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The relationship between innovation and subjective wellbeing

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ARTICLE INFO

Article history:

Received 8 September 2009

Received in revised form 6 March 2012

Accepted 4 April 2012

Available online 10 May 2012

Keywords:

Innovation

Creativity

Subjective wellbeing

ABSTRACT

Innovation should improve people's lives. The links made between innovation and subjective wellbeing (SWB) have, however, rarely been made. We use a representative survey of the British population and new primary data to explore the relationship between innovation and SWB. We show that creativity and SWB are correlated. This applies to questions related to self-reported creativity and for working in creative environments. More research is needed to determine the relative effects of each direction of causality in the relationship between innovation and SWB in the workplace and in life generally.

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1. Introduction

One of the key questions for academics and policy-makers is how best to measure and value the impact of innovation, defined here broadly as “*the successful exploitation of new ideas*” (NESTA, 2008). To date, much of the measurement of innovation has focussed quite narrowly on the inputs to innovation. The Advisory Committee on Measuring Innovation in the 21st Century Economy (2008, p. 17) recognises that “*more work needs to be done to define appropriate outcome measures and analyze their utility and effectiveness*”. The traditional measures of innovation have been expenditure inputs (e.g. investment in R&D as a percentage of GNP; see targets set by European Commission, 2002) yet such measures do not capture the impact of the innovation process on outcomes (Coombs et al., 1996, Morlacchi and Martin, 2009). The main aim of this paper is to consider whether and how the consequences of innovation could be measured and valued in terms of subjective wellbeing (SWB) and, additionally, whether SWB is important to innovation.

There are three main accounts of wellbeing: objective lists, preference satisfaction and mental states (Parfit, 1984). Objective list accounts, favoured by many philosophers, argue that wellbeing is highest when a person meets his material, social and psychological needs (e.g. Sen, 1999). So, innovation would be incorporated into this account of wellbeing through its impact on health, education, income etc. Preference satisfaction accounts, favoured by

many economists, argue that an individual's life goes better if she gets more of what she wants (e.g. Harsanyi, 1996). So, innovation in this context is related to people's willingness to pay for innovative goods or the increase in income from innovation that allows them to satisfy more of their preferences. Mental state accounts, favoured by many psychologists, argue that an individual's life goes better if it is experienced more positively by the individual (Diener et al., 1999). So, innovation in this account would be the impact that innovation products, etc. have on people's self-reports of their wellbeing.

There has been considerable debate about the merits of these accounts and we cannot hope to add further to that debate here. What we can say, however, is that mental states are important to individuals and policy-makers and we should like to see the effects of interventions – and innovation – show up in someone's SWB, somewhere and at some point. For instance, the recent Stiglitz et al. (2009) report has suggested that “*it is possible to collect meaningful and reliable data on subjective as well as objective wellbeing. Subjective wellbeing encompasses different aspects (cognitive evaluations of one's life, happiness, satisfaction, positive emotions such as joy and pride, and negative emotions such as pain and worry): each of them should be measured separately to derive a more comprehensive appreciation of people's lives*”.

So we define mental states (or SWB) broadly in terms of assessments of how we think and feel about life (Diener et al., 1999). SWB can be measured by global evaluations of life overall and also by experiences of daily affect (Kahneman and Riis, 2005). The former is an assessment of how well life is going for each individual (Dolan et al., 2008) and the latter is an assessment of affect over a specified duration of time (Kahneman et al., 2004; White and Dolan, 2009; Kahneman and Deaton, 2010). Such SWB measures

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have been validated against neurological evidence (Davidson, 2004), physiological evidence (Steptoe et al., 2005), and a range of behaviours (Lyubomirsky et al., 2005), including suicide (Daly and Wilson, 2009).

Therefore, and without denigrating the other accounts of wellbeing, this paper focuses on wellbeing as mental states. The focus of this paper is on three main relationships that have yet to be analysed in a representative survey of individuals: (i) is there a relationship between innovation and SWB in the general population?; (ii) does any innovation–SWB relationship rely on the measures of innovation and SWB that are used?; and (iii) to what extent are more creative workplaces conducive to higher SWB? We attempt to answer these questions using data obtained within the U.K. these questions are novel from the perspective of the SWB literature, and the innovation literature, and attempts to marry the two literatures together.

In Section 2, we discuss what is already known about the impact that SWB has on innovation and the impact that innovation has on SWB. As might be expected, remarkably little is known about causality in the relationship between innovation and different measures of SWB, especially in a representative population. In Section 3, we discuss our data and methodology that we use to address these gaps in the literature. In Section 4, we discuss our analyses of a secondary dataset (the British Household Panel Survey) and our own primary data that demonstrates how differing measures of SWB are correlated with self-reported innovation and creativity. We certainly need new studies to better understand the causal relationships between innovation and SWB, but this present study demonstrates a strong link between innovation and SWB. We do not know whether there is a causal connection and are not claiming such a thing in this paper. So we need to make better and innovative use of a range of methods, including natural and field experiments to understand the direction of the relationship between SWB and innovation. In Section 5, we provide some examples of where experiments might prove helpful, and we provide some concluding remarks in Section 6.

2. Existing evidence on the relationship between innovation and SWB

2.1. From SWB to innovation

A literature search of EconLit with the words “innovation” and “wellbeing” or “happiness” did not find any studies. Two relevant studies were found when we used the terms “creativity” and “positive affect”. Frederickson (1998) suggests that positive affect increases the scope of attention and the scope of cognition. Isen (1999) suggests that positive affect makes additional cognitive material available for processing and for increasing cognitive flexibility, which further increases the number of cognitive elements available. When positive moods were induced by a stimuli (e.g. gift, music, etc.), individuals who had the stimuli had higher levels of creativity (Isen, 1999). Other experiments with students show similar results (e.g. Isen et al., 1987; Burroughs and Mick, 2004).

The link between positive affect and innovation is not straightforward though. It seems that positive affect increases the consideration of multiple relevant factors in a task (Aspinwall, 1998) but for unpleasant or boring tasks, positive affect does not increase people's creativity more than negative affect (Isen et al., 1985, 1992; Isen, 2000). In terms of risk, it seems that positive affect leads to riskier behaviour when the risk is hypothetical but greater risk aversion when the risk is real (Isen and Geva, 1987; Isen and Patrick, 1983).

There has been one seminal field study by Amabile et al. (2005) using a longitudinal study of 222 employees across seven

companies each day over a 19-week period. They measured positive affect by using six self-report items (Russell, 1980) as well as measuring happiness and satisfaction with each day. They measured daily creativity by self-assessed creative thought and problem-solving and monthly creativity by peer assessment. The results suggest a positive linear relationship between positive affect and creativity (but no opposite relationship with negative affect). Higher positive affect was also found to be a direct consequence of creativity.

