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Andrew E. Clark • Fabrice Etilé

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German Socio-Economic Panel Study (SOEP)
DIW Berlin
Mohrenstrasse 58
10117 Berlin, Germany

Contact: Uta Rahmann | urahmann@diw.de

HAPPY HOUSE:

SPOUSAL WEIGHT AND INDIVIDUAL WELL-BEING

Andrew E. Clark[1] (Paris School of Economics and IZA)
Fabrice Etilé (INRA-ALISS and Paris School of Economics)

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Abstract

We use life satisfaction and Body Mass Index (BMI) information from three waves of the SOEP to test for social interactions in BMI between spouses. Social interactions require that the cross-partial effect of partner's weight and own weight in the utility function be positive. Using life satisfaction as a utility proxy, semi-parametric regressions show that the correlation between satisfaction and own BMI is initially positive, but turns negative after some threshold. Critically, this latter threshold increases with partner's BMI when the individual is overweight. The negative well-being impact of own BMI is thus lower when the individual's partner is heavier, which is consistent with social contagion effects in weight. However, this cross-partial effect becomes insignificant in instrumental variable regressions, suggesting that the uninstrumented relationship reflects selection on the marriage market or omitted variables, rather than social interactions.

Keywords: Obesity, subjective well-being, BMI, social interactions.

JEL Codes: C14, I12, I3.

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Happy House: Spousal Weight and Individual Well-Being

Andrew E. Clark and Fabrice Etilé

1 Introduction

One of the most remarkable social changes in developed countries over the past 30 years has been the sharp increase in the prevalence of obesity and overweight. This has been so rapid that the World Health Organisation (WHO) declared in 2003 that "obesity has reached *epidemic* proportions".[2] Although the rise in weight can be analysed through any number of different lenses, it is the use of the word "epidemic" here which has attracted a certain amount of attention. Epidemics are typically diseases that are transmissible through identifiable pathogenic agents; here the term is applied to health changes that are, *a priori*, under the individual's own control.

Obesity can however have an epidemic dimension if others' body weight somehow affects the individual's (optimal) decisions regarding their own body weight. Along these lines, a vigorous recent debate has developed regarding the existence of such contagion effects in social networks (Christakis and Fowler, 2007, and Fowler and Christakis, 2008, *vs*. Cohen-Cole and Fletcher, 2008a and 2008b).[3] This literature typically looks for contagion effects in data on what are arguably individual choice variables, such as BMI or obesity, with individual outcomes being modelled as a function of those in the individual's peer group.

The key question in this contagion literature is whether the identified correlations between individual and peer-group outcomes in the data are causal. As is by now well-known, finding that individuals in the same area (or network, or peer group) have similar outcomes along

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[2] In the 2003 fact sheet of the World Health Organization on obesity and overweight. Available on-line at http://www.who.int/hpr/NPH/docs/gs_obesity.pdf.

[3] Christakis and Fowler (2007) find a significant effect of others' obesity status on one's own risk of obesity in a set of social networks made up of individuals who are followed over two decades. Cohen-Cole and Fletcher (2008) use the Add Health data set to show that Christakis and Fowler's methodology does not distinguish correlation from causality: the estimated effects may well reflect the selection of obesity-prone individuals into common social networks and/or the impact of common unobservable factors. However, using the same data but a different methodological approach, Fowler and Christakis (2008) and Trogdon *et al.* (2008) do find evidence that weight status spreads out across individuals.

some dimension is not sufficient to show that they influence each other (Manski, 1993, 2000).

A first point is that these individuals may well be subject to the same prices, environment or other constraints. In the context of the current paper, those living close to each other will be very similar in terms of food prices and food supply. This is the standard issue of a hidden common factor or unobserved contextual effect: correlation in outcomes here does not reflect causality.

Second, individuals choose where they live and with whom they interact. For "birds of a feather" reasons, those we observe in close proximity to each other may well have similar (observed or unobserved) tastes. As above, their outcomes will then likely look the same, and again this does not prove causality.

The last possibility is that there are indeed contagion or peer effects, in the sense that the behaviour of my peer group affects my own marginal utility and therefore my decisions. Regarding body weight, a heavier peer group may reduce my own incentives to lose weight.

Empirically, it is not easy to distinguish between these three possibilities using only data on observable outcomes, which explains why the case of contagion effects in obesity is far from being closed. We here propose a complementary approach to the existing literature, by appealing to individual well-being scores and relating them to both own and peer-group weight.

The reason for doing so is that, as noted above, social contagion requires that others' outcomes change the marginal utility (or cost) of my own actions (Clark and Oswald, 1998). In the current paper's context, if my own disutility of being overweight falls with the weight of my peer group then snowball effects will result. Having access to well-being data allows us to test this implication directly. We here use life satisfaction as the utility measure, and the Body Mass Index (BMI: weight in Kilograms divided by height in Metres squared) to account for weight status. Absent good information on who is in the individual's peer group (and how much they weigh), we consider a very local peer group: the individual's partner. We thus estimate life-satisfaction equations as a function of own and partner's BMI in three waves of German Socio Economic Panel data (2002, 2004 and 2006). We introduce both main effects of own and partner's BMI, and, crucially, an interaction between the two. This latter is what identifies the effect of partner's weight on the marginal utility (or disutility) of own weight.

We find that partner's weight reduces the disutility of own weight when the individual is overweight, consistent with social contagion. We can calculate ideal BMI levels, at which life satisfaction is maximised. When both partners are thin, ideal BMI is close to 21-22 for women, and 24-25 for men.

However, BMI levels are likely endogenous, as they represent choice outcomes, and therefore unobserved preferences, and hidden factors common to both partners. We thus implement an instrumental-variable strategy, which changes the results: the interaction effects between BMIs become insignificant overall, and significantly negative in longer-lasting marriages.

The contrast between the instrumented and uninstrumented results is key. Observationally (*i.e.* in the uninstrumented results), own weight matters less for well-being when one's partner is overweight too. However, within a couple, if we exogenously make one member heavier, the marginal disutility of own weight is unaffected. The instrumented results are thus inconsistent with social contagion; the fact that couples with similar weights seem to be happier likely reflects positive assortative matching on weight in the marriage market (similar weight individuals are more likely to marry each other) or some hidden common factor.

The remainder of the paper is organized as follows. Section 2 presents the concept of well-being/utility spillovers, and reviews predictions about the effect of partner BMI on well-being. Section 3 presents the data. Section 4 proposes linear and semi-parametric regression results, while Section 5 discusses how these may be affected by endogeneity. Last, Section 6 concludes.

2 Social Interactions, Utility and BMI

Our aim in this paper is to evaluate the relationship between BMI and utility within couples.[4] The critical questions are thus how partner's BMI affects the individual's own utility, and whether this effect depends on the individual's own BMI. The remainder of this

[4] The analysis here, and the term "married", refers to men and women who report being together in a couple, regardless of the actual legal arrangement describing their relationship.

section appeals to the existing literature in Economics and Sociology to discuss the basis of such interaction effects with respect to body weight.

2.1 Social interactions, contagion and the utility function

Clark and Oswald (1998) explore in detail the consequences of social interactions, both from a normative (they may generate multiple equilibria, with no guarantee of Pareto optimality) and a positive point of view (they can explain both following and deviant behaviours). We here use a similar theoretical framework.

Consider two individuals $\{i,j\}$ in a couple, and imagine that individual i chooses BMI_i, with preferences represented by the utility function $U_i(BMI_i,BMI_j,x_i,\varepsilon_i)$. Here, x_i and ε_i are the observed and unobserved variables that shift preferences and constrain choices, *e.g.* the socio-demographic characteristics of the individual and the household, and contextual factors such as food prices or the supply of sport facilities etc. Following the terminology proposed by Manski (2000), there are social interactions in preferences when individual *j*'s choice, BMI_j, affects the marginal utility of individual *i*'s choice, BMI_i. Then, if we assume that individuals react to others in a best-response manner, we have a simple first-order condition for individual *i*'s BMI. A comparative static analysis reveals that the direction of the response of individual *i* to a change in individual *j*'s BMI will depend on the sign of cross-partial derivative, $\partial^2 \mathrm{U_i} / \partial \mathrm{BMI_i} \partial \mathrm{BMI_j}$:

$$\frac{\partial U_i}{\partial BMI_i} = 0 \Rightarrow \frac{dBMI_i}{dBMI_j} = -\frac{\dfrac{\partial^2 U_i}{\partial BMI_i \partial BMI_j}}{\dfrac{\partial^2 U_i}{\partial BMI_i^{\,2}}} \qquad \textbf{(1)}$$

Since marginal utility is decreasing ($\partial^2 \mathrm{U_i} / \partial \mathrm{BMI_i}^2 < 0$), we observe following behaviour ($dBMI_i/dBMI_j>0$) if and only if the cross-partial derivative is significantly positive, *i.e.* if an increase in my partner's BMI reduces the marginal disutility of my own BMI. The research in the domain of social interactions has mostly focussed on the identification of reaction functions. When preferences are represented by a quadratic utility function, the best-response function defined by the first-order condition in (1) corresponds to the linear-in-means empirical specification proposed by Manski (1993), whereby individual *i*'s choice is a linear function of *j*'s action, and other preference and constraint factors (observed and unobserved).

This is the empirical specification implemented in the economics literature on peer effects in obesity. Hence, the observation of significant social contagion effects in these models requires that the cross-partial derivatives of the utility function with respect to partners' choices be significantly positive. Instead of estimating a linear-in-means model for individual BMI, we here borrow empirical tools from the economics of well-being to identify directly one of the primitives of social interactions: the cross-partial derivative between own and others' body shape, where "others" here refers to the individual's partner.[5]

We will thus in this paper estimate, separately for men and women, empirical equations of the broad type:

$$S_i = \mathrm{U}(BMI_i, BMI_j, x_i, \varepsilon_i) \qquad \textbf{(2)}$$

where U(.) is the utility function we want to identify using life satisfaction S_i as a proxy measure of individual utility. With an estimate of equation (2) in hand, it is possible to compute the cross-partial derivative. As noted above, if this latter is non-zero having a heavier spouse affects the marginal utility of my own weight, and therefore my incentives to gain or lose weight.[6]

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[5] We therefore propose a test of a *necessary* condition for the existence of social contagion assuming that individuals in couples behave strategically *à la* Nash, as is implicitly the case in the economic literature on peer effects in obesity. We are aware that spouses may instead act collectively, *e.g.* be Nash-bargainers as in Manser and Brown (1980), McElroy and Horney (1981) or Bolin *et al*. (2001), or follow a more general Pareto-efficient decision process, as in the model of collective decision making proposed by Chiappori (1988). These models are unable to generate predictions in terms of influence effects within the couple, since spouses do not take their decisions individually but collectively. They can however predict a positive correlation between spouses' BMIs, as spouses are simultaneously affected by the determinants of household decisions: individual and collective preference factors; environmental variables such as food prices; and gender-specific distribution factors that affect the bargaining power of household members, such as the local sex-ratio or the local gender-specific unemployment rate etc. (see Browning and Chiappori, 1998). One way to re-introduce a strategic dimension is to assume that individuals play a two-step game. In the first step, each spouse chooses her/his BMI so as to maximize her/his bargaining power, given the BMI of her/his partner and, presumably, the distribution of BMIs in the pool of potential alternative partners. In the second step they collectively choose their consumption and labour supply, conditionally on their bargaining power. By backward induction, the utility function used in the first step is similar to the utility function we consider here.

