tables 4 and 5 here]**

Women who experience a series of employment shocks that are greater than 3 sample standard deviations increase their external control tendencies by an equivalent of a 3.9 percent decrease in average hourly wages (approximately €1.17). Men, on the other hand, who lost at least two immediate family members between 2004 and 2007 have an increase in their internal control tendencies that is equivalent to a 2.7 percent increase – rather than decrease – in average hourly wages (approximately €1).<sup>23</sup> This latter result is surprising and is not easily explained by the previous psychological evidence. These sequence of events are associated with the largest locus-of-control changes observed in our sample. However, it is important to note also 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, reporting more common life events, such as a worsening of finances between 2004 and 2007 is associated with an increase in external

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<sup>23</sup>Average hourly wages for men in GSOEP in 2010 were €38.50 and for women €31.10.

control tendencies that is equivalent to an increase in average hourly wages of 1.3 percent. This translates into a fall in hourly wages of less than €0.50 for both men and women.

#### 5.4 What is the magnitude of the attenuation bias?

Data availability and/or concerns about potential reverse causality often lead economists to use lagged (and occasionally lead) measures of non-cognitive skills as a proxy for concurrent non-cognitive-skill endowments. As Almlund et al. (2011) note, however, this results in an errors-in-variables problem if non-cognitive skills do in fact change over time (see Section 3). In this section, we use our HILDA data to quantify the extent of attenuation bias that results when a lagged measure of locus of control reflects the true measure only with error. To place these results into context, we again focus specifically on the wage returns to locus of control.

Specifically, we construct the theoretical reliability parameter  $\lambda$  (see eq. (4)) resulting from the use of lagged data to proxy current locus of control. Our maintained assumption is 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.<sup>24</sup> The measurement error ( $v_{it}$ ) is then given by  $v_{it} = LOC_{it-k} - LOC_{it}$  (see eq. (2)). The subscript  $t$  refers to locus of control measured in the current year (either 2007 or 2004) and  $t - k$  refers to a previous year (2003). Figures 2(a) and 2(b) show the distribution of the measurement error in our data.

The direction of the attenuation bias can only be calculated without ambiguity in bivariate models (see Section 3). 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 to 39, 40 to 49, 50 to 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 on the variables of interest.<sup>25</sup>

In columns (1) and (2) of Table 6, we present the estimated reliability statistic ( $\hat{\lambda}_1$ ) and its standard error under the assumption that our measurement error is classical (see

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<sup>24</sup>We repeated the same analysis for using lead data as proxy for contemporaneous locus of control. However, the results are almost identical to using lagged data, due to the fact that the formula used to calculate the bias is based on the variance of a difference that will always be positive.

<sup>25</sup>We use bootstrap methods with 200 iterations to obtain standard errors for  $\hat{\lambda}$  (Mooney and Duval, 1993).

eq. (4)). The corresponding reliability statistic ( $\hat{\lambda}_2$ ) and standard error for the case of general measurement error (see eq. (5)) are presented in columns (3) and (4). Finally, columns (5) and (6) report the ‘true’ log hourly wage penalty resulting from a one standard deviation increase in external locus-of-control tendencies. The attenuation bias associated with estimating this wage penalty using lagged locus of control is the product of the true wage effect and  $\hat{\lambda}_1$  or  $\hat{\lambda}_2$ , depending on the underlying assumption about the nature of the measurement error. Thus, the greater are  $\hat{\lambda}_1$  and  $\hat{\lambda}_2$ , the smaller is the corresponding bias.

**[Insert Table 6 here]**

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 slightly 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). Even though the reliability parameters are slightly greater for both men and women when considering shorter time spans between the “true” and “proxied” measure of locus of control (see lower panel of Table 6), these differences are within the margin of error. Overall, our results imply that the “true” wage return to locus of control is almost twice as high as estimated.<sup>26</sup>

We can also put these results into context by comparing them to a range of studies which attempt 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 lagged locus of control as a proxy for current locus of control appears to be much lower than the reliability estimates reported in Bound and Krueger (1991) and Kapteyn and Ypma (2007). For instance, the reliability of CPS data as a proxy for Social Security Earnings data is around 0.80 for men (see Bound and Krueger, 1991, Table 6). The authors judge these reliability figures to be reasonably high. 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)

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<sup>26</sup>Consistent with this, in related work we use lagged non-cognitive skill measures as instrumental variables and find the estimated wage returns are approximately twice as large as those generated when we use OLS.

to be 0.7 (0.735). However, survey data on pension payments appear to be less reliable (0.363) resulting in large potential biases (see Kapteyn and Ypma, 2007, Table 5).

## 6 Conclusions

The increasing availability of standard psychological items in the large-scale, nationally-representative panel surveys that economists often analyze has allowed us to make tremendous progress in understanding the links between non-cognitive skills and economic behavior. 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, labor market, and health events unfold. By carefully analyzing the change over time in individuals' locus of control, this paper makes an important contribution to improving our understanding of the stability of non-cognitive skills more generally.

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, labor 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 imply that major life events are associated with no more 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 strong evidence to suggest that the errors-in-variables problem results in a substantial attenuation bias when estimating the wage returns to locus of control.

What estimation strategies should be adopted then when incorporating non-cognitive skills like locus of control into empirical analyzes of economic behavior? First, the fact that locus of control appears to be stable – but not time-invariant – implies that researchers will not be able to solely rely 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 (see Heineck and Anger, 2010), and it may be useful to restrict analyzes to the working-age population for whom changes in non-cognitive skills are particularly small. Finally, and perhaps most importantly, researchers need to employ estimation strategies that can account for the potential error in the skill measures they employ.

While our analysis of the stability of locus of control has been very important in allowing us to draw conclusions about the potential biases facing applied researchers, we are nonetheless left with a number of unresolved issues. In particular, it would be useful to know more about the stability of other non-cognitive skills like personality traits, self-esteem, risk tolerance, emotional intelligence, etc. Our preliminary investigation of the Big Five personality traits suggests that these traits may be even more stable than locus of control and we can only speculate about the extent to which that applies to other important non-cognitive skills. Moreover, we use a simple wage example to provide a benchmark for the economic (as opposed to statistical) significance of our results and to quantify the extent of attenuation bias. We need to extend these results to other contexts, for example educational attainment, occupational choice, and cognitive skill development, in order to understand the extent to which we can generalize.