This study suggests that SWB precedes creativity, which supports the neurological studies that stipulate that positive moods in conjunction with incubation periods (i.e. sleep) enforce memory and enhanced performance in tasks (Wagner et al., 2004). It also supports the psychological evidence that positive affect is an effective retrieval cue for positive material in memory, but that negative affect is not an effective cue for negative material (Isen et al., 1978; Snyder and White, 1982). The link between SWB, memory, and creativity might not be so straightforward though given that healthy people with low levels of dopamine receptor activity in the brain (associated with mental illness) are more divergent thinkers (de Manzano et al., 2010; see also Chermahini and Hommel, 2010).

Positive affect at work is highly related to overall job satisfaction (Judge and Ilies, 2004), and thus it may be reasonable to assume that creative workplaces would be more pleasant places to work (Bryson et al., 2009, examines this from analysing changing workplaces that are unionised). In general, most research using specific population samples show a positive correlation between positive affect and creativity (Barsade and Gibson, 2007). It has also been found that people who report themselves as being time pressured in work also report themselves as being less creative (Amabile et al., 2002; Huhtala and Parzefall, 2007), although the relationship between pressured at work at negative affect has not been fully explored. There are, of course, potential problems of response bias and acquiescence bias, which would create an erroneously significant correlation between the two measures. In general, there is a lack of evidence on causality, a lack of evidence on using different measures of SWB (most have used general positive affect), and a lack of evidence from representative samples of a population.

2.2. From innovation to SWB

The obvious link from innovation to SWB comes in the form of economic growth. Endogenous growth theories stipulate that the interaction between technology and the structure of the economic system induces economic growth (Grossman and Helpman, 1991; Aghion and Howitt, 1998). So, if innovation has direct effects on economic growth (see Galor and Tsiddon, 1997) and economic growth (or income) has direct effects on SWB (see Frijters et al., 2004; Stevenson and Wolfers, 2008), then innovation may well have causal consequences for SWB. This link relies on measuring the tangible inputs of innovation on economic growth and SWB. There may also be important intangible inputs to innovation that affect economic growth and that also directly impact upon SWB. It is this direct link to SWB that we know very little about.

Since Easterlin (1974), the research examining the role of income on SWB has suggested that income increases both evaluations and experiences up to a point. The recent research suggests that SWB always increases in income (Deaton, 2008; Sacks et al., 2010). Whether the income–SWB relationship becomes flat or increases very slightly at high levels of income is, for the purposes of this, a somewhat moot point – that the SWB gains from increases in income become very small is enough motivation to look more closely at the impacts of innovation. If income does not have much of an impact beyond a point, then people maybe not spending their income correctly (see Dunn et al., 2011) and/or the increased income comes at a price in terms of other things that reduce

wellbeing (e.g. commuting – see Kahneman et al., 2006; Stutzer and Frey, 2008). Whatever the reasons, the impact of innovation, investment, R&D, and consumer choice all need to be carefully considered.

There have been some attempts to look at how innovation can enhance objective indicators of wellbeing, particularly in the medical sector (which could then be related to SWB). For example, Cutler and McClellan (2001) found that innovations in the treatment of heart attacks, low birth-weight infants, depression, cataracts, and breast cancer have led to increased longevity and less absenteeism from the workplace. These innovations are also likely to have improved SWB but no direct data were available. Other studies suggest that more expenditure on medical innovations does not necessarily lead to improved outcomes, let alone represent an efficient use of resources (e.g. Berndt et al., 2002; Lichtenberg, 2004). So there is a large gap in the literature on the degree to which resources allocated to innovations actually improve SWB.

As an interesting aside, there is some evidence to suggest that ‘innovators’ are getting older as more time is spent getting to the knowledge frontier (Jones, 2009). Jones (2010) provides evidence of longer doctorates and older Nobel laureates. Galenson (2004) and Weinberg (2006) suggest that older people often make set off innovations, while younger individuals are more involved throughout the whole innovation process. So, innovation might be U-shaped through the life-cycle, just as SWB is, i.e. higher SWB at younger and older ages (Blanchflower and Oswald, 2008; Stone et al., 2010). It is striking how little else we know (or at least could find) about the impact of innovation on SWB. In a recent comprehensive review of the economics literature on the determinants of SWB, Dolan et al. (2008) did not find anything on the relationship between innovation and SWB.

So, from this overview of the existing literature on SWB and innovation in Sections 2.1 and 2.2, we can generate some initial research questions that have not been answered to date:

1. Is there a relationship between innovation and SWB in the general population?
2. Does any innovation–SWB relationship rely on the measures of innovation and SWB that are used?
3. To what extent are more creative workplaces conducive to higher SWB?

We attempt to provide some initial, necessarily tentative, answers to these questions using the BHPS and our own primary dataset.

3. Data and methodology

It has already been argued that a better understanding of innovation requires greater use of secondary datasets (NESTA, 2008). Whilst fully accounting for the effects of hidden innovation on wellbeing will require new data, it is possible to begin using existing data, such as the British Household Panel Survey (BHPS), to determine how innovation might affect SWB, and to answer our research questions. The BHPS is a nationally representative sample of British households, and has been running since 1991. Respondents are interviewed in successive waves and the sample remains broadly representative of the British population. The entire sample of the unbalanced panel contains 30,336 observations (17,206 individuals). Of those, 4197 respondents have stayed in all waves from wave 6 onwards.

Since wave 6 (with the exception of wave 11), respondents have been asked a life satisfaction question with response options from 1 (not satisfied at all) to 7 (completely satisfied). In every wave, respondents have been asked questions about their job satisfaction

on the same seven-point scale. In every wave respondents have also been asked the General Health Questionnaire (GHQ). The Caseness scale of GHQ-12 ranges from 0 (best mental wellbeing) to 12 (worst mental wellbeing). Many studies in economics have used the GHQ as a measure of subjective wellbeing (see Metcalfe et al., 2011).

Our own dataset is derived from University students across a random selection of UK Universities during October and November 2010. We asked administrators of undergraduate and postgraduate degree programmes to the survey link to the students on their degree programmes. The survey was titled as a general wellbeing survey to avoid any focussing effects or selection into the survey (Schkade and Kahneman, 1998). We received 827 responses after asking only twelve administrators. The novelty of this dataset is that we not only ask innovation/creativity questions, but we obtained data on a range of SWB measures (as well as on range of basic background demographic variables).