[6] Blanchflower *et al.* (2009) use SOEP data to analyse the impact of own BMI, relative to the average BMI by age, on life satisfaction. Our work differs from theirs in three key ways. First, we consider a much tighter reference group than the age cohort: the partner, who arguably is much more salient for everyday decisions (especially eating). Second, we use a non-specific measure of well-being, life satisfaction, rather than a directly weight-related one (feeling overweight). Last, we present results with instrumented weight.

The drawback here is that own BMI is likely to be endogenous in equation (2), since unobserved individual characteristics (e.g. risk aversion, taste-for-food, lack of self-control) or environmental factors (e.g. the local supply of sport facilities) are likely to have an impact on both well-being and body weight: BMI_i may be correlated with ε_i. In addition, partner's BMI may be endogenous in equation (2), as common environmental factors affect individual and/or household decisions, and the formation of couples in the marriage market follows a matching process based on individual characteristics. If these are unobserved by the econometrician, BMI_j will also be correlated with ε_i.

Whether food choices are made collectively or by the household meal planner, shocks to food prices or food availability will likely affect both partners' BMIs in the same direction. Imagine for instance that a new mall with a cinema and a supermarket opens in a deprived neighbourhood. This may have a negative impact on BMI, by enhancing access to fresh fruit and vegetables, and a direct positive effect on life satisfaction by providing new leisure activities. Such hidden common factors will bias the estimated coefficients from equation (2), including that on the cross-partial derivative. However, the direction of the bias with respect to the latter is *a priori* unclear.

Individuals have aesthetic preferences over both themselves and their partners. Rational choice models of mate selection assume that individuals search for the best match among potential partners and compete with one another via their own resources. These latter resources include various forms of cultural, human and social capital, and the quality of the match is determined by the joint productivity of partners' resources in a marital production function (Becker, 1973, 1974). Resources that are complementary in the production of marital output should give rise to marital homogamy (positive assortative mating).[7] Homogamy has been found with respect to physical appearance, measured, *inter alia*, by height and weight.[8] In particular, the existence of positive assortative mating by BMI on the

[7] This holds if the marriage market is characterised by the optimal sorting of partners, whereby "*persons not married to each other could not marry and make one better-off without making the other worse off*" (Becker, 1973, 1974).

[8] On the positive impact of height on marital outcomes, see Herpin (2005) and Belot and Fidrmuc (2009). A nice historical illustration of the role of physical appearance is provided by Sköld (2003), who shows that in Eighteenth- and Nineteenth-century Sweden, those who were pockmarked by smallpox married about two years later than those without disfigured faces. This effect was gender-neutral, and revealed positive assortative

marriage market is revealed by the positive interspousal correlation in body weights between spouses (Schafer and Keith, 1990, Allison *et al*., 1996, Silventoinen *et al.*, 2003, and Oreffice and Quintana-Domeque, 2010). Empirical work has also shown the value of a healthy BMI on the marriage market by estimating an obesity penalty on the probability of being married rather than single (work in this direction on the U.S. National Longitudinal Survey of Youth includes Fu and Goldman, 1996, Averett and Korenman, 1996, and Mukhopadhyay, 2008). This penalty is more severe for young white women than for black women or men. These racial differences may be related to social norms of beauty, while gender differences are consistent with a greater willingness of women to trade their partner's BMI for other attributes such as higher income, better education or greater commitment to marriage.[9]

It is however important to note that positive assortative mating over BMI may pertain not only because BMI is an important dimension of physical attractiveness, but also because it reflects spouses' (unobserved) preferences, for example over rich food or exercise.[10] As these preferences are likely complements in the production of individual utility, the closer are my spouse's preferences to my own, the more satisfied I am. BMI here does not matter *per se*, but simply acts as an observable signal of unobserved preferences. People in couples with similar BMI will record higher happiness scores because they have similar unobserved preferences, and this will likely produce a positive cross-partial derivative (or at least bias its estimate upwards). In this case, if BMI acts only as a signal for stable unobserved preferences on the marriage-market, the fact that my spouse gains a couple of kilograms will not affect my own incentive to change my own weight.

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mating, as "healthy" individuals were more likely to marry each other, whereas pockmarked individuals were more likely to remain single or found only pockmarked partners.

[9] However, using subjective evaluations of physical attractiveness, Carmault *et al.* (2008) find in the Add Health data that both men and women "buy" physical attractiveness with years of education (and therefore income). Gender differences in evaluations may well thus be shrinking over time, as the Add Health survey covers a relatively young cohort.

[10] Whatever the individual marital status, own BMI is likely endogenous as it is correlated with individual preferences for food and exercise, and the latter are unobserved. BMI is an adjustment variable in the energy-balance equation: when calorie intake exceeds calorie expenditure, excess calories are stocked in fat cells and body weight increases (and the opposite when calorie expenditure exceeds calorie intake). Matching on unobserved preferences simply implies that, in addition, partner's BMI is endogenous.

Both hidden common factors and assortative matching on unobserved preferences correlated with BMI imply that both own and partner's BMIs are endogenous in equation (2). As such, Sections 4 and 5 will compare the results from regressions with and without instrumental variables techniques.

2.2 The utility of own BMI

Individuals have some degree of control over their body shape, even though this latter is limited by physiological mechanisms, at least in the short run (Cabanac, 2001). There is evidence from the social-psychology literature that individuals have an ideal body shape, which maximizes their satisfaction with body size. This latter can be thought of as a sum of satisfactions over a number of domains, amongst which probably figure health and beauty (see Etilé, 2007, and the references therein). Ideal body shape, and so BMI, is therefore likely related to health concerns and aesthetic preferences.[11]

The health aspect of BMI typically concerns both under- and over-weight. According to the WHO, underweight individuals have a BMI under 18.5, the overweight a figure over 25, and the obese a BMI of 30 or more. Epidemiological work has shown that mortality and morbidity risks increase significantly for BMI over a threshold of 27-28 for most adults and at all ages (see for instance Stevens *et al*., 1998, and Adams *et al*., 2006). For this reason alone, we imagine that, at least beyond a certain level, higher levels of BMI will lower utility.

The Health Services Research literature has underlined the strong correlation between overweight and obesity and various measures of Health-Related Quality of Life (HRQoL), which latter can be considered as a component of overall quality of life and a sub-domain over which individuals evaluate their utility (Ferrans *et al*., 2005). Those with high values of self-reported or measured BMI have a lower HRQoL, with an impact that varies by age, sex and race. This negative association stems more from the effect of obesity on physical functioning than that on mental functioning, and is not country-specific (see the review in

[11] While BMI is a good predictor of weight-related morbidity at the population level, it does not take into account the distribution of fat and muscle in the body, and may not be a very good predictor of body shape at the individual level (Burkhauser and Cawley, 2008). However, for most adults, the correlation between BMI and body fat remains fairly strong (Prentice and Jebb, 2001).

Kolotkin *et al*., 2001, and the country studies in Le Pen *et al*., 1998, Han *et al*., 1998, Hassan *et al*., 2003, and Søltoft *et al*., 2009). The relationship between BMI and HRQoL is robust to the measure of well-being used, with qualitatively similar results from 'universal scales', such as the SF-36, the EuroQol EQ-5D, and the EuroQol Visual Analog scale, and utility measures developed specifically for the obese (see for example Le Pen *et al*., 1998, Jia and Lubetkin, 2005, and Sach *et al*., 2007). Observational studies using large cohorts have found that weight loss is associated with improved HRQoL (Fine *et al*., 1999). However, there is also evidence that individuals seeking treatments for obesity are likely to have lower HRQoL than those who do not look for treatment (Kolotkin *et al*., 2002). Additional research is thus needed to assess the causal effect of weight loss on quality-of-life, which is key for the evaluation of the benefits of medical weight-loss programs and public-health policies aimed at the overweight and obese. In this perspective, Section 5 in the current paper appeals to instrumental variable techniques.

Last, health is likely linked to productivity, and therefore labour-market outcomes. Both Averett and Korenman (1996) and Cawley (2004) find that medically-obese white women earn lower wages in the USA. Beyond its direct effects on HRQoL, BMI may then affect utility through health-related labour-market outcomes.

Aesthetic preferences are especially influenced by social norms of beauty, which differ across time and social classes.[12] Using individual French data on actual and ideal BMIs, Etilé (2007) finds that, for given levels of education, income and household structure, average ideal BMI does not differ between employees, professionals and executives, while blue-collar workers have higher ideal BMIs. Ideal BMI will not thus necessarily correspond to any health threshold (*i.e.* neither the 27-28 BMI health threshold, nor the official WHO overweight threshold of 25). This diversity in ideal BMI may spill over to the labour-market outcomes

[12] The turn of the Twentieth century was marked by a change in ideals of beauty, especially for women. Women's thinness became a status signal in societies typified by the Protestant ethic between 1890 and 1920: fatness was supposed to go hand-in-hand with gluttony and lack of self-control (Kersh and Morone, 2002). The ideal of thinness then spread from the upper to the middle classes after World War II, especially for women as they were able to take greater control of their body *via* birth control (Fischler, 1990). This diffusion process was limited to white-collar workers, consistent with a certain separation between the lifestyles (foodways, body practices) of different social classes (Bourdieu, 1979). For instance, a strong body is a requisite for manual work, and Boltanski (1971) notes that working-class men often expressed their disdain for the effeminate bodies of upper-class men.

evoked above: using ECHP data, Brunello and D'Hombres (2007) show that the wage-BMI relationship is significantly negative in Southern European countries, but zero in Northern Europe.

Health and labour-market concerns then produce a BMI – utility relationship which is fairly flat up to the threshold of 27-28, and negative and concave thereafter. Aesthetic preferences imply that any departure from the aesthetic ideal will reduce individual utility: we thus expect well-being to be hump-shaped in own weight. The sum of these two effects will produce a BMI – utility relationship which is also hump-shaped, but with a peak that likely differs from the medical threshold of 27-28, and asymmetric, being flatter to the left of this peak. This peak represents the ideal BMI, which maximises individual utility.

2.3 The utility of partner's BMI

Although the impact of BMI on well-being or HRQoL has been widely investigated, little is known about the well-being effect of others' BMIs. In a couple, partner's BMI may well have a direct effect on utility, independently of the individual's own BMI.

Partner's health and labour-market outcomes depend on their BMI, as discussed above. Part of the individual's preference for their partner's health is undoubtedly altruistic. A more self-interested argument is that individuals prefer to have a healthy partner to look after them in case they become ill themselves. Conversely, if their partner's health deteriorates due to overweight-related illness, then they will be responsible for more of the domestic tasks.

Marriage-market outcomes partly reveal the 'aesthetic' value of partner's body weight. However, little is known about what happens after people enter in a marriage or a cohabiting spell. Recent work by Averett *et al*. (2008) concludes that individuals tend to gain weight during marriage or cohabitation (see also Sobal *et al*., 2003). This is interpreted as evidence of the impact of social obligations linked to marriage (eating regularly, and/or richer food), or that maintaining a low BMI is too costly once individuals have been matched. While this might suggest that aesthetic preferences over one's partner have little effect on one's own utility,[13] this is perhaps less true if the partner becomes obese.