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.

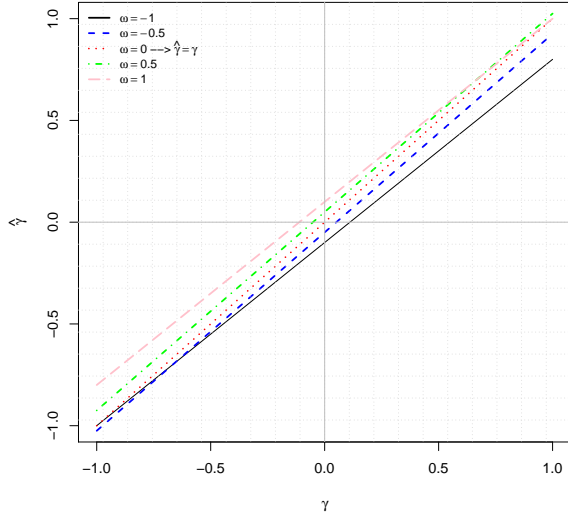


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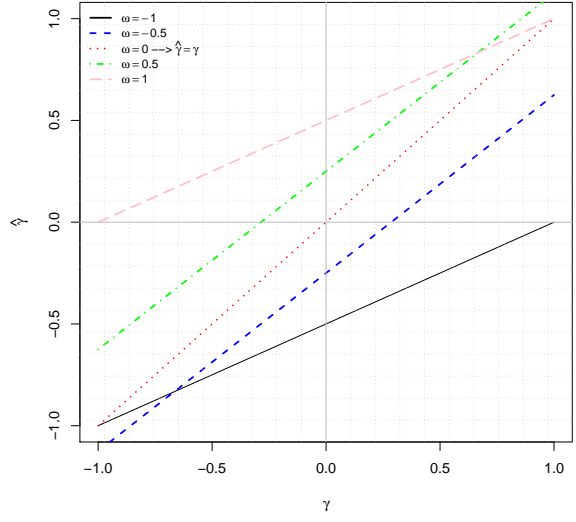
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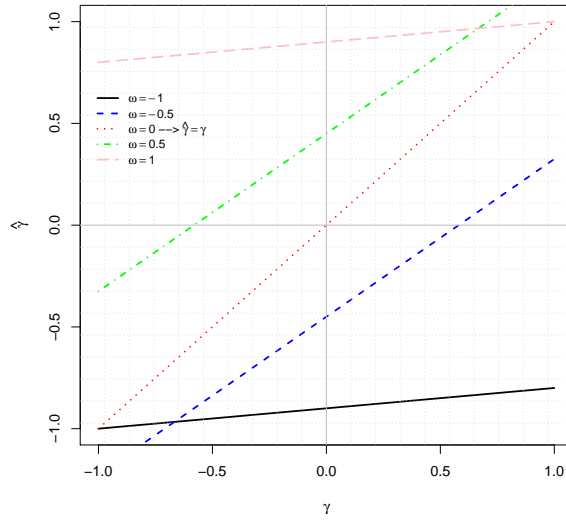
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(a) N-T-S Ratio = 0.1



(b) N-T-S Ratio = 0.5



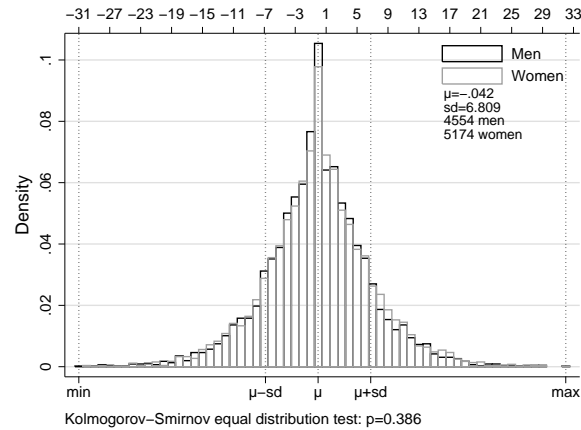
(c) N-T-S Ratio = 0.9

Figure 1: Theoretical bias in  $\hat{\gamma}$  as a function of Noise-To-Signal (N-T-S) ratio,  $\gamma$  and  $\omega$

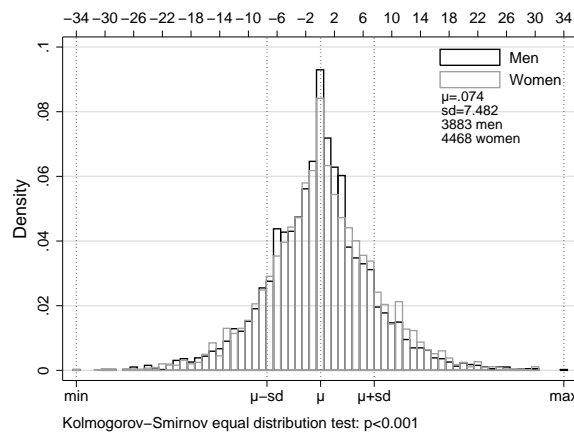
Table 1: Dimensions of locus of control: Number of observations (Proportions)