For evaluation, we used a widely used life satisfaction question (Dolan et al., 2008) or Cantrill’s ladder of life which has been used recently in large scale surveys by Gallup (Stone et al., 2010). For experience, we asked about ‘happiness’ and ‘worried’ yesterday. These are the two main adjectives used in the original day reconstruction method by Kahneman et al. (2004) and they are consistent with the main headline indicators in the Gallup–Healthways data (Diener et al., 2010). We asked about the whole day yesterday (rather than a number of discrete episodes) for ease of completion and because it is consistent with the latest research by Gallup.

Our empirical methodology will be to use linear regressions, and to control for third variables that we know are correlated with SWB, such as age, marital status, income, etc., and control for individual heterogeneity where possible. More specifically, for question 1, we will estimate:

$$innov_i = \beta_1 SWB_i + \phi' X' + \varepsilon_i \quad (1)$$

where $innov_i$ is the measure of innovation or creativity for person i , SWB_i is the measure of SWB, and X' is the vector of control variables in the innovation estimation. For question 2, we will estimate Eq. (1) but we change the measure of SWB in a specific population to understand the differences. For question 3, we will estimate:

$$JS_{it} = \beta_1 (RD)_{it} + \phi' X' + \alpha_i + \varepsilon_{it} \quad (2)$$

where JS_{it} is the job satisfaction for individual i over time t , individual fixed effects, α_i , and RD_{it} is a dummy variable which is one when the individual works in an innovative company, and zero otherwise.

4. Results

4.1. Is higher SWB conducive to creativity?

In wave 15 of the BHPS, respondents were asked whether they are original and can come up with new ideas, and whether they have an active imagination. The response options range from 1 (least able) to 7 (most able). These questions are part of a larger module to explore personality. While personality and SWB has been examined previously (see DeNeve and Cooper, 1998; Diener et al., 2003), they have not been disaggregated previously to examine the link between innovation and SWB. So we focus on these two questions in the BHPS, which are from the self-completion booklet part of the BHPS (where respondents can observe the whole range of questions before completing them).

The two main measures of creativity in the BHPS and in our own data that will be the dependent variables, which we will attempt to explain, are “I see myself as someone who is original, comes up with new ideas” on a five or seven point scale, and “I see myself as someone who has an active imagination” on a five or seven point scale – clearly these are self-reported innovation. Fig. 1 presents a histogram of these two variables in the BHPS. The ‘original’ measure is

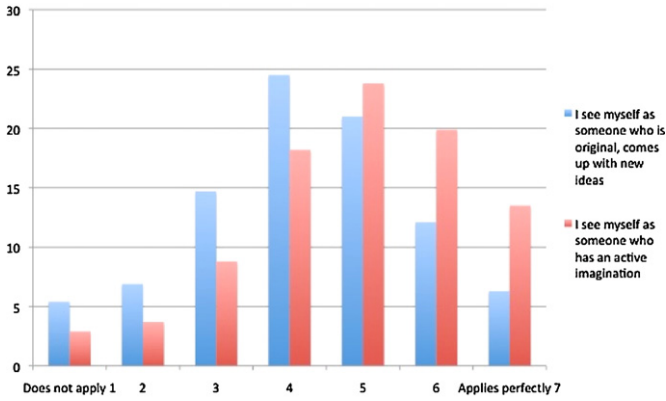


Fig. 1. Histogram of innovation measures in the BHPS.

Table 1

Associations between innovation and SWB.

	(1) Original	(2) Original	(3) Imagination	(4) Imagination
GHQ		-0.018 [0.006]**		-0.013 [0.007]*
Life satisfaction	0.112 [0.017]**		0.165 [0.017]**	
Male	0.307 [0.035]**	0.286 [0.035]**	0.237 [0.035]**	0.214 [0.035]**
Age	0.001 [0.007]	-0.002 [0.007]	-0.002 [0.007]	-0.005 [0.007]
Age ²	-0.021 [0.007]**	-0.018 [0.007]*	-0.009 [0.008]	-0.006 [0.008]
Log of household income	0.094 [0.027]**	0.108 [0.028]**	0.036 [0.026]	0.042 [0.026]
Cohabiting	-0.089 [0.061]	-0.074 [0.060]	0.03 [0.057]	0.056 [0.058]
Widowed	-0.128 [0.097]	-0.126 [0.097]	0.083 [0.095]	0.025 [0.095]
Separated	-0.013 [0.079]	-0.045 [0.078]	0.177 [0.079]*	0.125 [0.078]
Divorced	0.090 [0.136]	0.065 [0.137]	0.067 [0.138]	0.01 [0.141]
Never married	-0.140 [0.066]*	-0.175 [0.065]**	0.024 [0.063]	0.005 [0.064]
Marriage	-0.547 [0.286]	-0.587 [0.286]*	0.283 [0.260]	0.288 [0.266]
Self-employed	0.344 [0.069]**	0.369 [0.069]**	0.204 [0.064]**	0.231 [0.065]**
Unemployed	-0.042 [0.111]	-0.019 [0.110]	0.065 [0.112]	0.048 [0.111]
Retired	-0.041 [0.078]	0.005 [0.078]	-0.048 [0.077]	-0.006 [0.077]
Family care	0.301 [0.217]	0.38 [0.227]	-0.265 [0.207]	-0.162 [0.206]
Full-time student	-0.174 [0.081]*	-0.169 [0.081]*	0.021 [0.077]	0.015 [0.078]
Long-term disabled	0.323 [0.088]**	0.383 [0.090]**	0.072 [0.089]	0.127 [0.091]
On maternity leave	-0.234 [0.110]*	-0.261 [0.110]*	-0.019 [0.117]	-0.098 [0.119]
Govt. Training scheme	0.156 [0.514]	0.186 [0.529]	0.476 [0.222]*	0.491 [0.241]*
Something else	0.120 [0.242]	0.037 [0.251]	0.241 [0.221]	0.143 [0.231]
Health: poor	-0.120 [0.175]	-0.037 [0.176]	0.014 [0.187]	0.111 [0.189]
Health: fair	-0.205 [0.168]	-0.118 [0.169]	-0.062 [0.174]	0.056 [0.177]
Health: good	-0.133 [0.168]	-0.029 [0.169]	-0.076 [0.174]	0.083 [0.178]
Health: excellent	-0.073 [0.172]	0.066 [0.173]	-0.024 [0.177]	0.199 [0.181]
Health: missing	1.356 [0.536]*	1.617 [0.581]**	-0.597 [0.537]	-0.356 [0.582]
Highest edu: first degree	0.237 [0.053]**	0.251 [0.054]**	0.167 [0.050]**	0.173 [0.050]**
Highest edu: higher degree	0.566 [0.092]**	0.577 [0.094]**	0.262 [0.094]**	0.274 [0.095]**
Constant	3.085 [0.532]**	3.534 [0.545]**	3.846 [0.606]**	4.576 [0.627]**
Observations	8009	8001	8009	8004
R ²	0.15	0.14	0.06	0.05

Notes: Reference variables are single, employed, very poor health, no degree. We also use 19 regional dummies in these regressions, as well as number of children in the household. The dependent variables are: *Original* – I see myself as someone who is original, comes up with new ideas (1 (strongly disagree) to 7 (strongly agree)). *Imagination* – I see myself as someone who has an active imagination (1 (strongly disagree) to 7).