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[13] Lundborg *et al*. (2007) uncover empirical evidence of a negative correlation between Body Mass Index (BMI) and the aggregate risk of divorce (proxied by the national rate) among married middle-aged European

As was the case for the impact of own BMI, the impact of partner's BMI on own utility is the sum of its aesthetic, health and labour-market effects. This is again likely to produce a hump-shaped relationship, flatter for low BMI values than for high BMI values, and decreasing after some threshold that can be interpreted as the ideal partner's BMI in the individual's own view.

We now consider the interactions between own and partner's BMI in utility, which determine the sign of the cross-partial derivative. As discussed in Section 2.1., a necessary condition for the existence of contagion effects is that the latter be positive.

2.4 The interaction between own and partner's BMI

There are at least three channels through which partner's BMI can influence the marginal utility of own BMI.

First, individuals may compare their body weights to each other, as in the literature on relative utility (see Clark, 2008, and Clark *et al.*, 2008). While being overweight likely reduces utility, ***social comparisons*** with a household-based reference group imply that this negative impact is watered down if the partner is overweight as well. Under social comparisons, the cross-partial effect is positive when both partners' BMIs are both under or both over some ideal levels, and negative when one of the partners' BMIs is under and the other is over the ideal level.

Second, there is a ***productivity and household bargaining*** argument. We can first imagine the joint production of leisure, where a significant gap in BMIs may prevent the couple from undertaking certain activities together (e.g. eating or strenuous physical activity). As for social comparisons, this implies a positive cross-partial derivative when both partners' BMIs are both under or both over some ideal levels, and negative when one of the partners' BMIs is under and the other is over the ideal level. In addition, the BMI-income relationship will have an effect on both the amount of household output, as discussed in Section 2.3 above, but also potentially on its division. An overweight spouse may earn less, reducing household

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individuals in SHARE data. This correlation is insignificant for singles, which is interpreted by the authors as evidence of forward-looking behaviour: the greater the risk of divorce, the more individuals prepare their body for a future come-back on the marriage market. If this is true, body sizes would have some importance only for those individuals who grant some importance to their potential value on the marriage market.

resources. However, if bargaining power in the household depends on relative weight (via individuals' chances in the remarriage market), then those whose spouse puts on weight will see their bargaining power rise. The marginal utility of own BMI in terms of bargaining power is likely to decrease for high BMI values, but it will decrease much less if the partner's BMI is also high. The cross-partial effect should once again be positive when both partners' BMIs are both under or both over some ideal levels, and negative when one of the partners' BMIs is under and the other is over the ideal level.

Last, individuals with largely overweight or obese partners are likely to take care of more domestic tasks, and may even be responsible for part of their partner's health care if the latter is ill. Both of these will be easier if they are not overweight themselves. In this case, an overweight partner's BMI will have a negative impact on own utility, and this utility spillover will be larger if the individual is also overweight or obese. In addition, partner's BMI is likely to carry information about the potential health risks of being overweight. A positive shock to partner's BMI may be correlated with health problems (e.g. the diagnosis of diabetes) that we do not observe. The individual may use this information to learn about the likely impact of own BMI on utility, as in Clark and Etilé (2002): a positive shock to partner's BMI will then have a negative impact on the marginal utility of own BMI, for BMI values higher than some ideal levels. The presence of ***health care needs*** and ***information*** about health risks may switch the complementarity of BMIs in the production of utility into substitutability when both partners have large BMIs.

These three aspects of spousal interactions imply that partners' BMIs may be complements or substitutes in the production of utility, depending on the values of own and partner BMIs relative to their ideal levels. Only complementarity (a positive cross-partial effect) is consistent with contagion effects. In terms of public policy, it is particularly interesting to consider those couples who both have high BMIs and are therefore both above these ideal levels. For them, the social comparisons and production/household bargaining arguments suggest complementarity, while the health care and learning arguments imply substitutability. For the other couples, we expect complementarity, *i.e.* a positive cross-partial derivative, when both partners' BMIs are in the healthy range, and substitutability when one partner is overweight and the other is not. Section 4 will test these predictions, assuming away hidden common factors and the selection bias. Section 5 will then challenge Section 4's results by proposing an instrumental variable approach to the estimation of equation (2).

Section 3 below now presents the data that we will use to evaluate the sign of the cross-partial effect in life-satisfaction regressions.

3 Data

Our empirical analysis is based on data from three waves of the German Socio-Economic Panel (SOEP), 2002, 2004 and 2006, which contain data on height and body weight. The SOEP is a long-run panel data set, starting in 1984, with data collected at the household and individual levels (see Wagner *et al.*, 2007). Information on our key variables is non-missing for 19899 individuals aged 18 or over (adults) living in private households: 14386 of these individuals (72.3%) were observed over all three years, 4028 over two years and 1485 for one year only. We refer to these observations as sample 1. In this sample, 73.4% of the 52699 individual-year observations refer to individuals who are living in a couple ("married"). Our main estimation sample, Sample 2, is made up of paired observations on the couples of men and women in Sample 1. Over the three waves, this produces information on 6555 couples, of whom 4328 (66.0%) are observed over all three waves. The different numbers of observations in these samples are described in Table A1.

Table A2 in Appendix A presents the descriptive statistics for the married and unmarried in both samples. There are significant differences between these two groups in Sample 1. Single women are older and are more often retired, with less education, partly because they are more often widowed. Single men are on the contrary younger, less educated and are more often in apprenticeship or unemployed than are married men. These statistics reflect the matching equilibrium in the marriage market, wherein older women and younger men are more likely to be single. The married in Sample 2 are mostly similar to those in Sample 1. We now present our two key variables: life satisfaction and BMI.

3.1 Life satisfaction

The dependent variable in the empirical analysis is life satisfaction. This comes from the response to the question "*How satisfied are you with your life, all things considered*"? This question is asked of all respondents every year in the SOEP. Responses are on a eleven-point scale from zero to ten, where 0 means completely dissatisfied and 10 means completely satisfied.

A recent literature has argued that utility can usefully be measured by well-being questions in large-scale surveys, and there is now a wide body of evidence supporting the evidence that life satisfaction is a valid measure of subjective well-being (Ferrer-i-Carbonell and Frijters, 2004; van Praag and Ferrer-i-Carbonell, 2004, Clark *et al*., 2008). More specifically, individuals are able to recognise and predict the satisfaction level of others (cross-rater validity). There is also evidence of a strong positive correlation between physiological expressions of emotions (from smiles to brain activity known to correspond to specific feelings) and answers to well-being questions. Last, current satisfaction has been shown to predict a number of future behaviours, including job quits, marital break-up and life expectancy (see Clark *et al*., 2008, Section 2 for more details).

The medical literature has tended to focus on measures of HRQoL. These are constructed from responses to a number of items, as multi-item scores are considered to produce more accurate measurement. By way of contrast, subjective well-being is much less specific, and is interpreted as a synthetic measure of overall quality-of-life (Ferrans *et al.*, 2005). Life satisfaction is thus a summary measure of quality-of-life over all the domains that are relevant to the individual, including physiological and psychological health. It is perhaps therefore unsurprising that work looking at the impact of life events or some specific condition on well-being finds similar effects, whether well-being is measured by life satisfaction or HRQoL. For example, Blanchflower and Oswald (2008*a*) note positive and significant correlations between levels of hypertension and both life satisfaction and a more specific General Health Questionnaire mental distress score (the GHQ-N6). Equally, Blanchflower and Oswald (2008*b*) find a similar U-shaped relationship between age on the one hand, and life satisfaction and various measures of mental stress (GHQ-N6, anxiety, depression) on the other hand. Last, it is worth noting that HRQoL data are often used to estimate utility values of health states in cost-benefit analyses. By using life satisfaction as a utility measure, we thus combine traditions from both the economics of happiness and the health services research literature.

3.2 BMI

The main explanatory variable in our analysis is BMI. Table A2 shows that the single have lower BMIs than do the married, with this BMI gap being smaller for women than for men. This gender difference may partly reflect age, as individuals generally gain weight up to a fairly advanced age, and single women are more likely to be old (widowed) than are single men.

Figure 1 presents non-parametric regressions of life satisfaction on own BMI for women and men (the solid line) in sample 1, together with the associated 95% confidence interval (the dotted lines). Women's satisfaction is almost always decreasing in own BMI, while men's satisfaction is hump-shaped, increasing up to a BMI of about 25 (the threshold for overweight), and then falling. Men with low BMIs are more satisfied than men with BMIs of over 32, but less satisfied than overweight men. One reading of Figure 1 is that ideal BMI is relatively low for women, but close to the overweight level for men. This gender asymmetry may reflect gender differences in aesthetic norms or tastes for food, since medical norms are not gendered.[14]

The other control variables in the regressions include age, real equivalent after-tax and transfers income per unit of consumption (in 2004 Euros),[15] the number of individuals in the household, labour-market status (full-time employee, which is the reference category, part-time employee, apprentice, retiree, unemployed, housewife/husband, and other), education (in years), and wave and region (Länder). Note that, in each life-satisfaction equation, both partners' individual variables (education, age, labour-market status) will be entered as control variables.

4 Satisfaction and Couple BMI

This section estimates life satisfaction equations using both least squares and semi-parametric methods. The empirical model is:

$$LS_{it} = f(W_{it}, W_{jt}) + \alpha X_{it} + \varepsilon_{it} \qquad \textbf{(3)}$$

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[14] The relationship between BMI and the proportion of fat mass in total body mass is likely to be more heterogeneous for those men who are just slightly overweight than in obese men (Prentice and Jebb, 2001). An ideal BMI of 25 may just reflect the social requirement of having muscles (or, at least, looking muscular).

[15] We do not control for individual income, as the latter is the sum of labour and non-labour incomes, and the structure of the SOEP data set renders it impossible to impute non-labour income to one or other of the partners. Nevertheless, to test whether own income matters in addition to household income – it is likely to influence the bargaining power of each spouse - all of our models have been re-estimated with two additional control variables: the husband's and wife's labour earnings. The main results were unchanged.

where W_{it} and W_{jt} are the two partners' BMIs at time *t*, X_{it} is a set of control variables for both partners' individual characteristics and for household characteristics, ε_{it} is an error term, and f(.) is a function to be specified (or not).

4.1 Parametric regressions

We first estimate equation (3) parametrically by gender, specifying the function f(.) as a series of dummy variables. We construct three dummies showing whether the individual is not overweight (BMI<25), overweight but not obese (25≤BMI<30) or obese (BMI≥30). The dummies for the two partners are then interacted, producing nine possible combinations of spou-sal weights.

These linear equations for men and women are estimated simultaneously by seemingly unrelated regression techniques.[16, 17] The omitted BMI category in these regressions is "Man not overweight: Woman not overweight". The estimated coefficients in Table 1 show that life satisfaction is lower for all other spousal weight categories. For ease of presentation, the pattern of estimated coefficients in Table 1 is also depicted graphically in Figure 2, with the error bars corresponding to the 95% confidence interval. These confidence intervals are quite wide, so that there are few significant differences between levels of life satisfaction as spouses' BMIs vary.

The top-left panel of Figure 2 shows that women's life satisfaction falls with their partner's BMI, as long as they are not overweight themselves. However, when they are overweight they are better-off when their partner is overweight too (top-middle panel), and when they are obese, they are better off when their partner is overweight or obese. For women then, the best life-satisfaction situation is always to have the same weight status as their partner. These results also suggest that an overweight woman married with a non-overweight man does not suffer from a loss of well-being when she becomes obese, if at the same time her partner becomes overweight, while she is significantly less satisfied if he

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[16] The ordered probit model is very popular in the well-being literature. In our sample, Seemingly Unrelated REgressions and ordered probit with or without individual random effects yield very similar results.

