ISSN 1471-0498

DEPARTMENT OF ECONOMICS
DISCUSSION PAPER SERIES

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Number 446
August 2009

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The research for this paper was conducted while Ramani Gunatilaka was visiting the Department of Economics. We are grateful to The Nuffield Foundation for a grant under its Small Grants Scheme. We wish to thank Glenn Goldsmith for his advice and assistance on econometric issues and Richard Povey for his advice and assistance on theoretical issues; a theoretical appendix appears under his name. We are grateful to Nicholas Christakis, Paul Frijters, and Maryann Martin for helpful comments.

Is Happiness Infectious?

Abstract

The paper uses an appropriate survey from rural China to answer the question: Is happiness infectious, i.e. does the happiness of an individual depend positively on the happiness of their reference group? The evidence is consistent with this hypothesis, but the challenge is to solve the 'reflection problem', i.e. is the apparent effect of neighbours' happiness on own happiness a causal one or merely a reflection? A 'quasi-panel' approach is adopted, treating villages as groups and individuals as multiple observations within each group, and using an error components 2SLS estimator. The results suggest that a major part of the relationship is indeed causal: Adam Smith's insight was correct! The normative and policy implications are briefly considered.

Key Words
Happiness; Social interaction; Relative deprivation; China

JEL Classification
D01, D60, D64

1. Introduction

In this paper we pose a question which, to the best of our knowledge, economists have not previously tried to answer. Is happiness infectious? We address this question by means of a national socioeconomic survey for rural China that includes information on respondents' subjective well-being. The particular advantage of this survey for our purpose is that it contains information on close neighbours. One reason why the question has been neglected is that most datasets containing information on subjective well-being have sample designs that do not permit testing for such externalities.

We do indeed find evidence consistent with happiness being infectious. Our methodological task will be to choose between this explanation for the positive relationship between own happiness and neighbours' happiness and alternative explanations. We shall have to address the 'reflection problem' (Manski, 1993): is the apparent effect of neighbours' happiness on own happiness a causal one or merely a reflection?

We explore the relevant literature in Section 2, we explain the survey instrument in Section 3, and we set out the testing methodology in Section 4. Section 5 presents and interprets the empirical results. Section 6 briefly considers the implications of our interpretation for welfare economics. Section 7 concludes. Appendix 1 provides a rigorous account of the argument in Section 6.

2. The Relevant Literature

There is a considerable literature, dating back to the classical economists, on the effect of relative variables on peoples' welfare. Thus for instance, Adam Smith wrote, on the one hand, that satisfaction with income depends on such things as the need for status and the avoidance of shame in society (Smith, 1776: 466) and, on the other, of there being a natural fellow-feeling for others which, however, is weakened by social distance (Smith, 1759: 11, 156-8, 270). Karl Marx (1849: 163) argued that we live in society and we take our values from society, and that this can give rise to feelings of relative deprivation. The concept and determinants of relative deprivation were explored sociologically by Runciman (1966).

The pioneering economic research on subjective well-being was done by Easterlin (1974). He posed a puzzle: why did measures of subjective well-being remain fairly constant over several decades in the United States and Japan whereas real incomes rose substantially? His solution to the puzzle was that peoples' aspirations for income, based on the incomes of people with whom they made comparisons, rose along with the average income in society. Happiness is a positive function of own income but a negative function of aspirations, which depend on relative income: there is a 'hedonic treadmill'.

Economic research on subjective well-being has in some cases incorporated relative variables into happiness functions (well surveyed by Clark et al., 2008). A common finding is that subjective well-being varies inversely with comparator incomes. The reference groups that are used vary from one study to another and are generally inferred rather than identified directly. Thus, for instance, Clark and Oswald (1996) found that job satisfaction of British workers is inversely related to the wage rates of workers who have the same wage-generating characteristics. Ferrer-i-Carbonell (2006), analysing a German data set, found that the income of the respondent's reference group, defined by a combination of age, education and region, is roughly as important for happiness as the respondent's own income, but it has the opposite sign. Similarly, McBride (2001), estimated a negative relative income effect for the United States, based on the income of parents and of people in the same age group. Within-race group income comparisons reduced happiness in South Africa (Kingdon and Knight, 2007). Graham and Pettinato (2002), using panel data for Peru and Russia, found that the change in happiness over time depended on relative rather than absolute income gain.