Question N=33,749	Categories							Mean (SD)
	Strongly disagree	2	3	4	5	6	Strongly agree	
(a) I have little control over the things that happen to me	7701 (22.82)	10204 (30.23)	5423 (16.07)	4765 (14.12)	2958 (8.76)	1679 (4.97)	1019 (3.02)	2.83 (1.61)
(b) There is really no way I can solve some of the problems I have	9214 (27.30)	11343 (33.61)	4718 (13.98)	3297 (9.77)	2359 (6.99)	1649 (4.89)	1169 (3.46)	2.64 (1.63)
(c) There is little I can do to change many of the important things in my life	8876 (26.30)	11139 (33.01)	4922 (14.58)	3684 (10.92)	2439 (7.23)	1633 (4.84)	1056 (3.13)	2.67 (1.61)
(d) I often feel helpless in dealing with the problems of life	9662 (28.63)	10897 (32.29)	4704 (13.94)	3629 (10.75)	2397 (7.10)	1585 (4.70)	875 (2.59)	2.60 (1.59)
(e) Sometimes I feel that I'm being pushed around in life	9777 (28.97)	9992 (29.61)	4768 (14.13)	3840 (11.38)	2812 (8.33)	1640 (4.86)	920 (2.73)	2.66 (1.63)
(f) What happens to me in the future mostly depends on me	1229 (3.64)	1313 (3.89)	1447 (4.29)	2895 (8.58)	4903 (14.53)	11111 (32.92)	10851 (32.15)	5.54 (1.59)
(g) I can do just about anything I really set my mind to do	925 (2.74)	1238 (3.67)	1934 (5.73)	4508 (13.36)	7012 (20.78)	10026 (29.71)	8106 (24.02)	5.31 (1.51)

Data Source: HILDA 2003, 2004, 2007. Self-completion Questionnaire (SCQ), Question B10.

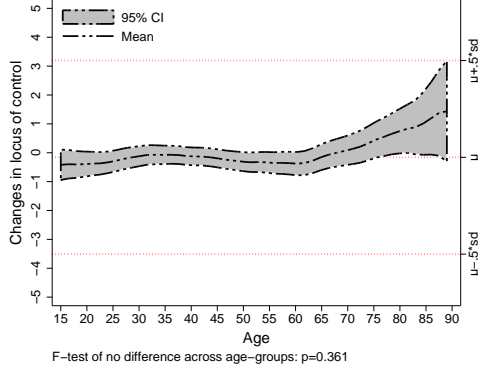


(a) Short-run (2003-2004)

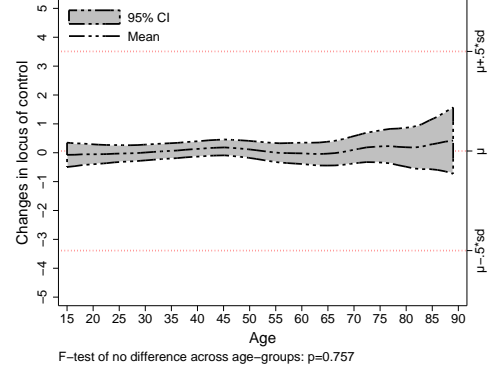


(b) Medium-run (2003-2007)

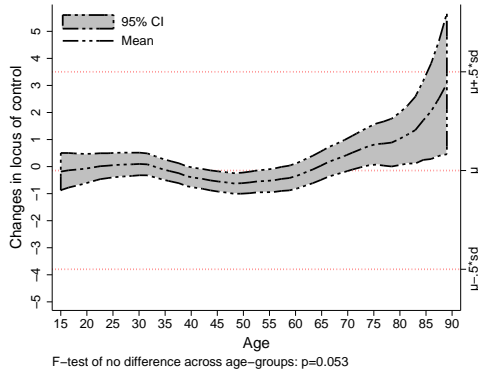
Figure 2: Distribution of changes in locus of control by gender (HILDA 2003, 2004, 2007)



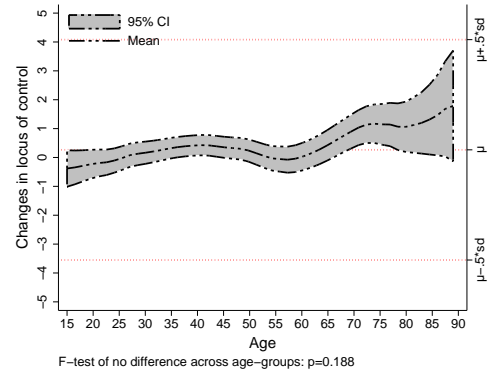
(a) Men 2003-2004



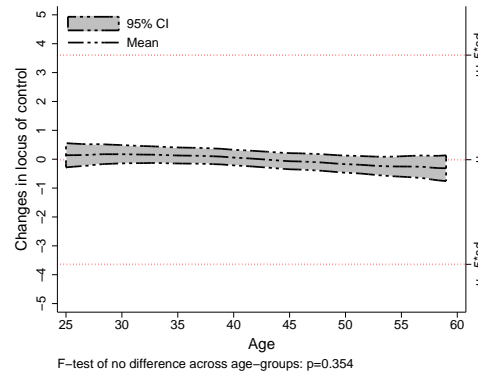
(b) Women 2003-2004



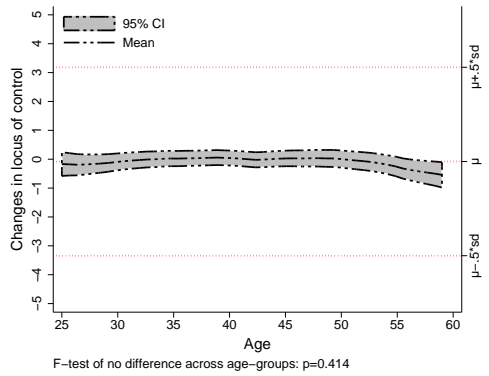
(c) Men 2003-2007



(d) Women 2003-2007



(e) Men and women 2003-2004



(f) Men and women 2003-2007

Figure 3: Changes in locus of control over the life-cycle in the short (2003-2004) and medium run (2003-2007)