[17] We here use an unbalanced panel, and attrition may be an issue if it is correlated with divorce and divorce depends on partners' BMIs and life satisfaction. To test whether attrition matters, we re-estimated the model using the balanced sample: the results were unaffected. Attrition does not play a role in the Instrumental Variable results in the following Section as these apply to the balanced sample.

remains at a healthy weight: in the top-right panel, the life-satisfaction difference between the first two-bars is 0.25 points (significantly different from 0 at the 10% level). This loss in women's life satisfaction is sizable, and is tantamount (comparing to the estimated coefficient on income) to a 38% increase in equivalent income.

The story for men is somewhat different. As for women, non-overweight men are most satisfied, *ceteris paribus*, when their partner is not overweight either. However, and contrary to women, overweight men are also the most satisfied when their partners are not overweight. The situation changes for obese men, who are the most satisfied with an obese partner. The complementarity between partners' weights thus seems more relevant for women than for men, which latter are most satisfied with partners in the lowest-weight category, as long as they are not obese themselves. The overall conclusion from these parametric regressions is that there seem to be significant positive cross-partial effects in BMI for women, but rather less so for men.

The regressions in Table 1 include all of the standard control variables described above. We have not shown their estimated coefficients for space reasons (and because there are now any number of published pieces of work which appeal to SOEP life satisfaction regressions – for example Blanchflower *et al*., 2009, and Ferrer-i-Carbonell and Frijters, 2004). As is often found, life satisfaction is higher for the richer and the better-educated, lower for the unemployed, and there is a U-shape relationship with age, minimising in the late forties.

The results so far have relied on an *ad hoc* specification of the f(.) function in equation **(3)**. Following Section 2.4, the sign of the cross-partial effect likely depends on own and partner's BMIs. To trace out the pattern of the interaction effect, and to check that our empirical results do not depend on the choice of functional form, we now turn to semi-parametric estimation.

4.2 Semi-parametric regressions

We here estimate equation **(3)** without explicitly specifying the shape of the relationship between partner BMI and own life satisfaction. To this end, we use a penalized-spline approach, which is implemented using linear mixed models and bivariate basis functions of partner BMI (Ruppert *et al.*, 2003). Some technical details of the estimation procedure are provided in Appendix B.

The regression results are depicted by a series of figures which represent contour maps of life satisfaction levels, marginal effects and cross-partial effects, in the space of own and partner BMIs. In all of the figures, husband's BMI appears on the Y-axis and wife's BMI on the X-axis.

The left- and right-hand panels of Figure 3 show the conditional mean life satisfaction scores for men and women respectively. These are conditional in the sense that all of the standard control variables described in Section 3 and used in Section 4.1 above are also included in these regressions (which controls attract coefficients that are qualitatively extremely similar to those in the parametric analysis).

The figures are to be read as contour maps. The highest life satisfaction scores are reached at the peak of the hills. In the left-hand panel, this peak satisfaction corresponds to an own BMI of between 22 and 23 for women, and a partner BMI of between 24 and 25. Remarkably, the coordinates of peak satisfaction for men in the right-hand side panel are almost exactly the same. There hence seems to be little gender difference in the BMI values at which both partners' satisfactions are maximised.

The iso-satisfaction lines around the peak are approximately symmetric around the 45-degree line. Any deviation from this line corresponds to lower life satisfaction. Satisfaction also falls as we move away from the peak along the 45-degree line, be it to the South-West or the North-East. Hence, both jointly high and jointly low levels of BMI are associated with lower well-being compared to the ideal point, as is the BMI gap between partners.

Figure 4 presents the results of significance tests for the marginal effects of women's BMI on their own and their partner's life satisfaction. The black area here denotes BMI pairs for which the marginal effect of women's BMI is significantly positive at the 5% level, the grey area BMI pairs for which it is significantly negative, and white areas insignificant effects. These figures thus provide information about the significance of the slopes of the hills depicted in Figure 3.

Figure 4 refers to the marginal satisfaction effects of female BMI. As women put on weight we move horizontally from left to right in this figure. For example, in the left-hand panel, consider a very slender woman (*i.e.* at the far left of the figure) whose partner has a BMI of 25. As this woman gains weight, her satisfaction increases significantly, but only up until her BMI hits around 19.5. After that point, increasing BMI has no significant effect on her satisfaction, and indeed starts to reduce it significantly once she hits a BMI of 23.5. With a male BMI level of 25, the woman's ideal BMI from her point of view is thus somewhere between 19.5 and 23.5.

Now imagine the same women, but this time with a partner whose BMI is 30 (so that we start from a point in the North-West of the figure). As she gains weight her satisfaction increases significantly up to an own BMI level of 21.5, and now does not turn down again significantly until an own BMI level of 26.5. With a much heavier male partner, the woman's ideal BMI from her point of view is now in the interval between 21.5 and 26.5.

The right-hand panel of Figure 4 shows the effect of female BMI on her partner's satisfaction. This figure is read completely analogously to the left-hand panel for female satisfaction described above. From a BMI of 25 male point of view, the woman's ideal BMI is in the 20.5-24.5 range, while from a BMI of 30 male point of view, the woman's ideal BMI is in the 23.5-30.5 range.

For completeness' sake, Figure 5 shows the analogous figures for the marginal effect of male BMI on both own and partner's life satisfaction. As men put on weight we move vertically from bottom to top in this figure. The results here are comparable to those in Figure 4 and probably do not call for any particular further comment.

Figures 4 and 5 thus underline three main points about weight and well-being in couples. The first is that the cross-partial effect is positive. The marginal effect of own BMI on own and partner's life satisfaction is higher at higher values of partner's BMI. This is illustrated in Figure 6 which shows that the cross-partial effect is always positive, although it is not significant for low-BMI couples and very-high BMI couples. This result is only partially consistent with the social comparison and productivity/household bargaining arguments presented in Section 2.4 above, as these also imply negative cross-partial derivative for couples when one partner is above and the other is under some ideal level. These couples can be found in the upper left and lower right part of the panels, but are associated with insignificant or positive cross-partial interaction effects in the production of utility. However, since there are far fewer couples with dissimilar BMIs than there are couples with similar BMIs, the shape of preferences (the function f(.)) is more accurately identified for the latter than for the former (see Appendix B).

The second main point that comes out of these figures is that, perhaps unsurprisingly, males' ideal BMI from both their own and their partner's point of view is greater than females' ideal BMI (again, both from their own and their partner's point of view).

Last, there is a sex difference in terms of views of women's ideal BMI: the ideal woman from the male point of view has a higher BMI than the ideal woman from the female point of view. One interpretation of this finding is that women may be more sensitive to would-be body-shape norms regarding their own weight than are men regarding their partner's weight.[18]

This section has thus presented evidence of significant positive cross-partial effects in partners' weights, for both men and women, potentially driven by social comparison and/or productivity and household bargaining motives. The key remaining issue here is whether the BMIs are endogenous, as discussed in Section 2.1. Under social interactions, an exogenous movement in one partner's weight affects the marginal utility of one's own weight (and thus one's own behaviour). Alternatively, considering weight as endogenous, these cross-section results may instead reflect either a hidden common factor driving both partners' weights and their satisfaction, or the selection into couples of individuals of roughly the same weight. In the latter case, weight is acting as an index of underlying preferences, and an exogenous movement in one partner's weight will have no effect on the marginal utility of the other partner's weight.

The following section attempts to distinguish between these alternatives by appealing to instrumental variable techniques.

5 Instrumental Variable Results

To instrument weight, we return to a parametric specification. This is justified by the fact that the cross-partial effect is mostly significantly positive in the Figures above. We consider a linear specification of equation **(3)** including quadratics in own and partner's BMIs plus an interaction term between the two weights:

[18] The same result is found using French data in Etilé (2007).

$$LS_{it} = \alpha_1 W_{it} + \alpha_{11} W_{it}^2 + \alpha_{12} W_{it} W_{jt} + \alpha_2 W_{jt} + \alpha_{22} W_{jt}^2 + \alpha_X X_{it} + \varepsilon_{it} \quad \textbf{(4)}$$

The key coefficient in this equation is α_{12}, the cross-partial derivative. A significant positive estimate of this coefficient is consistent with contagion effects in BMI between spouses. As noted above, the BMI variables are likely to be endogenous. The least-squares estimates in Section 4 are thus likely to be biased, and we now discuss an instrumental variable (IV) strategy to obtain unbiased estimates.

5.1 An IV procedure

Let W_{ijt} be the column vector of BMI variables $(W_{it}, W_{it}^2, W_{it}W_{jt}, W_{jt}, W_{jt}^2)'$, and $\alpha_W=(\alpha_1, \alpha_{11}, \alpha_{12}, \alpha_2, \alpha_{22})$ the row vector of corresponding coefficients. As in Cawley (2004), we can decompose the well-being residual ε_{it} into a time-invariant component $u_{i,LS}$ reflecting the impact of fixed unobserved individual characteristics, a time-varying component $v_{it,LS}$ which picks up the impact of hidden factors, and a residual $\eta_{it,LS}$ that is i.i.d. over individuals and time:

$$LS_{it} = \alpha_W W_{ijt} + \alpha_X X_{it} + u_{i,LS} + v_{it,LS} + \eta_{it,LS} \quad \textbf{(5)}$$

The BMI variables are in turn affected by a set of exogenous observable variables Z_{it} and unobserved time-invariant and time-varying factors, $u_{i,W}$ and $v_{it,W}$ such that:

$$W_{ijt} = \beta Z_{it} + u_{i,W} + v_{it,W} + \eta_{it,W} \quad \textbf{(6)}$$

where the residual $\eta_{it,W}$ is i.i.d. over individuals and time. The assumption that the BMI variables are exogenous in (5) will hold only if the unobserved factors that influence BMI are uncorrelated with the unobserved factors affecting well-being. The literature proposes two strategies to deal with these correlations, using the information available in the survey.

First, fixed-effect estimators can control for fixed unobserved heterogeneity (*i.e.* the $u_{i,LS}$), and imply the analysis of changes in well-being within individuals over time. The fixed-effect estimator is unbiased if the within-individual time variation in unobserved heterogeneity is uncorrelated with the same variation in BMI (Baum and Ford, 2004). This assumption is fairly strong, as any shock to life satisfaction may well go hand-in-hand with changes in body weight.