Some studies have explored neighbours as the relevant reference group. Using a broad definition of neighbourhood, Luttmer (2005) found for the United States that 'neighbours are negatives'. Similar results have been obtained for China (Knight and Gunatilaka, 2007, Knight et al., 2009). Fafchamps and Shilpi (2008) found that in Nepal the subjective assessment of the adequacy of consumption rises with own consumption and falls with the consumption of neighbours. By contrast, it is found that 'neighbours are positives', i.e. subjective well-being rises with comparator income, among close residential neighbours, in South Africa (Kingdon and Knight, 2007). After tests, this effect is interpreted as reflecting fellow-feeling. Ravallion and Lokshin (2005) estimate a similarly positive effect of neighbours' incomes in Malawi. Peers' income is also found to raise subjective well-being in Russia by Senik (2004), a result which is explained as a demonstration effect.

We were unable to find any economic literature which specifically addresses our question. This might be for lack of data or for lack of economic interest. Given that we have appropriate data, there are reasons why the question is worth examining. Just as the phenomena of relative deprivation and the hedonic treadmill raise important normative issues, so also do the externalities arising from the effect of one person's happiness on another's have implications for welfare economics.

The psychological literature is relevant. It has been found that emotional status can be transferred from one individual to another. Hatfield et al. (1994) adduced much evidence of emotional contagion among interacting people. There is also evidence of one of the mechanisms: particular brain neurons known as 'mirror neurones' fire in imitation when someone else is seen to do a particular action. For instance, Sato and Yoshikawa (2007) found that dynamic facial expressions elicit spontaneous and rapid facial mimicry, which they interpreted as indicating activation of the mirror neurone system. However, the psychological research is consistent with the transmission of current mood and not of (longer term) satisfaction with life, unless the same stimulus is repeated frequently within a social network.

The only empirical testing of our hypothesis of which we are aware also comes from outside the economic literature. Fowler and Christakis (2008) examined the spread of happiness from person to person in a small town in Massachusetts that had been the subject of a longitudinal medical survey. The social network was defined by the relationship between 'ego' and 'alter' (co-resident spouse, sibling, friend, next door neighbour, workmate) and also by distance between their residences, and happiness was measured in the conventional way. It was found that there were clusters of happy, and unhappy, people within a social network that could not have arisen by chance, and that the happiness relationship extended up to three degrees of separation. The authors exploited the panel element in the data set to show that the clusters resulted from the transfer of happiness among people and not from selectivity in the choice of social network.

3. Data and Hypotheses

The data we use are from the rural sample of the Institute of Economics, Chinese Academy of Social Sciences, national household cross-section socioeconomic household survey for 2002. It was designed by the research team for the China Household Income project (CHIP) and conducted by the National Bureau of Statistics (NBS). It covers 22 of the 31 provinces, and is intended to be nationally representative. It draws on a sub-sample of the NBS annual household income and expenditure survey. In addition to the information on each household gathered by the NBS in its own survey, the rural questionnaire asks many questions with research hypotheses in mind. A special module on subjective well-being was designed by one of the authors and included in the rural questionnaire, and there was also an administrative questionnaire intended to obtain information on local communities. Within each province on average 5.5 counties were sampled, and within each county on average 7.9 villages; in both cases selection was based on a ranking by income per capita with random starting point. Within each village normally 10 households were randomly selected. Thus the rural sample contains roughly 10x7.9x5.5x22 = 9,560 observations. It is the concentration of observations in villages and in counties that permits our hypothesis testing.

We make use of two questions from the module on subjective well-being. These questions were answered by only one member of the household, normally the household head. One can be translated as: 'How happy are you these days?' and allows one of five answers: very happy, happy, so-so, unhappy, not at all happy. We convert these answers into a cardinal variable, with the highest happiness category having a value of 4 and the lowest 0. Ferrer-I-Carbonnel and Frijters (2004) using the German panel survey, and also Knight et al. (2009) using this data set, found that the choice of cardinal or ordinal dependent variable made no notable difference to their results.