Table 2: Correlation coefficients by age-groups

<i>Short-run (2003-2004)</i>										
	LOC	Extrav	Agree	Consc	Emote	Open	Income	Life sat	Health	Cath <sup>a</sup>
Average	0.605						0.815	0.548	0.708	
15 to 19	0.524						0.414	0.493	0.029	
20 to 24	0.631						0.729	0.499	0.578	
25 to 29	0.622						0.667	0.493	0.608	
30 to 39	0.614						0.708	0.544	0.659	
40 to 49	0.647						0.758	0.565	0.703	
50 to 59	0.640						0.864	0.593	0.750	
60 to 69	0.570						0.981	0.560	0.745	
70 to 79	0.531						0.814	0.536	0.759	
80 +	0.508						0.852	0.492	0.717	
p-value	0.000						0.000	0.000	0.000	
<i>Medium-run: 2003-2007 locus of control, 2005-2009 Big-Five personality, 2004-2007 Catholic</i>										
	LOC	Extrav	Agree	Consc	Emote	Open	Income	Life sat	Health	Cath <sup>a</sup>
Average	0.517	0.735	0.573	0.671	0.600	0.708	0.876	0.431	0.625	0.911
15 to 19	0.371	0.595	0.466	0.494	0.515	0.600	0.450	0.304		0.741
20 to 24	0.536	0.647	0.511	0.535	0.508	0.638	0.537	0.381	0.202	0.847
25 to 29	0.496	0.715	0.580	0.628	0.559	0.675	0.375	0.355	0.468	0.890
30 to 39	0.515	0.794	0.602	0.676	0.567	0.712	0.805	0.407	0.557	0.907
40 to 49	0.545	0.778	0.616	0.727	0.641	0.756	0.933	0.446	0.609	0.906
50 to 59	0.562	0.745	0.607	0.713	0.630	0.757	0.856	0.491	0.663	0.944
60 to 69	0.507	0.733	0.559	0.706	0.649	0.708	1.200	0.434	0.643	0.961
70 to 79	0.521	0.667	0.520	0.661	0.610	0.623	0.718	0.420	0.723	0.956
80 +	0.343	0.593	0.515	0.567	0.499	0.668	0.885	0.404	0.631	0.956
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Note: Correlation coefficients are obtained from OLS regression, controlling for gender and age-groups.

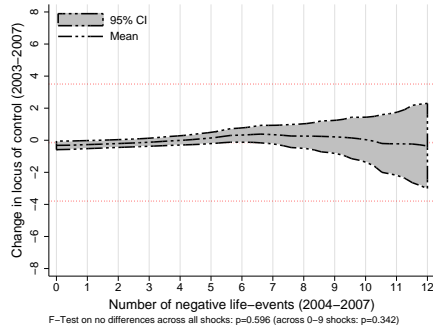
a: Data on Catholic affiliation are taken from Waves 4 and 7. Similar results hold for other religions.

Table 3: Negative and positive life events

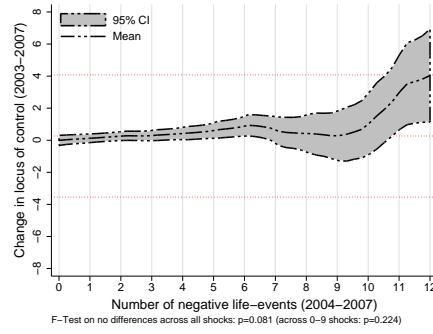
Questions	
Negative life events	Serious personal illness or injury Serious personal illness to family member Death of spouse or child Death of close family member or relative Death of a close friend Victim of physical violence Victim of property crime Detained in jail (dropped due to insufficient number 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

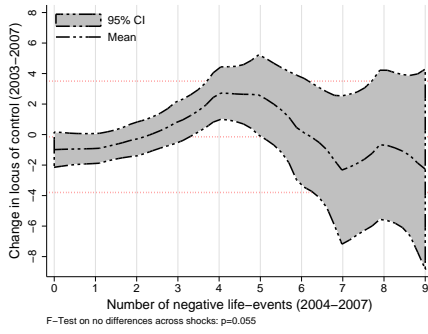
Life-event data is available from Wave 2 (2002) onwards



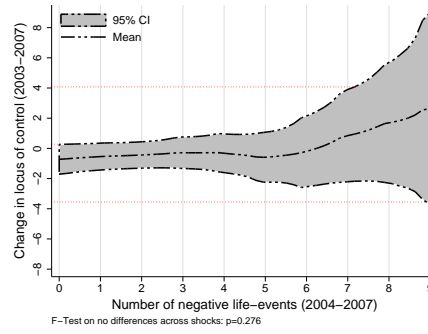
(a) Men



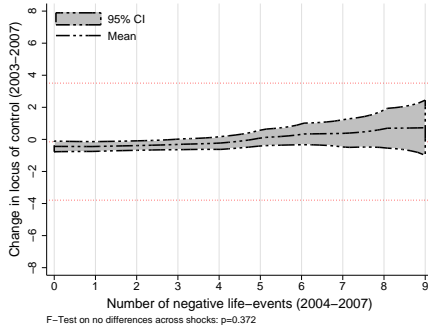
(b) Women



(c) Men 15 to 24



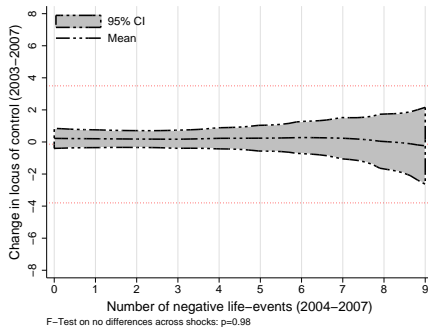
(d) Women 15 to 24



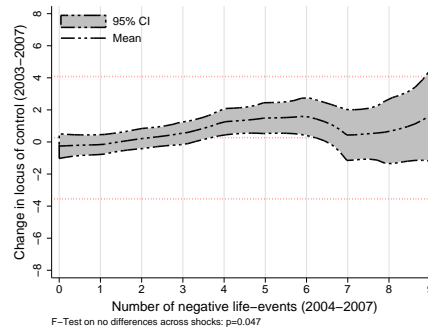
(e) Men 25 to 59



(f) Women 25 to 59



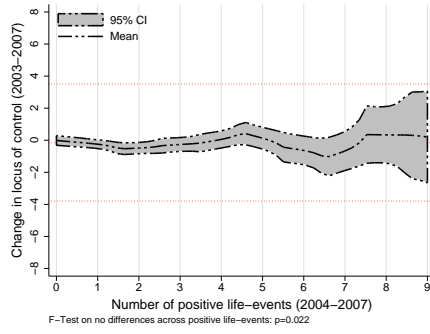
(g) Men 60 +



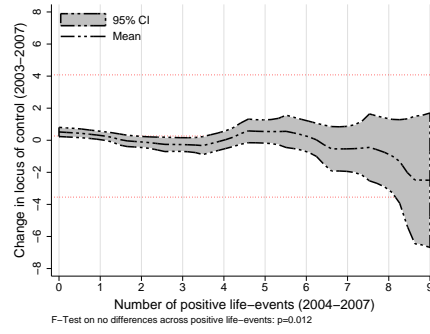
(h) Women 60 +

Figure 4: Association between negative life events and changes in locus of control, by gender (HILDA 2003-2007)