* <5% significance.

** <1% significance.

much more normally distributed than the ‘imagination’ measure, with the median in original being less than the median in imagination. For original, about half of the respondents are not very original (i.e. 1–4), and about 18% perceive themselves as very original (i.e. 6–7). For imagination, about 34% perceive themselves as not very imaginative, and about 33% perceive themselves as very imaginative. In Fig. 2, we present these two innovation measures from our own data. The difference here is the scales used (always five points as opposed to sometimes seven), but the wording of the question is identical to the BHPS. The median for original and imagination are the same, but the mean is lower for original, and more than twice as many people rate themselves as very imaginative (i.e. strongly agree 5) than very original. Both datasets have a very similar distribution of innovation responses.

We can run an OLS regression with SWB as an explanatory variable for the responses to these innovation questions to see whether happier people tend to be more creative, while controlling for a range of background variables. The SWB coefficients are reported in Fig. 3a and b, where we can see that people with low SWB are also significantly less likely to be original and creative, whereas people with higher SWB report themselves to be more original and more imaginative than others, on average.

Table 1 presents the full regressions that generate these figures. We will first discuss marginal effects of SWB, and then the relative magnitudes of these effects. In terms of marginal effects, we find that the coefficient on life satisfaction for originality and

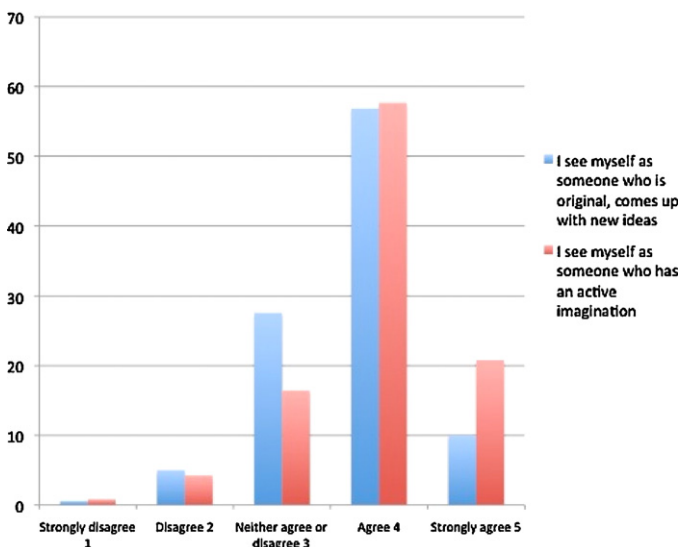


Fig. 2. Histogram of innovation measures in our own data.

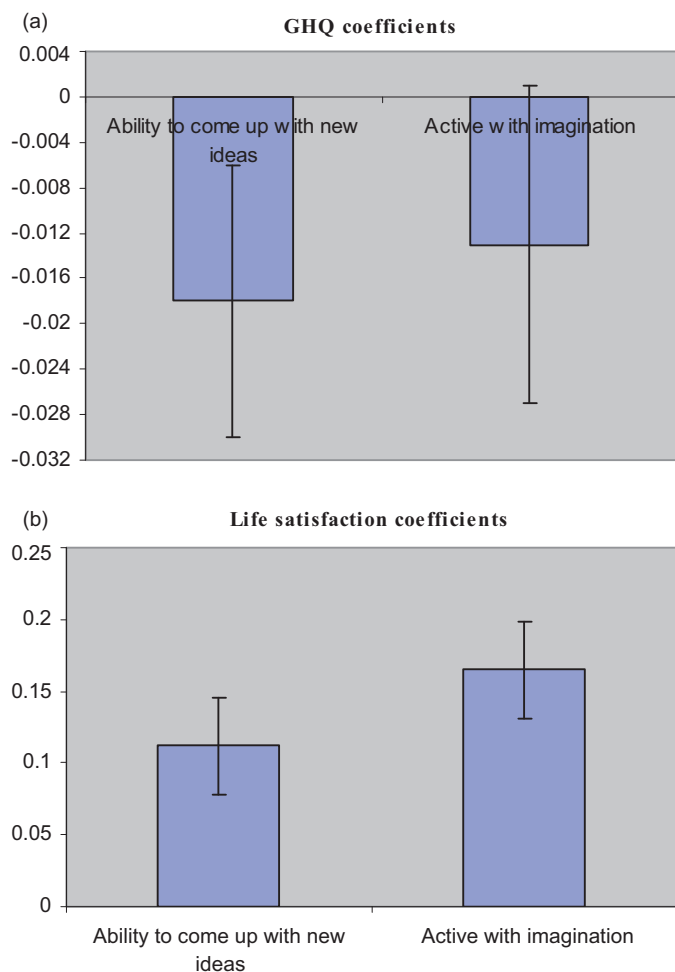


Fig. 3. (a and b) Estimated correlations between SWB and ability to come up with original ideas, BHPS 2005. Note: 4-standard-error-band (i.e. 95% confidence level). Both dependent variables (ability to come up with new ideas and active with imagination) are both on a 7-point scale and range from 1 (least able to) to 7 (most able to). All regressions control for gender, age, age-squared, employment status, marital status, education, subjective health status, number of children, household income and regional dummies. Standard errors are robust to cluster at the household level.

imagination are 0.112 and 0.165 respectively. These coefficients mean that for a one-point increase in life satisfaction, originality increases by 0.112 points on a 0 to 7 scale – this is equivalent to a 1.6% increase in originality. For imagination, the coefficient on life satisfaction is 0.165, which suggests that a one-point increase in life satisfaction is equivalent to increasing imagination by 2.4%. The respective marginal effects for the GHQ are lower – roughly about one-tenth of the life satisfaction effects (they are negative because the GHQ is reverse-coded suggesting that negative values represent lower mental distress). This suggests that the SWB–innovation link is much stronger for people’s evaluation of their life on a global scale than a measure of distress (which encapsulates the GHQ).

It is interesting to observe the other background variables that are important to both originality and imagination. Men state that they are about 4% more original and imaginative than women, and older individuals have declining originality. Increasing household income by one natural logarithm is associated with 1.5% change in originality, and those who are self-employed have 5% more originality and 3% more imagination than those who are employed. Interestingly, as compared to the employed, students report having 2.5% lower originality, the unemployed have no difference in stated originality and imagination, and the long-term disabled have 4% higher originality. Being on a government training scheme is

Table 2
Associations between innovation and evaluative SWB measures from our own data.