A particular strength of the survey is that respondents were asked about the people with whom they compared themselves. The great majority reported that their reference groups lay within the village. Most respondents (at least 68%) make comparisons with their neighbours and fellow-villagers, and a mere 11% have their main orbit of comparison beyond the village. Thus, whereas other studies of comparative effects need to infer the identity of comparators from their results, we know that we must look within the village for the potential effects of relative income or relative happiness on the respondent's own happiness.

The main hypothesis we wish to test is that, controlling for other determinants, the happiness of the respondent depends positively on the happiness of neighbours. The underlying argument is that human interaction makes states of mind contagious: there are peer effects, which can operate either to raise or to lower happiness.

4. Methodology

Our methodology is to estimate happiness functions with a wide set of socioeconomic variables, relating to the individual, the household and the community. Many of these variables are conditioning variables. They serve the further purpose of showing that there are powerful and predictable regularities in the equations, so giving greater credence to the exercise. The variables of most interest are those that represent neighbours' corresponding states of mind.

Even if the hypothesis variables have positive and significant coefficients, we still have to deal with the 'reflection problem' that arises when an aggregated version of the dependent variable is included as an explanatory variable (Manski, 1993, Soutevent, 2006). Does the happiness of fellow-villagers cause the happiness of the respondent or merely reflect it? On the one hand, the happiness of fellow-villagers might raise the respondent's happiness through social interaction and a bandwagon effect. On the other hand, the respondent's happiness might be high because the measured, or the unmeasured, characteristics of the village or of the villagers raise the happiness of the respondent. Whether a positive coefficient on neighbour's happiness in the estimated equation was due to the infectiousness of happiness or to unobserved heterogeneity, the variable denoting village mean happiness would be endogenous.

There are thus four possible influences on individual happiness: own characteristics, village characteristics, other villagers' characteristics, and other villagers' happiness. Denoting the individual as *i* and the individual's village as *v*, we have:

$$H_i = a + X_i b + Z_v c + X_v d + H_v e + \eta_v + \theta_i \qquad (4.1)$$

where X_i is a vector of individual characteristics, Z_v is a vector of village characteristics, X_v is a vector of other villagers' mean characteristics, H_v is other villagers' mean happiness, and η_v and θ_i are village-level and individual-level error terms. Note that the village variables which

are aggregated from individual variables are the means of village members other than member *i*.

We seek to identify *e*, the coefficient of particular interest. There are three distinct issues: correlation between H_v and the individual-level error term θ_i , arising from the effect of H_i on H_v ; distinguishing the effect of others' characteristics X_v (what Manski (1993, 2000) calls *contextual* effects) from the effect of others' happiness H_v ; and correlation between the Z_v or X_v variables and the village-level error term η_v (*correlated* effects).

The solution to the reflection problem that we adopt is a 'quasi-panel' approach along the lines suggested by Graham and Hahn (2005). The panel structure treats villages as groups and individuals as multiple observations within each group. This approach extends the ideas in Hausman and Taylor (1981) to the simultaneous equations context. It is in line with testing strategies suggested by Moffitt (2001) and Soetevent (2006). The model is estimated using the error components SLS estimator proposed by Baltagi (1981).

The combination of all three of the issues noted above complicates the selection of valid instruments. Identification is achieved by combining the sources of instruments suggested by Hausman and Taylor (1981) with exclusion restrictions on the contextual effects. We require instruments both for others' happiness, H_v, and for any of the X_i, X_v, and Z_v variables that might be correlated with the village-level unobservables, η_v. The instruments must themselves be uncorrelated with both the village-level and the individual-level errors, η_v and θ_i. Such instruments can come from two sources:

(i) deviations from village means of all the X_i variables, X_{iv}, these being uncorrelated with the village-level errors η_v by construction.

(ii) village means of any *X* and *Z* variables that are assumed to be uncorrelated with η_v.