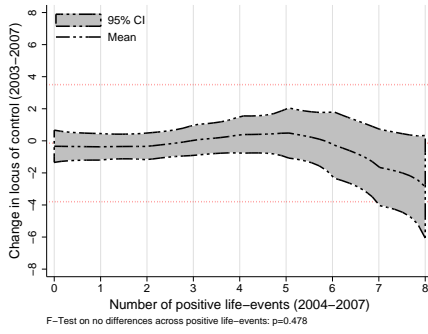




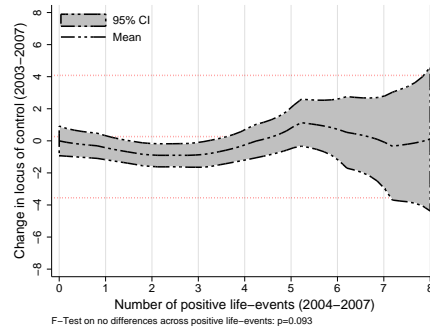
(a) Men



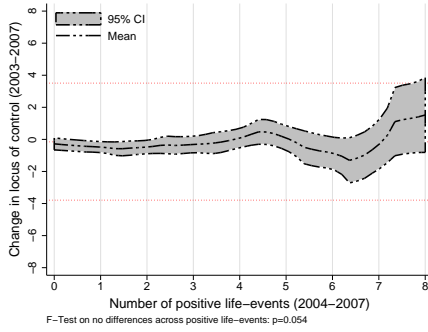
(b) Women



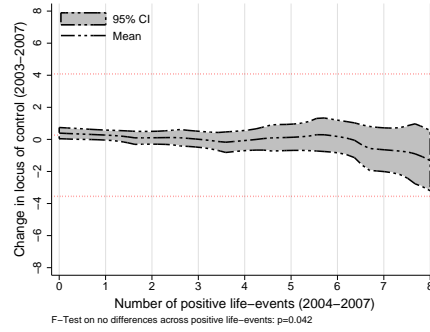
(c) Men 15 to 24



(d) Women 15 to 24

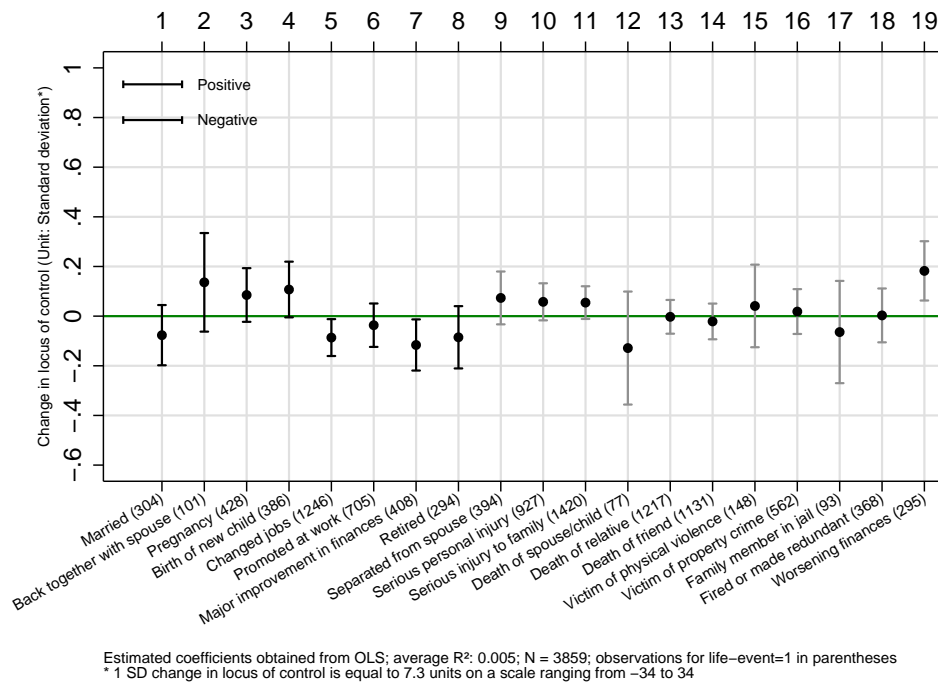


(e) Men 25 to 59

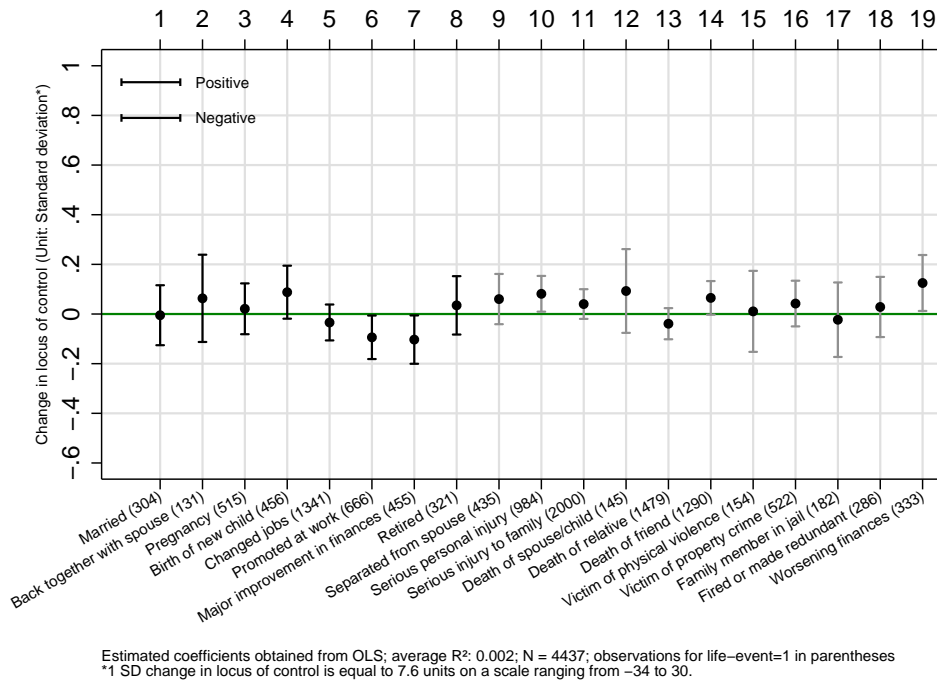


(f) Women 25 to 59

Figure 5: Association between positive life events and changes in locus of control, by gender and age (HILDA 2003-2007)