	(1) Original	(2) Original	(3) Imagination	(4) Imagination
Ladder of life	0.041 [0.025]		0.025 [0.027]	
Life satisfaction		0.031 [0.023]		0.021 [0.024]
Observations	336	487	338	489
R ²	0.01	0.01	0.00	0.00

Notes: The dependent variables are: *Original* – I see myself as someone who is original, comes up with new ideas (1 (strongly disagree) to 5 (strongly agree)). *Imagination* – I see myself as someone who has an active imagination (1 (strongly disagree) to 5). Independent variables: *Life satisfaction* – How satisfied are you with your life overall? 0 (not satisfied at all) to 10 (completely satisfied) (in the BHPS this is a seven point scale). *Ladder of life* – Please imagine a ladder with steps numbered from zero at the bottom to 10 at the top. The top of the ladder represents the best possible life for you and the bottom of the ladder represents the worst possible life for you. On which step of the ladder would you say you personally feel you stand at this time? 0 (worst possible life) to 10 (best possible life).

associated with higher imagination, by around 7%, but different levels of self-reported health have very little associations with both originality and imagination. Having a degree (in comparison to not having a degree) is associated with 3.5% and 2.5% higher originality and imagination respectively, and having a postgraduate degree is associated with 8% and 4% higher originality and imagination respectively.

For originality, a one-point increase in life satisfaction is comparable to half the effect of being male, the natural logarithm of household income, a third of being self-employed or long-term disabled, and half the effect of having a degree. For imagination, a one-point increase in life satisfaction is comparable to two-thirds of the effect of being male, three-quarters of the effect of being self-employed, and equivalent to having a degree.

These results are partial associations and not causations. Indeed, we might find a great deal of response bias for the ‘original/new ideas’ and ‘active imagination’ questions. Some respondents may also think that these attributes are important since the interviewer is asking about them and that they are therefore important attributes to have. There may also be some sort of acquiescence bias, whereby some respondents give high ratings to all subjective assessments (Hurd, 1999), so that the SWB questions and the creativity questions are highly correlated. Due to the BHPS only having one wave of innovation measures, we cannot control for these individual effects through a panel regression. More causal research is needed on the relationship between self-reported, peer-assessed and objective levels of creativity and SWB levels, which would require firm level data or patent data. We would like to stress that the relationship is strong from a representative sample of the UK population, but future research should find out the direction and magnitude of the causal relationships.

4.2. Does the type of SWB measure matter?

We begin by attempting to replicate the above innovation–SWB relationship from our own dataset using the measure of life satisfaction and ladder of life – both measures of evaluative SWB. Table 2 shows the basic associations between evaluation measures of SWB and original and imagination. All of the associations are positive, although both SWB measures are more highly correlated with original as opposed to imagination. The significance of these two SWB variables is well under 20% with a small sample. Table 3 uses the same innovation dependent variables, but now we include basic socio-demographic variables. The positive association between life satisfaction and the two dependent variables now disappear, but the association between innovation and the ladder of

Table 3
Associations between innovation and evaluative SWB measures from our own data – controls used.

	(1) Original	(2) Original	(3) Imagination	(4) Imagination
Ladder of life	0.068 [0.030]**		0.041 [0.032]	
Life satisfaction		-0.002 [0.024]		-0.003 [0.026]
Male	0.171 [0.090]*	0.041 [0.073]	0.068 [0.098]	0.042 [0.077]
Age	-0.057 [0.041]	0.016 [0.040]	-0.082 [0.045]*	0.002 [0.042]
Age ²	0.001 [0.001]	-0.000 [0.001]	0.001 [0.001]*	0.000 [0.001]
Log of household income	-0.105 [0.146]	0.023 [0.123]	0.052 [0.159]	0.089 [0.131]
Cohabiting	0.063 [0.158]	0.204 [0.162]	-0.433 [0.170]**	0.262 [0.172]
Married	0.132 [0.236]	0.668 [0.265]**	-0.143 [0.256]	0.310 [0.281]
Divorced	2.170 [0.897]**	-0.533 [0.779]	1.282 [0.974]	-1.462 [0.827]*
Separated		0.146 [0.570]		-0.068 [0.605]
Employed part time	-0.257 [0.324]	0.257 [0.306]	-0.010 [0.348]	0.431 [0.325]
Self-employed	-0.251 [0.502]	0.353 [0.428]	0.218 [0.544]	-0.419 [0.454]
Housewife		-2.248 [0.783]**		1.107 [0.832]
Student	-0.206 [0.305]	0.222 [0.251]	0.037 [0.327]	0.593 [0.267]**
Unemployed	-0.039 [0.404]	0.152 [0.370]	0.325 [0.436]	0.227 [0.393]
Education level 2 (A'levels)	0.129 [0.251]	-0.047 [0.300]	0.099 [0.272]	-0.095 [0.318]
Education level 3 (undergrad)	0.029 [0.097]	0.184 [0.079]**	0.046 [0.106]	0.171 [0.084]**
Education level 4 (postgrad)	0.474 [0.182]**	-0.007 [0.152]	0.228 [0.195]	-0.064 [0.162]
Constant	5.101 [1.574]**	2.984 [1.384]**	4.299 [1.709]**	2.357 [1.470]
Observations	288	437	290	439
R ²	0.09	0.05	0.06	0.05

Notes: Independent variables: *Life satisfaction* – How satisfied are you with your life overall? 0 (not satisfied at all) to 10 (completely satisfied) (in the BHPS this is a seven point scale). *Ladder of life* – Please imagine a ladder with steps numbered from zero at the bottom to 10 at the top. The top of the ladder represents the best possible life for you and the bottom of the ladder represents the worst possible life for you. On which step of the ladder would you say you personally feel you stand at this time? 0 (worst possible life) to 10 (best possible life).

* 10% significance.
** 5% significance.
*** 1% significance.

life is increased. We will discuss the other independent variables when we combine the two datasets below.¹

Table 4 shows the results for the two affective measures of yesterday. Happiness yesterday is largely related to originality, but less related to imagination. Worried yesterday is negatively related to originality, but is positively related to imagination, although the coefficients are small. Table 5 uses the same dependent variables but includes the background variables. The first thing to note is that happiness yesterday is still significant at the 1% level with a coefficient of around 0.040. This means that a one point (10%) increase in happiness yesterday is associated with a 0.8% increase in originality. The comparable ladder of life effect from Table 3 is in the

¹ Each respondent was randomised into answering either a life satisfaction question or a ladder of life question. All respondents were, however, given the same experience questions.

Table 4
Associations between innovation and experience SWB measures from our own data.