For identification there must be more explanatory variables that do not have contextual effects (at least one more restriction on the contextual effects) than there are variables that are correlated with the village-level errors.[1]

[1] If there are K_x *X* variables and K_z *Z* variables, then with *R* exclusion restrictions, equation (4.1) has $2K_x+2K_z+1-R$ parameters to be estimated. If K_x* of the *X* variables and K_z* of the *Z* variables are correlated with the village-level errors, then the $(2K_x - K_x^*) + (K_z - K_z^*)$ Hausman-Taylor instruments will be sufficient to estimate all of the parameters provided that $R \geq K_x^* + K_z^* + 1$.

5. Empirical Results

We proceed by stages. We start with a typical happiness function of the sort estimated for the same rural sample in Knight et al. (2009), but with the addition of the variable of particular interest for this paper, mean village happiness (Table 1, columns 1-3).

Consider first the personal variables (X_i). In common with that paper and most happiness studies from around the world, being female, being married, and being in good health all raise happiness; and the age-happiness relationship is U-shaped. The variable indicating good mood is significantly positive as expected, and helps to purge out transitory effects. Turning to the economic variables, we find the expected significant effects: ln income and net wealth, both household per capita, raise happiness whereas working hours lower it.

The coefficient on ln income is reduced when village variables, and county dummies, are added to the equation (column 3). The first four rows of the village variables, representing Z_v, reflect the respondent's satisfaction with living in that village. The last four indicate the effect of the respondent's perceived rank in the village income distribution. We see that it has a powerful monotonic effect on happiness, with the poorest village households being particularly unhappy. The great variation in income levels across villages means that these terms cannot merely be reflecting absolute incomes. This result suggests that relative income is important: households suffer from relative deprivation in relation to their reference group.

Mean village happiness (H_v) has a large positive and significant coefficient, with a value of 0.59 in the basic equation (column 1) and 0.40 even when village variables and county dummies are included. This is evidence that own happiness and mean village happiness are indeed positively related: a unit rise in the happiness score of the village is associated with a rise in the respondent's own happiness of at least 0.40. However, further tests are required in order to establish whether that relationship is causal.

In Table 2 we introduce additional characteristics of other village members (X_v) that might influence individual happiness. Columns 1-3 of Table 2 correspond to columns 1-3 of Table 1 respectively, except that two village-level variables are introduced: mean income and mean education. None of their coefficients is significant, although the mean income coefficient is consistently negative. The coefficients on mean village happiness are if anything a little higher than in columns 1-3. The withdrawal of the village income rank terms makes no

notable difference to the mean income coefficients (equations not shown). The village income rank dummies are a better measure of relative income than is mean village income.

It is possible that income is endogenous in equation (4.1). For instance, a person's happiness might influence their income, or their unobserved personal characteristics such as aspirations or optimism might influence both their income and their happiness. In Table 3 we re-estimate the equations with income now instrumented. The instruments (father's and spouse's years of education) pass the conventional tests of good instruments. The coefficient on the instrumented variable is higher, suggesting that unobserved aspirations raise income but lower happiness or that measurement error produces downward attenuation bias in the coefficient on actual income. There are no other notable changes in the results. The same patterns are found, and the village mean income and education variables remain insignificant. Most important, the coefficients on average village happiness are barely changed from those of Table 2 and are again significantly positive.

The results so far, although suggestive, cannot solve the 'reflection problem'. They cannot establish that the positive effect of village happiness on own happiness is causal, i.e. due to its infectiousness rather than to unobserved characteristics. Table 4 presents estimates from our use of the Graham and Hahn (2005) methodology, which is intended to correct for the potential endogeneity of the average village happiness variable. We see that the Sargan-Hansen tests indicate clearly that the instruments cannot be rejected. The patterns of results are no different from those of the previous tables. Age has a U-shaped effect, marriage is good and divorce bad for happiness, ethnic minorities are happier, current mood is important, and ln income has a positive effect. Happiness is increased if income rose over the last five years and decreased if it fell, friends are important for happiness, and people are happier if they live in villages considered to be harmonious, or having an effective spokesman, or located in a non-mountainous area. Village income rank again has a powerful and significant effect. Some other variables become significantly different from zero when the village rank variables are excluded (col. 2): average village income (now significantly negative), net wealth (positive), the expectation of a big increase (positive) or decrease (negative) in income over the next five years, and a materialistic attitude (negative).