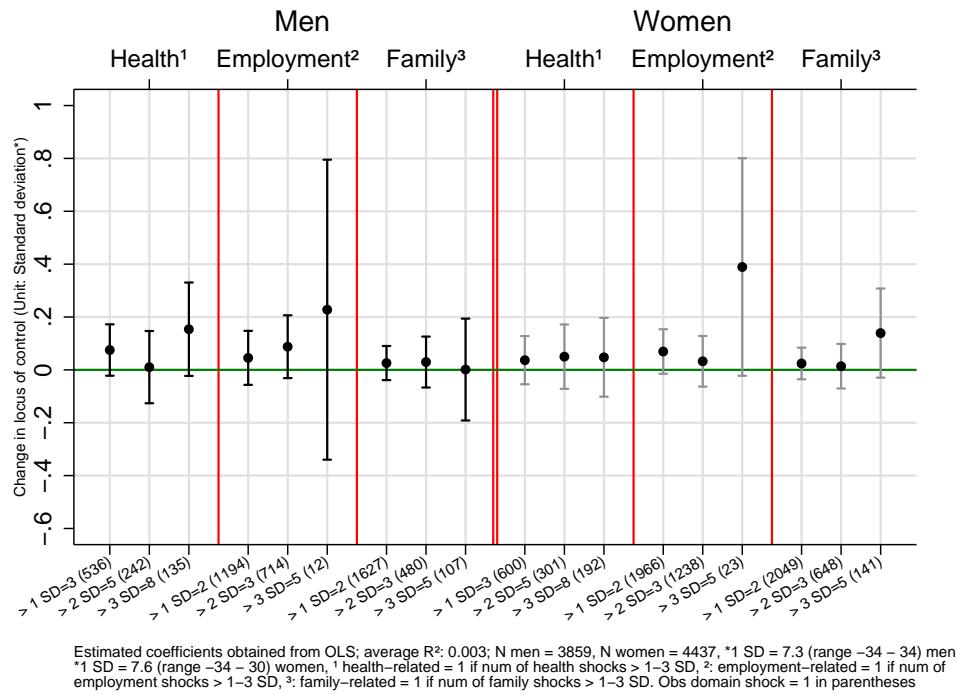


(a) Men

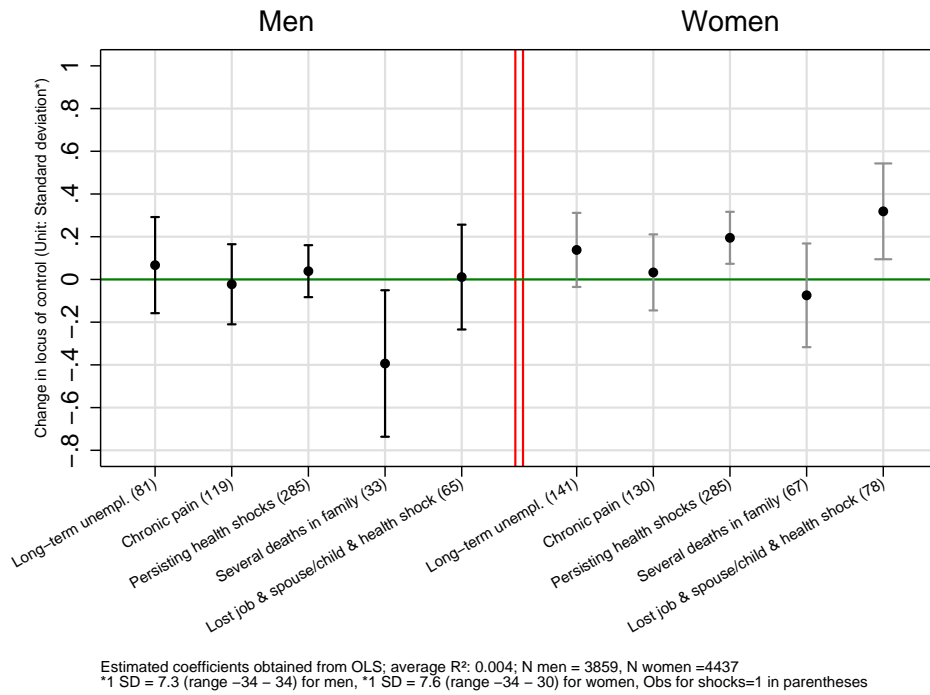


(b) Women

Figure 6: Effect of individual life-events on changes on external control tendencies (OLS)



(a) Domain-specific shocks



(b) Chronic shocks

Figure 7: Relationship between intensity of shocks and changes in external control tendencies (OLS)

Table 4: Estimated wage effects of locus of control

Study	Data	Elasticity	Locus of control measured
Heineck and Anger (2010)	GSOEP <sup>a</sup>	Men: 7% Women: 4-10%	in 2005, earnings in 1991-2005
Cebi (2007)	NLSY <sup>b</sup>	Men: 2.1%	in 1979, earnings in 1979-82
Osborne Groves (2005)	NLSYW <sup>c</sup>	Women 5-7%	in 1970/1988, earnings in 1991-93
Andrisani (1977)	NLS <sup>d</sup>	Young men: 7.5% Middle-aged men: 5%	in same year as earnings
Semykina and Linz (2007)	3 surveys on Russian employees	Women: 6.4% Men: 4.6%	in same year as earnings