The second strategy is to use instrumental variables in Z to predict the BMI variables. These instruments must satisfy two conditions: they should not be weak, in the sense that they must predict a significant part of the variance in the BMI variables; and they have to be orthogonal to the unobserved variables in equation (5), *i.e.* Z must be uncorrelated with both $u_{i,LS}$ and $v_{it,LS}$. Various types of instrument have been proposed to estimate the causal effect of BMI on human capital (schooling or labour-market outcomes). In particular, Morris (2007 and 2008) uses mean BMI and the prevalence of obesity in the area in which the individual lives. However, these variables are likely to be correlated with $v_{it,LS}$ since they act as a proxy for local norms of corpulence, and the latter may affect the marginal utility of spouses' BMIs.[19]

Our own strategy is to exploit the biological dynamics of body weight to instrument using past values. The idea is that body weight is a capital. BMI at time *t* can be broadly expressed as a function of BMI at time *t-1*, plus the kilograms produced by the disequilibrium between calorie intake and calorie expenditure. As Z_{it} includes W_{ijt-1}, we could use the latter as an instrument for W_{ijt} (see Averett and Korenman, 1996, for an example). However, this instrument is unlikely to be valid, as W_{ijt-1} depends on time-invariant heterogeneity $u_{i,W}$ and the latter is likely to be correlated with $u_{i,LS}$. We can nevertheless appeal to the instrumentation techniques used in linear dynamic models, and instrument BMI at time *t* by its first-difference and lags of its first difference (Blundell and Bond, 1998). We here instrument the five BMI terms *via* their first differences. As we only have three waves of data, this boils down to modelling life satisfaction in the third wave of our data (2006), and instrumenting the BMI variables by their change between waves 1 and 2, and 2 and 3 (*i.e.* 2002-2004, and 2004-2006).

Past changes in weight, and especially past weight increases, are good predictors of current weight for physiological reasons. Rising weight means either more muscle or more fat, and for most people it is the latter rather than the former. In the long-run, fat mass reflects the net balance between calorie intake and expenditure. Any permanent excess calorie intake is converted into fat and stocked in a particular type of cell called adipocytes. When adipocytes are 'full', they induce the proliferation and differentiation of other cells (called

[19] See Blanchflower *et al.* (2009) for the well-being effect of mean BMI. Other instruments in the literature include local food prices (Thomas and Strauss, 1997), the BMI of parents or siblings (Cawley, 2004, Brunello and D'Hombres, 2007) and genetic variations (Norton and Han, 2008). None of these variables is available in the SOEP which, in addition, can not easily be matched with alternative sources of area-level information.

adipocyte precursors) which increase the number of mature adipocytes (Pénicaud *et al.*, 2000). This has two major consequences. First, the loss of adipocytes seems much more tightly regulated than the proliferation of adipocytes: even the major weight loss from bariatric surgery fails to reduce significantly the number of adipocyte cells (Spalding *et al.*, 2008). Second, the adipose tissues not only store fat, they also play an important role in the signalling of satiety (among other endocrine functions). Individuals with more adipose tissues have their hunger more rapidly stimulated after a meal (Gale *et al.*, 2004, Ahima, 2006). Past increases in weight thus reduce the ability to lose weight and to maintain weight loss, and increase the probability of gaining weight for purely physiological reasons. This is depicted in Figure A1 in Appendix A, where the correlation between BMI at 2006 and the change in BMI between 2004 and 2006 is positive and significant for the overweight only.

The first difference W_{ijt}-W_{ijt-1} will be a valid instrument for W_{ijt} if the change in unobserved heterogeneity $v_{it,W}$-$v_{it-1,W}$ is orthogonal to $u_{i,LS}$ and $v_{it,LS}$. While changes in body weight are arguably orthogonal to fixed unobserved factors ($u_{i,LS}$), it is not clear that they will be uncorrelated with the time-varying unobserved variables affecting life satisfaction ($v_{it,LS}$). We can imagine that shocks to body weight due to life events, such as job loss or divorce, are correlated with the latter. However, given the construction of the instruments, we have restricted our sample to those couples who are observed over our three consecutive periods (2002, 2004, 2006). This excludes individuals who experienced marital break-up. We also control for both partners' labour market statuses and for household income, which rules out any potential correlation with economic shocks. Last, we have five over-identifying restrictions (one for each instrumented variable), and the Hansen-Sargan statistic tests the validity of these over-identifying restrictions. We also report the Cragg-Donald statistic to test instrument weakness in the first-step regressions, as weak instruments increase the probability of accepting the over-identifying restrictions. This statistic is the equivalent of the usual F-statistic for the first-stage instrumental equation when there is more than one instrumented variable, and a value over 10 indicates that the instruments are fairly strong (Stock and Yogo, 2005).[20]

[20] Note that all of the instruments are significant in the first-step regressions.

5.2 *Instrumental Variable Results*

Table 2 presents both the instrumental variable results and, for comparison purposes, those from OLS regressions using the same specification. The results are presented separately for men and women. Three different samples are used for each sex: everyone, and then distinguishing between shorter and longer marriages (as defined by the median duration of marriage of 22 years in our data). The statistics at the foot of the table show that the over-identifying restrictions are accepted, and that the instruments are of good quality.

Own BMI now exhibits a hump-shaped relationship with satisfaction in the instrumented results for women. This is to be compared to the negative correlation identified in Figure 1. The instrumented and uninstrumented results likely differ due to the presence of omitted variables that are correlated with BMI and satisfaction in opposite directions. (e.g. lack of self-control, absence of sport facilities, or urban deprivation). Between women, those with lower BMIs are thus more satisfied, but within subject the BMI-satisfaction relationship is not necessarily negative. Something similar can be seen for men. The weight-satisfaction relationship is hump-shaped in all specifications for them, but the peak shifts notably to the right in the instrumented results, again consistent with an omitted variable. It should also be borne in mind that the instrumented estimates give more weight to individuals with higher levels of BMI (see Figure A1), and the results should be thought of as more representative for the overweight.[21]

Of most interest in this table is the fifth line, which shows the estimated coefficient on the interaction between own and partner weight in a life satisfaction regression. This interaction, which is positive in the OLS regressions for both sexes in the full sample, becomes negative, but insignificant, after instrumentation. The change from positive to negative can be read as signifying a selection effect, whereby individuals are happier to be in a couple with someone who shares their preferences, with BMI being a signal and a proxy for these preferences. This complementarity in unobserved preferences implies positive assortative matching on BMI in the marriage market: individuals who are closer to some ideal BMI will tend to marry each

[21] As emphasised by Angrist and Imbens (1995), IV estimates of heterogeneous treatment effects identify the average causal response in the population, and over-represent individuals whose behaviour is more affected by the instrument.

other This selection effect is then what we pick up in the uninstrumented results. Alternatively, the uninstrumented results may have been driven by a hidden common factor. It may be the case for instance that richer areas both provide healthier food options and better sporting facilities, affecting weight, and are also in general more pleasant places to live. Once within these common areas, changing spousal weight does not affect the disutility of my own weight.

Within a given couple, the instrumental results then show that an increase in one member's weight no longer reduces the incentives of the other member to lose weight. As such, our results are not consistent with a contagion effect of weight within couples.

Columns 3 to 6 of each panel in Table 2 show the results when we split our sample up into shorter and longer marriage durations. It is striking that all of the difference between the OLS and the IV results comes from individuals who are in longer marriages. Any bias in the cross-partial effect then seems to concern primarily those in longer marriages.

The instrumented cross-partial effect for those in longer marriages is negative, and significantly so for women. As noted in Section 2.4, this is consistent with healthcare or learning effects. The healthcare effect may indeed be particularly salient in longer marriages where couples are likely older on average and are generally aware of the consequences of being overweight. It is also consistent with the fact that the instrument reflects more the experience of the overweight.

Social contagion in weight requires that the sum of all of the possible pathways associated with the cross-partial derivative of utility be positive. OLS estimation of this sum yielded a positive cross-partial effect, consistent with a snowball effect in health. However, the instrumental results produce a zero or negative cross-partial derivative, implying that the negative health care path dominates any other effects, so that an individual's exogenous weight gain will not be followed by their partner.

6 Conclusion

This paper has used three waves of German panel data to analyse the relationship between well-being and BMI in couples. While the analysis of well-being is of interest in its own right to describe the distribution of welfare, our particular aim here was to ask whether there exist social contagion effects in weight. To do so, we appeal to a very narrow peer group, the individual's partner. We then estimated life satisfaction equations to show that the negative effect of own weight was attenuated by partner's weight. Taken at face value, this is consistent with social contagion in weight: as others get heavier, my incentive to lose weight is reduced. This could reflect, amongst other things, social comparison of body shape or complementarity in household production.

However, we probably should not take these results at face value. While we are sure that the identified correlation is correct, it does not show causality and therefore does not prove contagion. To investigate, we instrument both own and partner's weight. The main result here is that the attenuation (or positive cross-partial) effect found above completely disappears in instrumental variable analysis. We argue that this is consistent with matching by unobserved preferences correlated with body weight on the marriage market, or a hidden common factor. Individuals are happy to be in a couple with someone who has the same body shape as them, but within a marriage the fact that their partner puts on a few pounds does not affect their own preferred body shape. In longer-lasting marriages, we even identify a negative cross-partial effect: the heavier I am, the less satisfied I am that my partner gains weight. This may well show that one of the positive returns of being in a couple is mutual health insurance.

We conclude that social contagion in weight is unlikely to pertain in overweight couples. Health policy may not be able to count on a snowball effect in weight, at least within the household. As perhaps in other health domains, intervention needs to target individuals directly.

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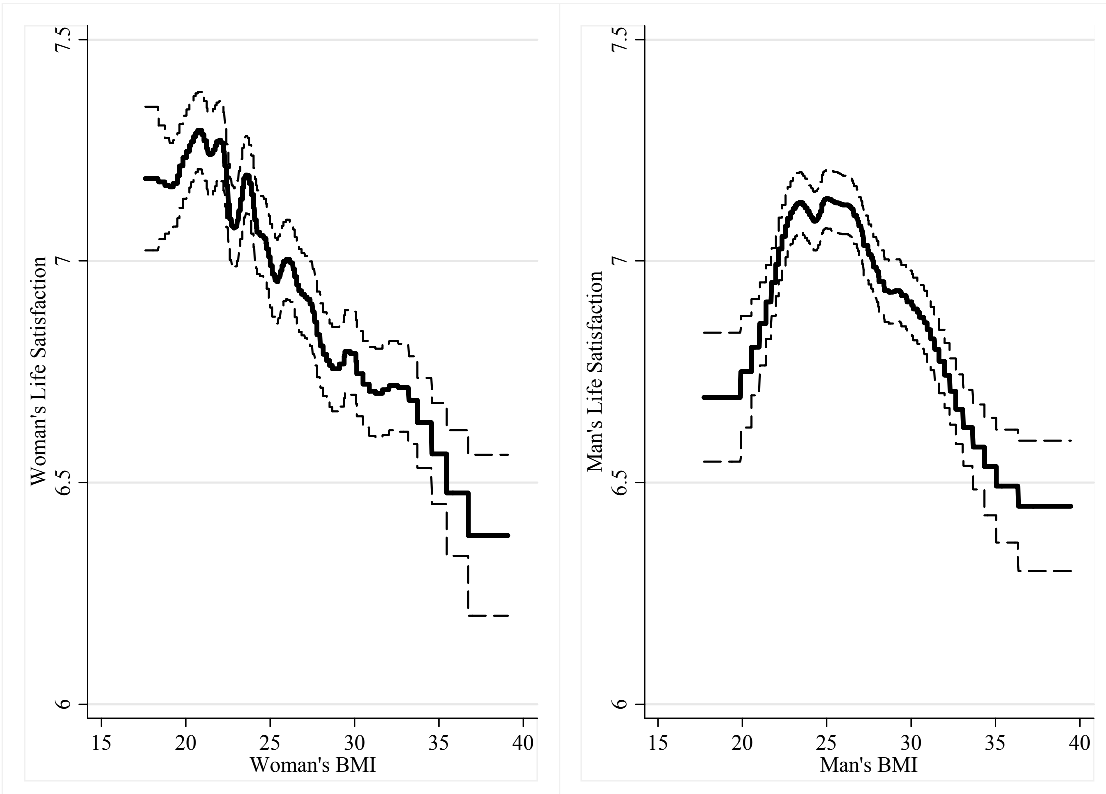
<u>Tables and Figures</u>