	(1) Original	(2) Original	(3) Imagination	(4) Imagination
Happiness yesterday	0.038 [0.014]**		0.014 [0.015]	
Worried yesterday		-0.016 [0.011]		0.005 [0.011]
Observations	823	820	827	824
R ²	0.01	0.01	0.00	0.00

Notes: Independent variables: *Happiness yesterday* – Overall, how happy did you feel yesterday? 0 (not happy at all) to 10 (completely happy). *Worried yesterday* – Overall, how worried did you feel yesterday? 0 (not worried at all) to 10 (completely worried).

*** 1% significance.

region of a 1.4% increase in originality. Imagination is not strongly predicted by either happiness yesterday or worried yesterday. For originality, we can observe other important predictors, such as married (as opposed to being single), being a housewife (as opposed to being employed fulltime), and having an undergraduate or

Table 5
Associations between innovation and experience SWB measures from our own data—controls used.

	(1) Original	(2) Original	(3) Imagination	(4) Imagination
Happiness yesterday	0.040 [0.015]**		0.019 [0.016]	
Worried yesterday		-0.013 [0.012]		0.003 [0.013]
Male	0.108 [0.055]*	0.099 [0.056]*	0.058 [0.060]	0.059 [0.060]
Age	-0.026 [0.027]	-0.029 [0.028]	-0.034 [0.029]	-0.035 [0.029]
Age ²	0.000 [0.000]	0.000 [0.000]	0.001 [0.000]	0.001 [0.000]
Log of household income	0.004 [0.091]	0.005 [0.092]	0.071 [0.098]	0.069 [0.098]
Cohabiting	0.148 [0.112]	0.150 [0.114]	-0.084 [0.120]	-0.100 [0.121]
Married	0.429 [0.173]**	0.447 [0.175]**	0.066 [0.187]	0.039 [0.188]
Divorced	0.505 [0.546]	0.536 [0.549]	0.091 [0.589]	0.095 [0.589]
Separated	-0.002 [0.535]	0.062 [0.539]	-0.081 [0.578]	0.015 [0.578]
Employed part time	0.061 [0.215]	0.041 [0.216]	0.154 [0.232]	0.157 [0.232]
Self-employed	0.163 [0.304]	0.180 [0.306]	-0.056 [0.328]	-0.027 [0.328]
Housewife	-1.980 [0.755]**	-2.050 [0.759]**	1.117 [0.814]	1.109 [0.814]
Student	0.051 [0.189]	0.035 [0.190]	0.234 [0.203]	0.237 [0.203]
Unemployed	0.206 [0.265]	0.154 [0.266]	0.310 [0.285]	0.293 [0.285]
Education level 2 (A'levels)	0.082 [0.189]	0.094 [0.190]	-0.028 [0.203]	-0.030 [0.204]
Education level 3 (undergrad)	0.131 [0.061]**	0.132 [0.061]**	0.129 [0.065]**	0.125 [0.066]*
Education level 4 (postgrad)	0.207 [0.115]*	0.182 [0.116]	0.043 [0.124]	0.019 [0.124]
Constant	3.672 [1.013]**	4.058 [1.009]**	3.326 [1.094]**	3.478 [1.008]**
Observations	725	725	729	726
R ²	0.04	0.04	0.04	0.04

Notes: Independent variables: *Happiness yesterday* – Overall, how happy did you feel yesterday? 0 (not happy at all) to 10 (completely happy). *Worried yesterday* – Overall, how worried did you feel yesterday? 0 (not worried at all) to 10 (completely worried).

* 10% significance.
** 5% significance.
*** 1% significance.

postgraduate degree (as opposed to only having GCSEs). For the latter, having an undergraduate degree is associated with a 3% increase in originality. This is equivalent to increasing happiness yesterday by three and a half points on an eleven-point scale. Interestingly, only obtaining an undergraduate degree is important to explaining increasing imagination.

Overall, it is important to note that there is not a significant difference at the 10% level between the coefficients on originality for the ladder of life and the happiness yesterday measure. This presents an interesting finding that gives an indication that innovation might be correlated with the both types of SWB – i.e. both evaluations and experiences.

4.3. Is working in an innovative environment conducive to higher SWB?

In order to consider whether people who work in the R&D sector report higher levels of SWB than others, we can look at the raw data of those who entered the R&D sector at time, t , and remained there at $t + 1$ ($N = 30$). We can see from Fig. 4a–c that there is a significant increase in the overall level of job satisfaction and satisfaction with pay, as well as satisfaction with the work itself after the individuals entered R&D. This starts to demonstrate the idea that the causal relationship might go from innovation to SWB. We test this idea more systematically using regression analysis in Table 6. Looking at the random effects results in the first column, it appears that people working in the R&D sector, on average, report a higher level of job satisfaction than those in other sectors by 0.2 points on a 1–7 scale. The R&D coefficient is also positive though statistically insignificant in 'satisfaction with pay' and 'satisfaction with the work itself' regressions (see columns 2 and 3).

Table 6 also reports fixed effects results i.e. the effect of moving into the R&D sector on job satisfaction. A similar pattern emerges. A move into the R&D sector is associated with a significant improvement in the level of job satisfaction. This effect is around a 0.2 point increase in job satisfaction on a 1–7 scale. Whilst we control for individual heterogeneity, it is important to note that there might selection effects here since it is difficult to establish a good counterfactual. For instance, it might be that moving into a new job (irrespective of whether it is a R&D job or not) provides the increase in job satisfaction that is found above. A similar inference can also be made about the relationship between moving into the R&D sector and SWB but the correlations between R&D and SWB are statistically insignificant.

5. Exploring the innovation–SWB relationship

The results above suggest a very important relationship between innovation and SWB, both in terms of evaluative and experience wellbeing. Notwithstanding some problems of making inferences about causality, it may also be possible to link the BHPS to other datasets, such as the Community Innovation Survey (CIS). The CIS is a survey conducted every four years by EU member states that allows innovation to be monitored. It measures innovation in products (including goods and services), process innovation in the way good and services are produced or provided, investment in innovation, such as R&D and capital goods, and wider innovation, such as strategic changes to the organisation of business. The UK Innovation Survey 2005, covering the period 2002–2004, was the largest so far conducted: 28,000 UK enterprises with 10 or more employees were sampled and 58% responded. Therefore, we might be able to determine whether there is a relationship between SWB by location and innovation in a location as defined by R&D expenditures, patent activities, and employees in creative industries.