Note: a German Socio-Economic Panel, b National Longitudinal Survey of Youth,  
c National Longitudinal Survey of Youth Women sample, d National Longitudinal Survey

Table 5: Wage equivalent of changes in locus of control

Men	Worsening Finances	Health Shocks > 3 SD	Employment Shocks > 3 SD	Several Deaths (in family)
Changes in locus of control (Proportion of SD)	0.18	0.15	0.23	-0.39
Percent change <sup>a</sup>	-1.26	-1.08	-1.61	+2.73
Implied change in wage (in €) <sup>b</sup>	-0.49	-0.42	-0.62	+1.05
N	295	135	12	33
Women	Worsening Finances	Persisting Health Shocks ≥ 2	Employment Shocks > 3 SD	Death spouse/child & Health shock & Fired from job (worsening finances)
Changes in locus of control (Proportion of SD)	0.13	0.20	0.39	0.32
Percent change <sup>c</sup>	-1.3	-2.0	-3.9	-3.2
Implied change in wage (in €) <sup>d</sup>	-0.39	-0.60	-1.17	-0.96
N	333	285	23	78

a: Wage elasticity from Heineck and Anger (2010) is 7%; b: Avg hourly wage (>0) in GSOEP in 2010: €38.5

c: Wage elasticity from Heineck and Anger (2010) is 10%; d: Avg hourly wage (>0) in GSOEP in 2010: €30.1

Table 6: Estimated reliability parameters and wage effects

Samples separated by gender, age, education	$\hat{\lambda}_1^a$ CME	SE	$\hat{\lambda}_2^b$ GME	SE	Wage <sup>e</sup> effect	SE	N
<b>True locus of control in 2007, mismeasured by using a proxy from 2003</b>							
<b>Men</b>							
Average	0.540	0.012	0.572	0.021	-0.050	0.010	1926
<i>Without any university degree</i>							
25-39	0.517	0.021	0.540	0.044	-0.046	0.017	535
40-49	0.531	0.024	0.540	0.046	-0.054	0.021	392
50-59	0.558	0.031	0.601	0.052	-0.044	0.024	264
<i>With a university degree</i>							
25-39	0.570	0.037	0.610	0.048	-0.001	0.023	332
40-49	0.507	0.034	0.512	0.060	-0.048	0.028	212
50-59	0.614	0.040	0.712	0.057	-0.064	0.033	191
<b>Women</b>							
Average	0.530	0.012	0.561	0.020	-0.047	0.010	2027
<i>Without any university degree</i>							
25-39	0.555	0.026	0.612	0.046	-0.020	0.020	400
40-49	0.515	0.026	0.533	0.048	-0.036	0.016	373
50-59	0.545	0.031	0.566	0.048	-0.049	0.025	309
<i>With a university degree</i>							
25-39	0.492	0.025	0.509	0.048	-0.026	0.020	443
40-49	0.542	0.029	0.562	0.049	-0.071	0.024	311
50-59	0.532	0.034	0.568	0.067	-0.042	0.028	191
<b>True locus of control in 2004, mismeasured by using a proxy from 2003</b>							
<b>Men</b>							
Men	0.548	0.012	0.582	0.019	-0.050	0.010	2063
<i>Without any university degree</i>							
25-39	0.541	0.021	0.563	0.036	-0.059	0.015	590
40-49	0.621	0.026	0.663	0.036	-0.055	0.020	423
50-59	0.531	0.026	0.546	0.052	0.005	0.028	257
<i>With a university degree</i>							
25-39	0.482	0.028	0.498	0.052	-0.036	0.021	363
40-49	0.568	0.035	0.635	0.051	-0.058	0.028	267
50-59	0.510	0.051	0.509	0.069	-0.045	0.040	163
<b>Women</b>							
Average	.560	0.012	0.608	0.019	-0.044	0.009	2016
<i>Without any university degree</i>							
25-39	0.539	0.025	0.560	0.044	-0.028	0.018	416
40-49	0.569	0.024	0.634	0.042	-0.045	0.017	404
50-59	0.549	0.033	0.597	0.049	-0.042	0.025	288
<i>With a university degree</i>							
25-39	0.576	0.024	0.608	0.039	-0.017	0.018	449
40-49	0.572	0.028	0.609	0.045	-0.057	0.021	307
50-59	0.557	0.043	0.613	0.070	-0.036	0.031	152

Note: a  $\hat{\lambda}_1$  measures the reliability parameter estimate under classical measurement error.

b  $\hat{\lambda}_2$  measures the reliability parameter estimate under general measurement error.

c Wage effects measured in percentage change due to a 1 SD change in locus of control.

Table A.1: Descriptive statistics of variables used in analysis for estimation samples<sup>a</sup>