<u>Figure 1. Life Satisfaction vs. own BMI, for men and women – univariate nonparametric regressions by gender - Sample 2</u>



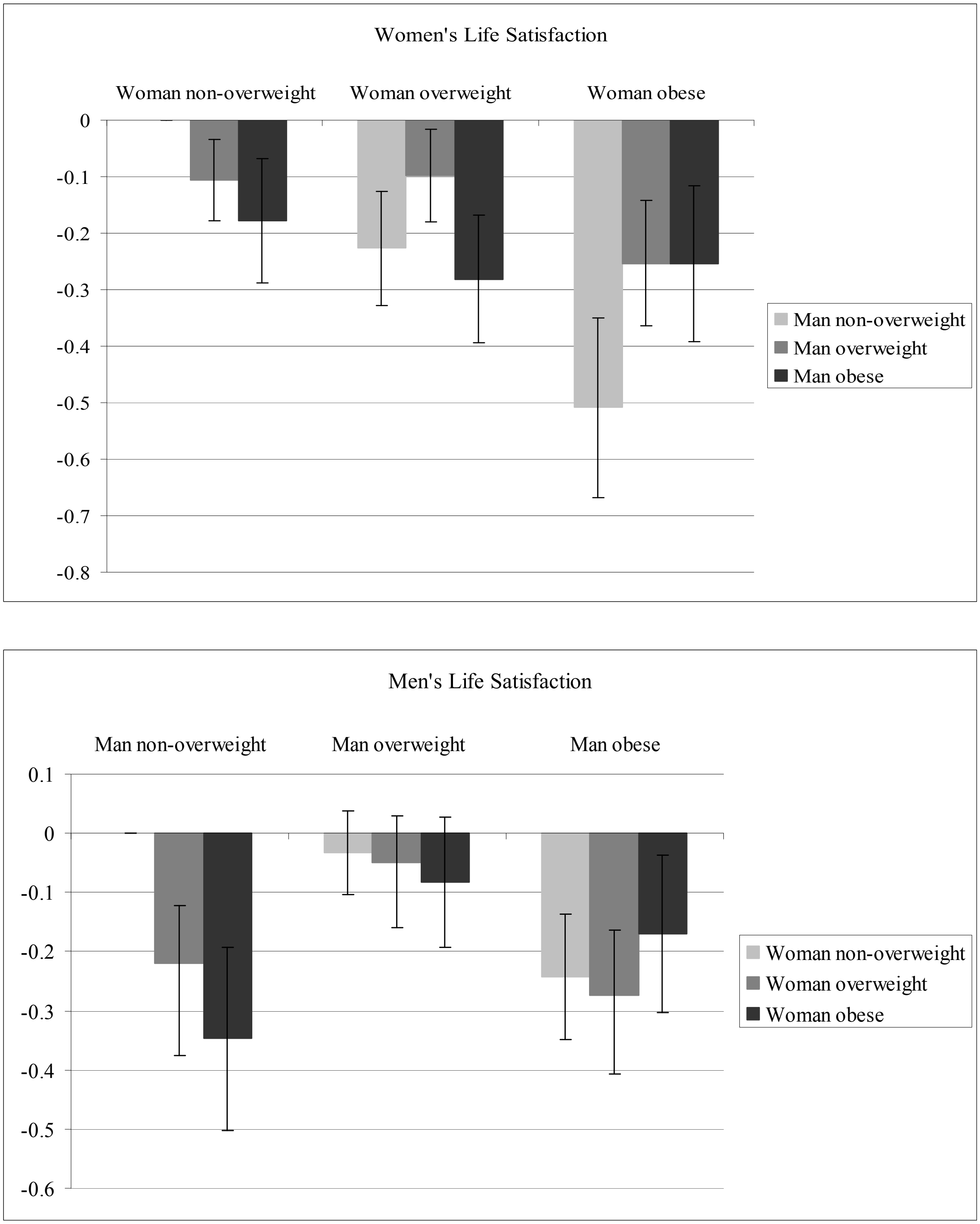
<u>Note:</u> This Figure shows the non-parametric regression of individual Life Satisfaction (measured on a 11-point scale) on individual BMI, for women (the left-hand panel) and men (the right-hand panel).

Table 1. Satisfaction and partners' BMIs – Parametric specification – Sample 2.

Gender	**Women**	**Men**
Technique	**Seemingly Unrelated REGressions**	
Man non-overweight, Woman non-overweight	Reference	Reference
Man overweight, Woman non-overweight	-0.106***	-0.032
	(0.037)	(0.036)
Man obese, Woman non-overweight	-0.178***	-0.243***
	(0.056)	(0.054)
Man non-overweight, Woman overweight	-0.227***	-0.220***
	(0.052)	(0.050)
Man overweight, Woman overweight	-0.098**	-0.050
	(0.042)	(0.041)
Man obese, Woman overweight	-0.281***	-0.273***
	(0.058)	(0.056)
Man non-overweight, Woman obese	-0.509***	-0.347***
	(0.081)	(0.079)
Man overweight, Woman obese	-0.253***	-0.083
	(0.057)	(0.056)
Man obese, Woman obese	-0.254***	-0.170**
	(0.070)	(0.068)
Control variables: partner's height, the interaction between own and partner's height, age, age squared, log(income), individual's years of education, number of household individuals, legal arrangement, dummies for labour market status (part-time worker, apprenticeship, retired, unemployed, full-time worker, house-wife/husband, and other), waves and Länder dummies.		
Coefficient of correlation	0.512*** Breusch-Pagan test of independence: p-value=0	

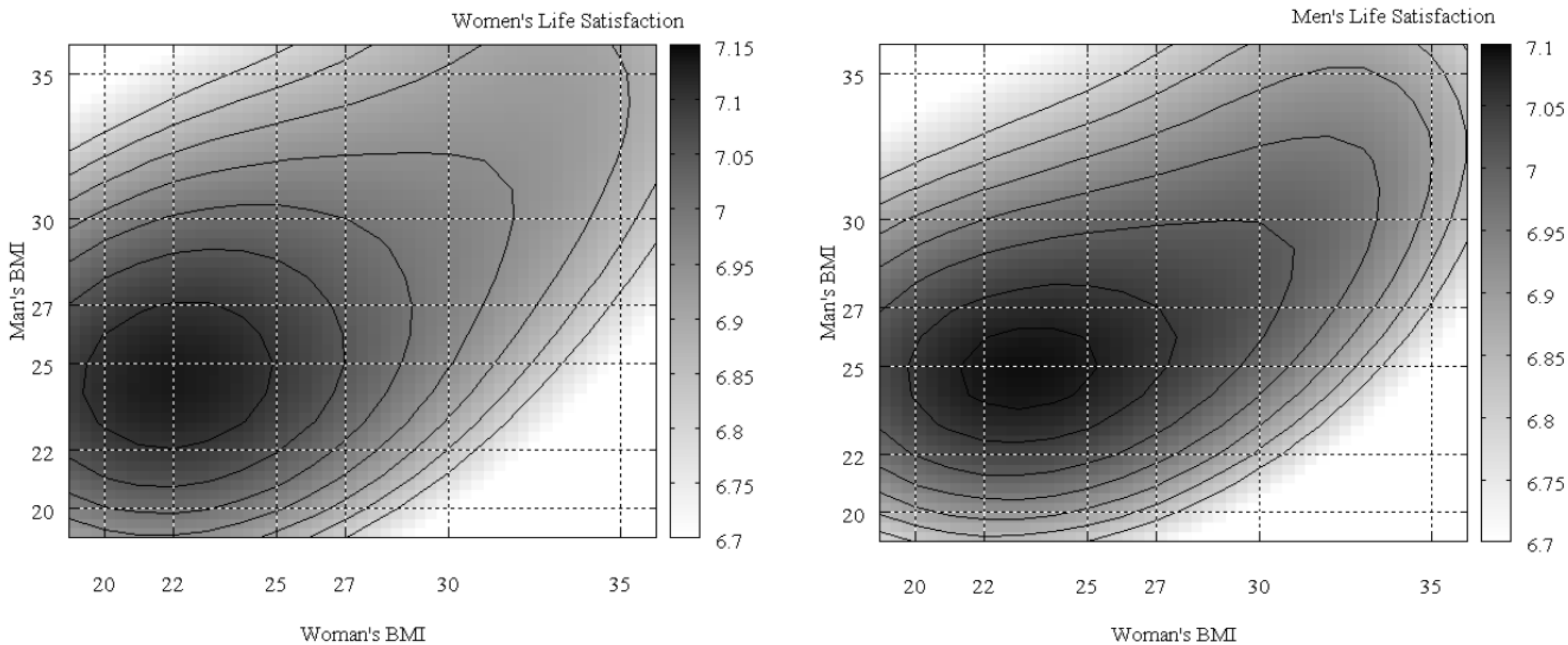
Note: Standard errors clustered at the household level in parentheses; ** significant at 5%; *** significant at 1%; Non-overweight = 1 if BMI<25 and 0 otherwise; Overweight = 1 if BMI ≥ 25 and BMI<30, and 0 otherwise; Obese = 1 if BMI ≥ 30 and 0 otherwise. These BMI statuses refer to the WHO medical norms.

Figure 2. The effect of the own and the partner's BMI on Life Satisfaction – based on Table 1