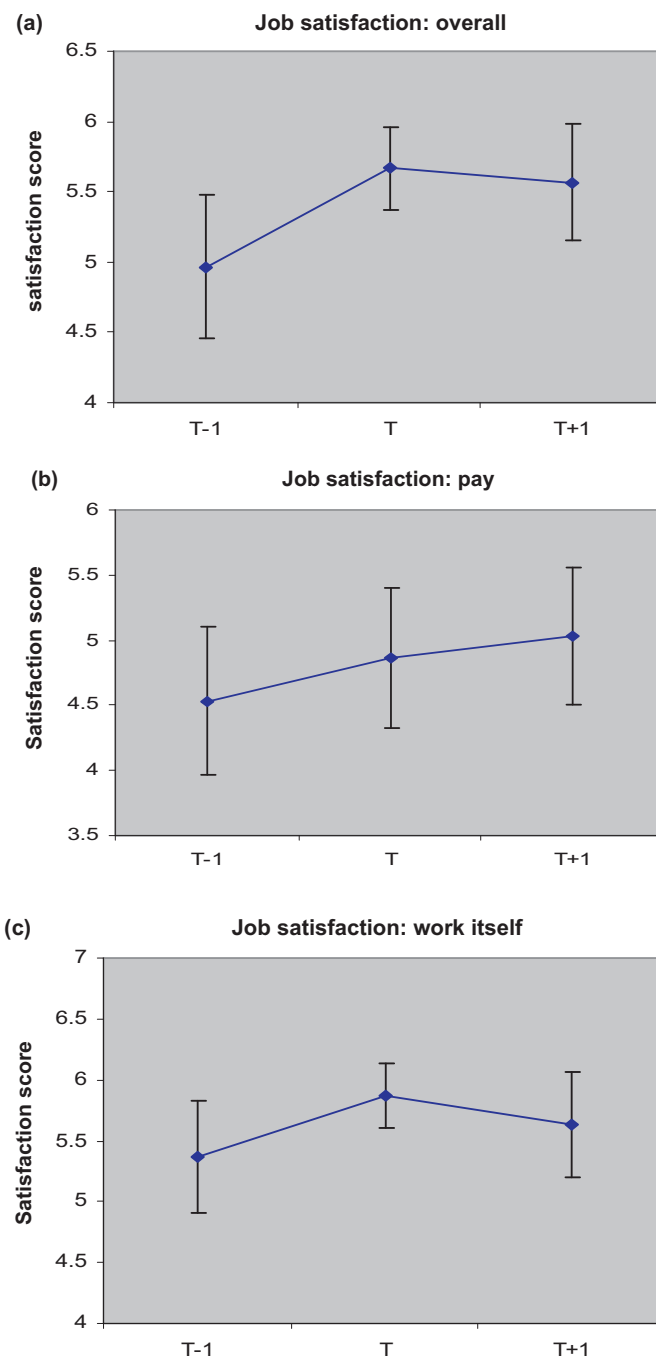


Figure 4. (a–c) The job satisfaction path of those who entered R&D sector at T and remained in there in $T+1$. Note: 4-standard-error-band (i.e. 95% confidence level). $N = 30$.

We need new datasets to examine the innovation and SWB relationship. This could be achieved through including more innovation and creativity questions in regular panel datasets that have SWB questions, such as the BHPS (now the UK Household Living Survey) and the German Socio-Economic Panel. This could also be achieved by SWB measures being included in innovation surveys or workforce surveys. Linking up such questions on these surveys would generate significant rewards. At one level it will help us to understand the link between affect and innovation at the microeconomic level, and at another level it will help us to understand the link between technological progress and SWB. Such relationships will become increasingly important over the 21st Century as more is known about SWB, and the implication such a measure has for public policy.

Table 6
Job satisfaction regression with working in the R&D sector, BHPS 1991–2005.

	(1) RE Job sat: overall	(2) RE Job sat: pay	(3) RE Job sat: work itself	(4) FE Job sat: overall	(5) FE Job sat: pay	(6) FE Job sat: work itself
In R&D sector	0.193 [0.090]*	0.137 [0.108]	0.172 [0.095]	0.212 [0.100]*	0.107 [0.118]	0.205 [0.105]*
Age	-0.060 [0.004]**	-0.041 [0.005]**	-0.034 [0.005]**	-0.013 [0.024]	-0.027 [0.028]	0.021 [0.025]
Age ² /100	0.078 [0.005]**	0.058 [0.006]**	0.049 [0.006]**	0.072 [0.008]**	0.027 [0.010]**	0.029 [0.009]**
Cohabit with partner	-0.043 [0.020]*	0.013 [0.024]	-0.439 [0.021]**	-0.035 [0.023]	0.044 [0.027]	-0.534 [0.024]**
Widowed	0.128 [0.066]	0.114 [0.081]	-0.004 [0.069]	-0.010 [0.089]	0.009 [0.105]	-0.201 [0.094]*
Separated	0.020 [0.034]	-0.114 [0.041]**	-0.098 [0.035]**	0.027 [0.042]	-0.043 [0.049]	-0.160 [0.044]**
Divorced	0.108 [0.045]*	0.055 [0.053]	0.012 [0.047]	0.145 [0.049]**	0.117 [0.057]*	0.013 [0.052]
Never married	-0.164 [0.025]**	-0.149 [0.030]**	-0.346 [0.026]**	-0.125 [0.032]**	-0.107 [0.038]**	-0.439 [0.034]**
Log of working hours	-0.176 [0.015]**	-0.380 [0.017]**	-0.211 [0.015]**	-0.145 [0.017]**	-0.323 [0.020]**	-0.273 [0.018]**
Temporary job	-0.144 [0.021]**	0.011 [0.025]	-0.118 [0.022]**	-0.106 [0.023]**	0.021 [0.027]	-0.068 [0.024]**
Self-employed	-0.124 [0.115]	-0.141 [0.136]	-0.175 [0.122]	-0.083 [0.121]	-0.136 [0.143]	-0.126 [0.128]
Opportunity for promotion at work	0.000 [0.000]*	-0.001 [0.000]**	0.000 [0.000]	-0.001 [0.000]**	-0.001 [0.000]**	0.000 [0.000]
Log of annual personal income	-0.011 [0.009]	0.126 [0.010]**	0.023 [0.009]*	0.030 [0.010]**	0.110 [0.012]**	0.041 [0.011]**
Work size: 1–24	0.053 [0.023]*	-0.126 [0.028]**	0.302 [0.024]**	0.002 [0.026]	-0.164 [0.031]**	0.266 [0.028]**
Work size: 25–199	-0.004 [0.021]	0.011 [0.025]	-0.032 [0.022]	-0.010 [0.024]	-0.006 [0.028]	-0.040 [0.025]
Completed first degree	-0.167 [0.030]**	-0.054 [0.037]	-0.129 [0.032]**	0.078 [0.053]	0.032 [0.062]	0.200 [0.056]**
Completed higher degree	-0.092 [0.058]	-0.053 [0.072]	-0.025 [0.061]	0.157 [0.097]	0.063 [0.113]	0.246 [0.102]*
Health: poor	0.034 [0.062]	0.083 [0.073]	-0.074 [0.065]	0.042 [0.065]	0.067 [0.077]	-0.033 [0.069]
Health: fair	0.178 [0.059]**	0.074 [0.070]	-0.031 [0.062]	0.171 [0.063]**	0.024 [0.074]	0.010 [0.067]
Health: good	0.288 [0.059]**	0.240 [0.070]**	0.173 [0.062]**	0.255 [0.063]**	0.172 [0.074]*	0.205 [0.067]**
Health: excellent	0.348 [0.060]**	0.227 [0.071]**	0.287 [0.063]**	0.279 [0.064]**	0.131 [0.075]	0.311 [0.068]**
Constant	7.180 [0.170]**	5.400 [0.203]**	6.948 [0.179]**	5.469 [0.716]**	5.300 [0.841]**	5.596 [0.756]**
Observations	61,976	61,932	61,970	61,976	61,932	61,970
Number of person	9071	9062	9069	9071	9062	9069
R ² (within)	0.0868	0.0895	0.1068	0.0898	0.0913	0.1096