Variable	Sample of men					Sample of women					Diff
	mean	SD	min	max	N	mean	SD	min	max	N	p-val <sup>b</sup>
Full index locus of control	18.28	7.55	7	49	3859	18.52	7.76	7	49	4435	0.148
Change in locus of control score (2003 - 2004)	-0.26	6.61	-30	32	3586	0.02	6.86	-30	29	4152	0.075
Change in locus of control score (2003 - 2007)	-0.13	7.29	-34	34	3859	0.26	7.64	-34	30	4435	0.017
<i>Life events that occurred between 2004-2007</i>											
Got married	0.03	0.16	0	1	3827	0.02	0.15	0	1	4406	0.323
Separated from spouse	0.04	0.19	0	1	3820	0.04	0.2	0	1	4388	0.208
Got back together with spouse	0.01	0.1	0	1	3823	0.01	0.11	0	1	4391	0.449
Pregnancy	0.05	0.22	0	1	3826	0.06	0.23	0	1	4398	0.178
Birth/adoption of new child	0.04	0.19	0	1	3822	0.04	0.19	0	1	4394	0.924
Serious personal injury/illness	0.09	0.28	0	1	3827	0.08	0.27	0	1	4395	0.073
Serious injury/illness to family member	0.16	0.37	0	1	3822	0.2	0.4	0	1	4396	0.000
Death of spouse or child	0.01	0.08	0	1	3824	0.01	0.1	0	1	4393	0.031
Death of close relative/family member	0.1	0.31	0	1	3825	0.11	0.31	0	1	4393	0.873
Death of a close friend	0.1	0.31	0	1	3824	0.11	0.31	0	1	4392	0.290
Victim of physical violence	0.02	0.13	0	1	3821	0.02	0.13	0	1	4395	0.451
Victim of a property crime	0.07	0.25	0	1	3826	0.06	0.23	0	1	4401	0.071
Detained in jail	0	0.04	0	1	3827	0	0.02	0	1	4399	0.060
Close family member detained in jail	0.01	0.09	0	1	3826	0.02	0.12	0	1	4401	0.001
Retired from the workforce	0.03	0.17	0	1	3825	0.02	0.15	0	1	4403	0.163
Fired or made redundant	0.04	0.19	0	1	3823	0.02	0.15	0	1	4399	0.000
Changed jobs	0.15	0.35	0	1	3822	0.12	0.32	0	1	4397	0.000
Promoted at work	0.07	0.26	0	1	3819	0.05	0.22	0	1	4386	0.000
Major improvement in finances	0.04	0.19	0	1	3827	0.04	0.19	0	1	4397	0.886
Major worsening in finances	0.03	0.17	0	1	3826	0.03	0.18	0	1	4401	0.809
Sum of all negative shocks	2.19	2.1	0	17	3859	2.32	2.2	0	19	4435	0.007
Sum of all positive shocks	1.4	1.77	0	11	3859	1.31	1.65	0	10	4435	0.016
Total number of new health conditions or health shocks	1.14	2.48	0	30	3859	1.16	2.66	0	26	4435	0.711
Total number of income related shocks between	1.2	1.62	0	7	3858	1.68	1.75	0	7	4435	0.000
Total number of shocks regarding family life	1.56	1.62	0	12	3856	1.73	1.71	0	13	4434	0.000
Health-related shock > 3 SD	0.03	0.18	0	1	3859	0.04	0.2	0	1	4435	0.066
Employment-related shock > 3 SD	0	0.06	0	1	3859	0	0.07	0	1	4435	0.241
Family-related shock > 3 SD	0.03	0.16	0	1	3859	0.03	0.17	0	1	4435	0.333
Health-related shock > 3 SD	0.06	0.24	0	1	3859	0.07	0.25	0	1	4435	0.387
Employment-related shock > 3 SD	0.19	0.39	0	1	3859	0.28	0.45	0	1	4435	0.000
Family-related shock > 2 SD	0.12	0.33	0	1	3859	0.15	0.35	0	1	4435	0.005
Health-related shock > 1 SD	0.14	0.35	0	1	3859	0.13	0.34	0	1	4435	0.591
Employment-related shock > 1 SD	0.31	0.46	0	1	3859	0.44	0.5	0	1	4435	0.000
Family-related shock > 1 SD	0.42	0.49	0	1	3859	0.46	0.5	0	1	4435	0.000
At least three times unemployed	0.02	0.14	0	1	3826	0.03	0.18	0	1	4401	0.002
In chronic pain in all years	0.03	0.17	0	1	3859	0.03	0.17	0	1	4435	0.685
At least two health shocks	0.01	0.11	0	1	3859	0.01	0.12	0	1	4435	0.553
At least two deaths in family	0.07	0.26	0	1	3827	0.06	0.25	0	1	4395	0.087
Lost spouse/child & health shock & lost job	0.01	0.09	0	1	3859	0.02	0.12	0	1	4435	0.006
<i>Other control variables measured in 2003</i>											
Age-group 15 to 19	0.08	0.27	0	1	3859	0.07	0.26	0	1	4435	0.369
Age-group 20 to 24	0.06	0.24	0	1	3859	0.06	0.23	0	1	4435	0.387
Age-group 25 to 29	0.07	0.25	0	1	3859	0.08	0.27	0	1	4435	0.058
Age-group 30 to 39	0.19	0.39	0	1	3859	0.2	0.4	0	1	4435	0.525
Age-group 40 to 49	0.22	0.42	0	1	3859	0.22	0.42	0	1	4435	0.793
Age-group 50 to 59	0.17	0.38	0	1	3859	0.17	0.37	0	1	4435	0.406
Age-group 60 to 69	0.12	0.33	0	1	3859	0.11	0.32	0	1	4435	0.174
Age-group 70 to 79	0.07	0.26	0	1	3859	0.07	0.26	0	1	4435	0.998
Age-group 80 and older	0.01	0.1	0	1	3859	0.02	0.13	0	1	4435	0.006
Married or de facto	0.57	0.49	0	1	3859	0.54	0.5	0	1	4435	0.001
Separated or divorced	0.03	0.16	0	1	3859	0.03	0.18	0	1	4435	0.056
Foreigner	0.22	0.41	0	1	3859	0.21	0.4	0	1	4435	0.246
Full or part-time employed	0.72	0.45	0	1	3859	0.58	0.49	0	1	4435	0.000
Household income (ln)	10.75	0.67	5.3	13.02	3859	10.67	0.70	5.23	13.02	4435	0.000
Postgrad - masters or doctorate	0.04	0.19	0	1	3859	0.03	0.16	0	1	4435	0.002
Grad diploma, grad certificate	0.05	0.21	0	1	3859	0.06	0.23	0	1	4435	0.019
Bachelor or honours	0.12	0.32	0	1	3859	0.13	0.34	0	1	4435	0.033
Adv diploma, diploma	0.09	0.29	0	1	3859	0.09	0.28	0	1	4435	0.159
Any certificate	0.28	0.45	0	1	3859	0.14	0.34	0	1	4435	0.000
Year 12	0.13	0.33	0	1	3859	0.15	0.36	0	1	4435	0.001
Year 11 and below	0.3	0.46	0	1	3859	0.41	0.49	0	1	4435	0.000

Note: a Number of observations vary between the regression models. Numbers presented here refer to samples from Figures 7(a) and 7(b).

b p-val refers to a t-test of differences in mean between men and women.