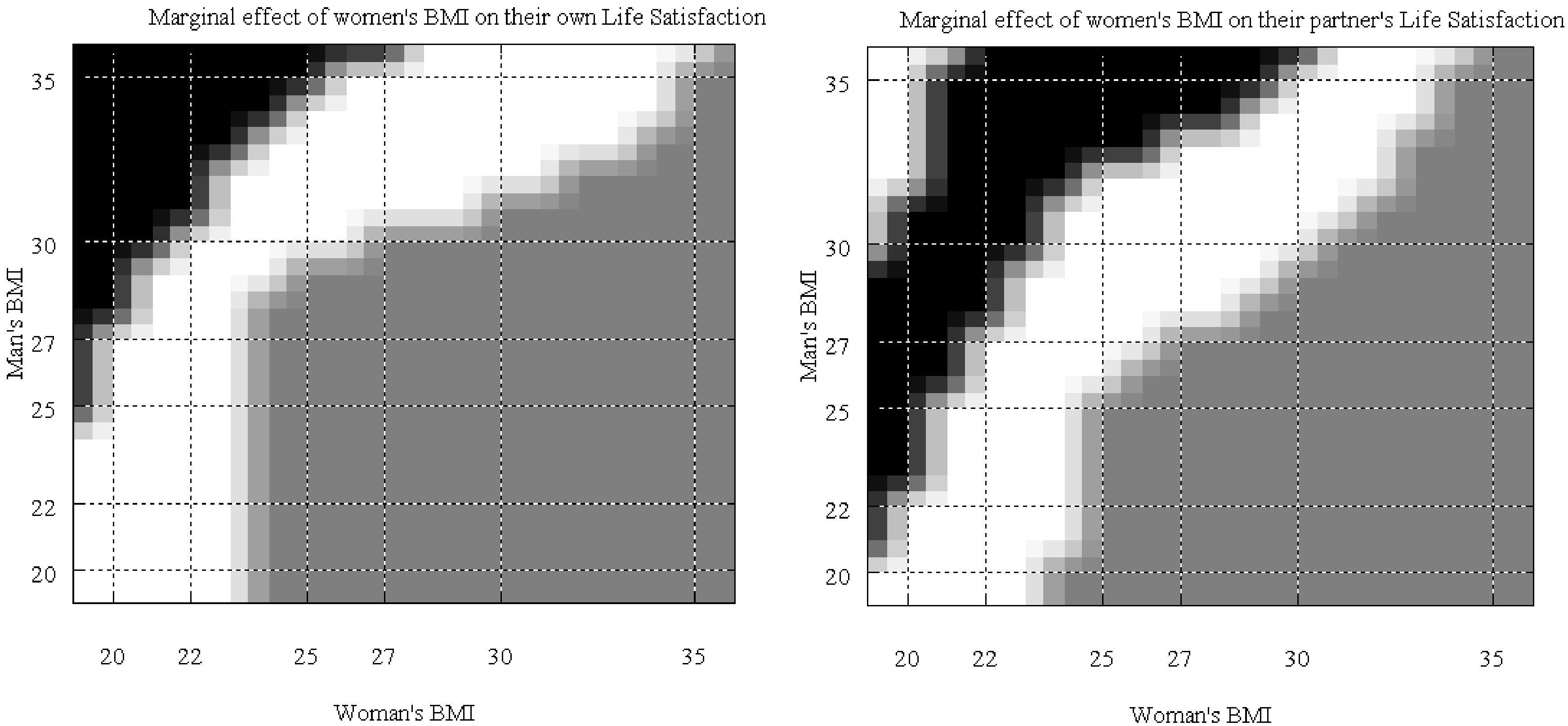
Note: These figures illustrate Table 1's results. They show for each sex, and for various assortments of BMI statuses, the average loss of Life Satisfaction in comparison with the Life Satisfaction of individuals in couples where both are non-overweight. The bars represent the 95% confidence intervals. The loss of life satisfaction is in points out on a 0-10 scale. 0.25 points of life satisfactions represents about 15% of a standard deviation in life satisfaction for both men and women.

Figure 3. Hills of Life Satisfaction – semi-parametric regressions – Sample 2



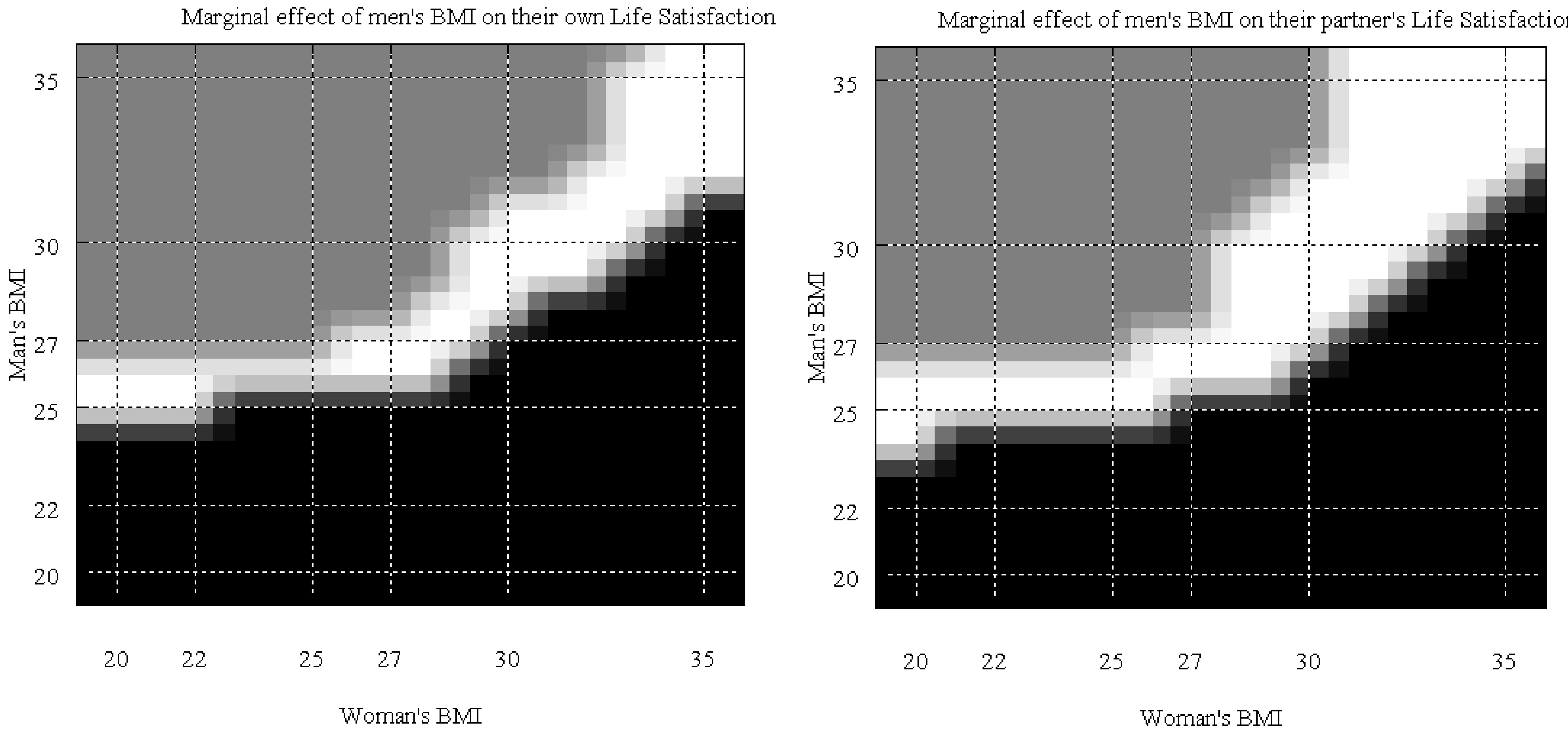
Note: This Figure shows the semi-parametric estimated relationship between individual Life Satisfaction and own and partner's BMI, for women (the left-hand panel) and men (the right-hand panel). The conditional mean of life satisfaction corresponding to the shading is shown on the scale to the right of each figure.

Figure 4. Slopes of the Hills - The marginal effect of women's BMI on their own and their partner's Life Satisfaction – significance at the 5% level



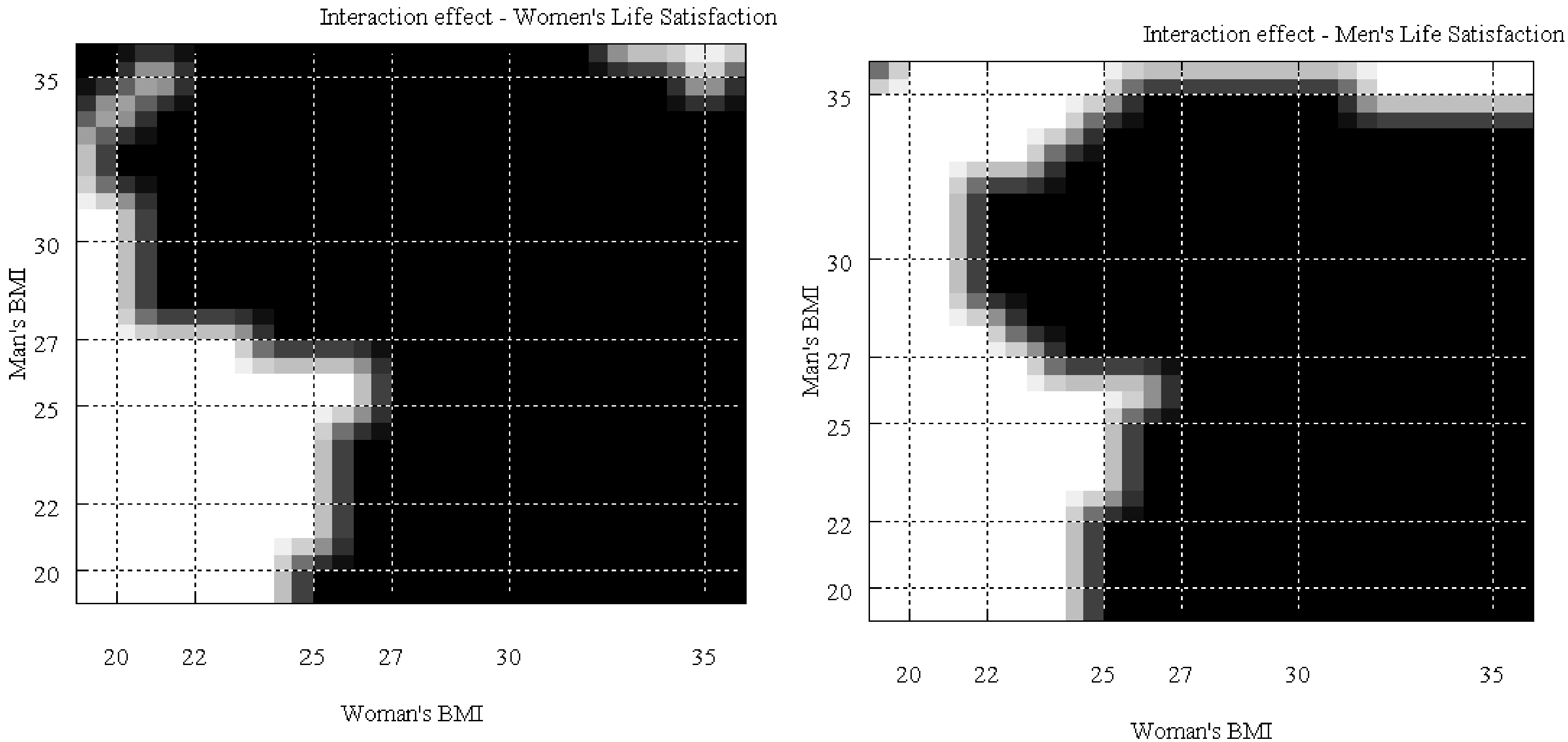
Note: Black areas correspond to a positive marginal effect, white areas an insignificant effect, and grey areas a negative marginal effect.

Figure 5. Slopes of the Hills - the marginal effect of men's BMI on their own and their partner's Life Satisfaction – significance at the 5% level



Note: Black areas correspond to a positive marginal effect, white areas an insignificant effect, and grey areas a negative marginal effect.

Figure 6. Interaction effects between own and partner's BMIs – significance at the 5% level



Note: Black areas correspond to a positive cross-partial effect, and white areas an insignificant effect.