Note: Standard errors are in parentheses. RE = random effects. FE = fixed effects. Job satisfaction scale ranges from 1 (not at all satisfied) to 7 (completely satisfied). Number of observations in R&D sector = 240. Other controls include social class, wave, and regional dummies.

* <5%.

** <1%.

A recent development to analyse the relationship between evaluative and experience SWB and innovation is using the Integrated Household Survey (IHS) in the UK (administered by the ONS with approximately 250,000 individuals surveyed per year). Given the recommendations by Dolan et al. (2011) and Dolan and Metcalfe (2012) on the measures of SWB that can be collected by governments, the ONS will now have include four measures of SWB in its HIS, which includes the UK labour force survey. This opens an exciting possibility for a much larger focus on the innovation–SWB relationship.

It is also necessary to think about how we could develop new studies and datasets to answer questions about those relationships and, crucially, about causality. We cannot claim causality in our paper, but there are at least three important questions of causality: (1) does higher SWB make people more creative and innovative; (2) does working in an innovative environment increase SWB; and (3) does innovation increase SWB? What are required to address each

of these questions are natural and field experiments. The use of such experiments in economics has increased dramatically over the past few years (Levitt and List, 2009) and are already being used to measure the effects of innovative technologies on education (Banjeree et al., 2007), although they are currently less widely used in the innovation field than in the development field. The use of natural and field experiments will inform various debates, including those around management science and the most appropriate ways to deliver education and targeted workplace initiatives for increasing creativity and innovation, in addition to how best to develop and refine policy and regulatory interventions.

6. Concluding remarks

In this paper we have found an important link between innovation and subjective wellbeing, from both a representative sample

and our own student sample. There is actually very little evidence pertaining to the relationship between innovation and SWB in the current literature, and no evidence at all of the causal relationships between them. Longitudinal data can help in addressing these issues as has been shown in this paper on job satisfaction. Nonetheless, this paper demonstrates a very large gap in the literature on the causal impact of innovation and people's subjective welfare. There is little causal evidence on the impact of SWB on innovation.

The analysis from this paper demonstrates some potentially interesting findings. Firstly, life evaluations are associated with higher originality and imagination in the general population. These associations are actually quite large in comparison to other variables that impact on both originality and imagination. For instance, for originality, a 20% increase in life satisfaction is equivalent to the impact of having a degree. Secondly, some measures of experience are associated with originality. For instance, a 30% increase in happiness yesterday is equivalent to having a degree. Thirdly, working in the R&D sector is associated with higher evaluations of the job.

Our research has only considered associations, and our primary data should only be seen as a first, tentative attempt to explore the innovation–SWB relationship further. Future research should attempt to find out the direction of causality in these various interesting relationships. Further consideration and measurement of SWB – particularly using natural and field experiments – will enable us to consider whether and how innovation policies should be targeted at individuals, businesses, sectors and locations to have the largest impact on SWB. This will further push the boundaries of innovation research and policy, and will lead to innovation that enhances wellbeing.

In fact, these relationships have potentially important implications for productivity and economic growth. For instance, a 33% increase in life satisfaction is associated with 8% higher imagination. If this relationship from SWB to creativity is causal, then changing people's SWB could be a very effective way of increasing productivity and economic growth. In the aggregation of individuals, SWB could be a vital missing piece in the debates and research in innovation and economic growth. This research has highlighted that the associations between SWB and innovation are large, and it warrants much more attention across the social sciences.

Acknowledgements

We are very grateful to Nattavudh Powdthavee for providing assistance with the analysis of the data and to Andy Beale and David Pritchard for contributing to an earlier draft of this manuscript. We thank three anonymous reviewers and the editor for their extremely helpful comments. We also thank NESTA for funding this study.

Appendix A. Description of variables used

A.1. SWB variables

Life satisfaction – How satisfied are you with your life overall? 0 (not satisfied at all) to 10 (completely satisfied) (in the BHPS this is a seven point scale).

Ladder of life – Please imagine a ladder with steps numbered from zero at the bottom to 10 at the top. The top of the ladder represents the best possible life for you and the bottom of the ladder represents the worst possible life for you. On which step of the ladder would you say you personally feel you stand at this time? 0 (worst possible life) to 10 (best possible life).

GHQ – How often (on a four point category scale) over the past few weeks they: (i) had lost sleep over worry; (ii) felt constantly under strain; (iii) felt they could not overcome difficulties; (iv) been

feeling unhappy and depressed; (v) been losing confidence; (vi) been feeling like a worthless person; (vii) were playing a useful part in things; (viii) felt capable of making decisions; (ix) been able to enjoy day-to-day activities; (x) been able to concentrate; (xi) been able to face up to problems; and (xii) been feeling reasonably happy. The number of times a person places himself or herself in the top two categories was given a one, and then all twelve questions were added together to produce what is known as a caseness measure of mental distress, with the highest level of distress value scores 12 and minimum distress level scores zero.

Happiness yesterday – Overall, how happy did you feel yesterday? 0 (not happy at all) to 10 (completely happy).

Worried yesterday – Overall, how worried did you feel yesterday? 0 (not worried at all) to 10 (completely worried).

A.2. Innovation variables

Original – I see myself as someone who is original, comes up with new ideas. 1 (strongly disagree) to 5 (strongly agree) (in the BHPS this was a seven point scale).

Imagination – I see myself as someone who has an active imagination. 1 (strongly disagree) to 5 (strongly agree) (in the BHPS this was a seven point scale).

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