Table 2. Instrumental variable regression results – Individuals in Sample 2 observed in 2002, 2004 and 2006

Gender	Women						Men					
Sample Selection	All		Short marriage		Long marriage		All		Short marriage		Long marriage	
Technique	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Own BMI/10	-0.133	5.243**	-0.014	1.446	-0.186	8.218***	2.740***	8.294***	1.946*	8.345*	3.467***	7.618**
	(0.716)	(2.090)	(0.966)	(2.798)	(1.083)	(3.016)	(0.858)	(2.774)	(1.134)	(4.302)	(1.290)	(3.395)
(Own BMI/10) squared	-0.186	-0.706**	-0.109	-0.330	-0.246	-1.037**	-0.681***	-1.256***	-0.435**	-1.422**	-0.896***	-1.061**
	(0.119)	(0.296)	(0.159)	(0.383)	(0.180)	(0.444)	(0.148)	(0.388)	(0.193)	(0.600)	(0.223)	(0.489)
Partner's BMI/10	0.402	4.465	-1.011	2.558	1.838	4.398	-0.409	3.095	-1.214	-0.736	0.780	6.928**
	(0.881)	(2.830)	(1.194)	(4.462)	(1.303)	(3.421)	(0.697)	(2.058)	(0.917)	(2.698)	(1.072)	(2.997)
(Partner's BMI/10) squared	-0.255*	-0.518	0.110	-0.470	-0.595***	-0.319	-0.135	-0.447	0.146	0.076	-0.456**	-1.051**
	(0.152)	(0.394)	(0.203)	(0.620)	(0.225)	(0.492)	(0.116)	(0.291)	(0.150)	(0.368)	(0.178)	(0.441)
Own BMI/10 crossed with Partner's BMI/10	0.334*	-0.556	0.098	0.008	0.503*	-0.888*	0.373**	-0.296	0.119	0.046	0.571**	-0.448
	(0.174)	(0.401)	(0.240)	(0.597)	(0.260)	(0.523)	(0.170)	(0.391)	(0.228)	(0.574)	(0.257)	(0.514)
Cragg-Donald Statistic		27.02		10.24		16.06		26.62		10.27		13.49
Hansen-Sargan test: p-value		0.85		0.91		0.83		0.77		0.86		0.65
Number of observations		4328		2127		2201		4328		2127		2201

Note: Standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. Control variables as in Table 1. IV = Instrumental Variables; OLS = Ordinary Least Squares. A Cragg-Donald statistic over 10 indicates that the instruments are not weak (Stock and Yogo, 2005). If the p-value of the Hansen-Sargan test of the over-identifying restrictions is greater than 0.1, then the exclusion restrictions can not be rejected.

Appendix A: Additional Statistics

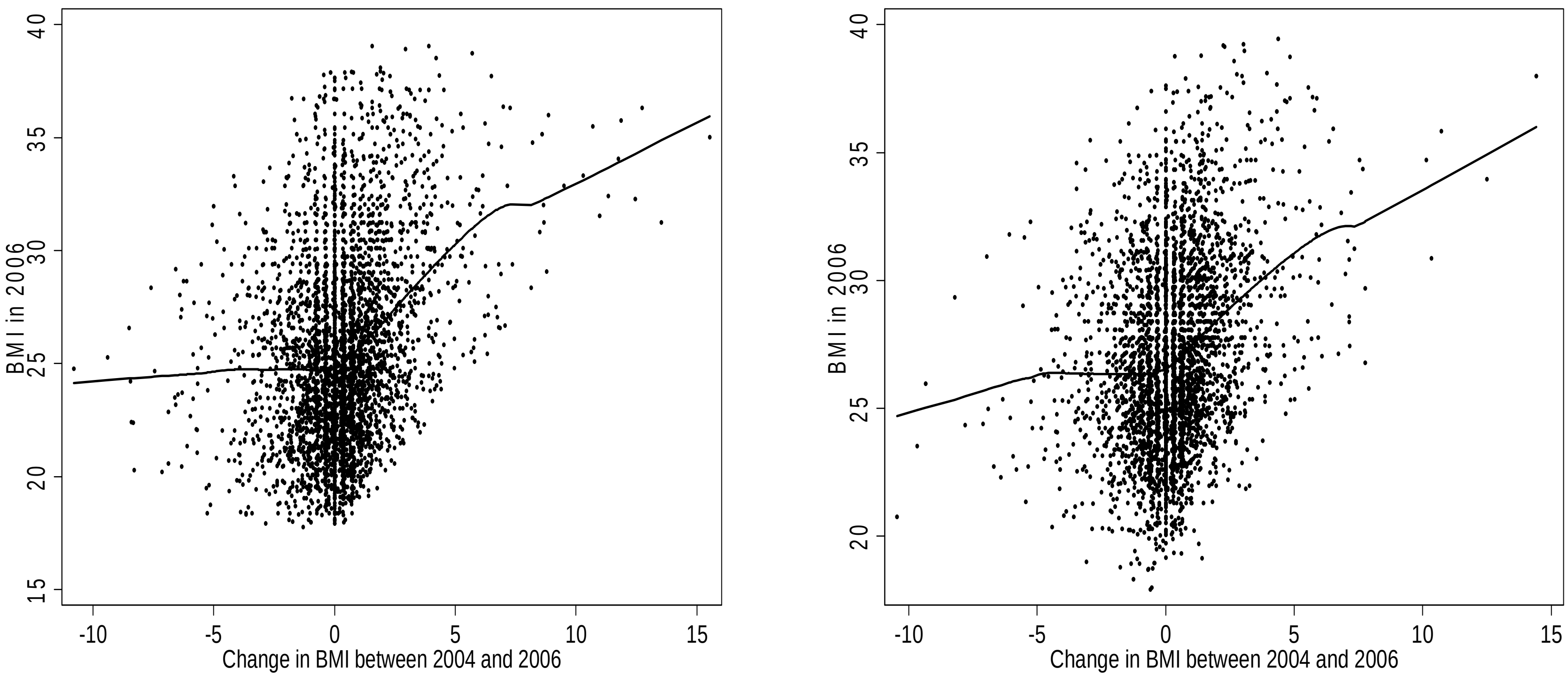
Table A1. Characteristics of the samples

		Sample 1	Sample 2
Number of individuals/couples		19899 Individuals	6555 couples (13110 individuals)
Number of individual-year observations		52699	16683 couple-year observations
Individuals/couples observed over…	…3 years	14386	4328
	…2 years	4028	1472
	…one year	1485	755
% Married individuals		73.4%	100%
% Men		48.5%	50%

Table A2. Descriptive statistics (Sample 1 and Sample 2)

Gender	Women			Men		
Sample	**1**	**1**	**2**	**1**	**1**	**2**
Marital status	**Single**	**Married**	**Married**	**Single**	**Single**	**Married**
N	**7753**	**19380**	**16683**	**6259**	**19307**	**16683**
Life satisfaction	6.62 (1.90)	7.00 (1.74)	7.02 (1.73)	6.68 (1.88)	6.98 (1.70)	6.99 (1.69)
BMI (Body Mass Index)	24.6 (4.4)	25.1 (4.2)	25.1 (4.1)	24.9 (3.6)	26.7 (3.5)	26.8 (3.5)
Height (in cm)	165.3 (6.8)	165.3 (6.3)	165.1 (6.2)	178.7 (7.4)	177.4 (7.1)	177.2 (7.1)
Age	49.2 (22.1)	48.9 (14.0)	50.1 (13.7)	38.4 (17.7)	51.8 (14.2)	52.8 (13.8)
Income: real equivalent after tax and transfer, in 2004 Euros	16397.2 (11149.6)	22384.4 (23325.7)	23 368.4 (24630.9)	21227.7 (27977.2)	22831.4 (23439.3)	23 368.4 (24630.9)
Years of schooling minus seven	4.6 (2.5)	5.0 (2.6)	5.0 (2.6)	5.0 (2.5)	5.5 (2.9)	5.6 (2.9)
Type of marital arrangement						
Legally married	0.0%	0.0%	94.5%	0.0%	0.0%	94.5%
Cohabiting couples	0.0%	12.5%	5.5%	0.0%	11.8%	5.5%
Other control variables						
Full-time worker	27.4%	25.1%	22.9%	47.3%	61.9%	61.1%
Part-time worker	13.5%	29.1%	29.8%	6.6%	3.6%	3.5%
Apprenticeship	5.6%	0.4%	0.2%	11.7%	0.3%	0.2%
Retired	34.2%	18.3%	19.6%	13.4%	24.9%	26.4%
Unemployed	6.1%	5.4%	5.1%	9.5%	5.9%	5.5%
Housewife/husband	10.8%	24.7%	25.9%	1.8%	1.8%	1.8%
Other job status	9.8%	2.6%	2.4%	11.2%	3.3%	3.2%
Number of individuals in the household	2 (1.4)	3.0 (1.1)	3.0 (1.1)	2.2 (1.5)	3.0 (1.1)	3.0 (1.1)
Year = 2002	31.7%	33.6%	34.0%	32.3%	33.7%	34.0%
Year = 2004	34.9%	35.3%	35.0%	35.5%	35.2%	35.0%
Year = 2006	33.4%	31.1%	31.0%	32.2%	31.2%	31.0%

<u>*Figure A1. BMI in 2006 vs. change in BMI between 2004 and 2006 – non-parametric regressions – Women (left) and Men (right)*</u>



Appendix B: Semi-parametric Regressions

Consider model **(3)**:

$$LS_{it} = f(W_{it}, W_{jt}) + \alpha X_{it} + \varepsilon_{it} \qquad \textbf{(3)}$$

In Section 4.2., the function f(.) is left unspecified and the model is estimated by the semi-parametric regression method proposed by Ruppert *et al*. (2003). The idea is to approximate the bivariate function f(.) by a mixture of radial basis functions defined over the space of partners' BMIs:

$$LS_{it} = \beta_0 + \beta_o W_{it} + \beta_p W_{jt} + \mathbf{Z}_{it,K}\mathbf{u} + \alpha X_{it} + \varepsilon_{it} \qquad \textbf{(B1)}$$

where **u** is a K x 1 random vector, and $\mathbf{Z_{it,K}}$ is a 1 x K vector of radial basis functions with the k^{th} element being:

$$Z_{it,K}(1,k) = \left\| \begin{pmatrix} W_{it} \\ W_{jt} \end{pmatrix} - \begin{pmatrix} \kappa_{ok} \\ \kappa_{pk} \end{pmatrix} \right\|^2_{1 \le k \le K} \log\left(\left\| \begin{pmatrix} W_{it} \\ W_{jt} \end{pmatrix} - \begin{pmatrix} \kappa_{ok} \\ \kappa_{pk} \end{pmatrix} \right\| \right) \qquad \textbf{(B2)}$$

In **(B2)**, $\boldsymbol{\kappa}' = (\kappa_{ok}, \kappa_{pk})$ represents a knot in the BMI^2 space, and ||.|| is the Euclidean distance. Hence, the estimator approximates the shape of the relationship between the BMIs and life satisfaction by a weighted sum of functions centred on different knots. The weights in **u** are random variables with mean 0.

The choice of the knots is a key issue in bivariate smoothing. Here, we select them using a two-stage procedure. First, we construct a rectangular grid containing all of the $\{W_{it}, W_{jt}\}$ observations, with grid points located at each integer value of BMI. Second, adjacent cells of this grid are merged when they contain less than 20 observations. The intersection points of the grid that we finally obtain are the knots we use in the estimates. As there are fewer observations in the corners of the $\{W_{it}, W_{jt}\}$ space, there are also fewer knots in these regions, which limits the loss of information (the variance is lower compared to the case in which there are more knots in sparse regions), but also the quality of the approximation.

The model is then estimated following the algorithm proposed in Chapter 13.5 of Ruppert *et al.*. Standard errors and the values of the derivatives are computed using the formulae in Chapters 6.4. and 6.8.