Most important, in both the equations reported in Table 4 the coefficient on average village happiness is positive and highly significant, having a value of 0.33 or 0.30. This is our best

evidence that the happiness of fellow-villagers has a causal effect on the happiness of the individual. The coefficient in column 1 is smaller than those in the nearest equivalent cases in the other tables by roughly 0.20, suggesting that some - but less than a half - of the association between the happiness of the reference group and individual happiness is non-causal.

6. Theoretical Implications

In this section we examine briefly the implications of our results for welfare economics. By drawing on several disciplines, some justification can be provided for assuming that measured happiness is the relevant concept for economic models based on utility maximisation, although inherent failure to predict how aspirations will change in response to economic changes can produce systematic differences between 'expected utility' and 'experienced utility' (Kahneman et al., 1998; Clark et al., 2008: 115-22).

We concentrate initially on the finding that happiness is infectious. When individual *i*'s happiness increases, this raises the happiness of other individuals who include *i* in their reference group, which in turn feeds back into the happiness of those who include these other individuals in their reference groups, and so on. Assuming that the reference group is a single unit, characterised by symmetrical relationships, as might be the case in a Chinese village, the feedback is restricted to the village. There is a contained multiplier effect.

Where H_i is *i*'s happiness, Y_i is *i*'s income, H_v is the mean happiness of village members other than individual *i*, and α and β are parameters, we have:

$$H_i = \alpha Y_i + \beta H_v \qquad (5.1)$$

This function can give rise to externalities (formalised in the Appendix). The income of each individual raises not their only own happiness but also the happiness of others within the social network The function, if assumed to be common to all members of the village, creates a simultaneous equation system. There is in principle a possibility that the multiplier effect is explosive but it is shown in the Appendix that the geometric series remains finite provided that $\beta < 1$. Recall that our best estimates of that coefficient have a value of about 0.3.

The model can be extended to include our other finding that income relative to that of the village raises individual happiness. Where the mean income of village members other than individual *i* is Y_v and γ is a parameter, equation (5.1) becomes:

$$H_i = \alpha Y_i + \beta H_v - \gamma Y_v \qquad (5.2)$$

Infectious happiness and relative income effects now pull in opposite directions. An increase in Y_v lowers H_i directly but, by also raising H_v, raises H_i indirectly.[2] In practice the relative strength of the two effects depends on factors such as the extent to which the reference groups of individuals overlap, and whether the reference group relevant to the happiness of others is the same as the reference group relevant to the income of others. For instance, although we use other village members as the reference group for both variables, individual happiness might depend on the happiness of a closely interacting subset within the village but on the income of a larger group albeit mainly within the village. The strength of social interaction can be relevant: closeness can generate co-operation and altruism but also envious sentiment towards those outside the interacting group (Dawes and Thaler, 1988).

Outcomes of experimental games in which, for instance, player A chooses to benefit player B whereas in response B chooses to harm A although it also means harming himself are often explained in terms of perceptions of ‘fairness’. Adreoni and Miller (2002) and Adreoni et al. (2003) argue that such outcomes are rational in that they follow the axioms of revealed preference. The outcomes might be viewed as the result of rational decisions based on a happiness function such as equation (5.2). Given declining marginal (e.g. logarithmic) happiness from own income and consciousness of infectious happiness, as others' income decreases the infectious happiness term sharpens the preference to make a 'fair' offer. As others' income increases, meanwhile, the relative income term becomes more important, leading to a potential willingness to forgo own income if by doing so it is possible to reduce others' income and thus create a 'fairer' income distribution.

[2] The former can give rise to malevolent and the latter to benevolent preferences and behaviour. The former can be illustrated in the anecdote, emanating from Russia, about a Chinese peasant and a Russian peasant, each of whom was allowed one request. Chinese peasant: ‘My neighbour has a tractor. I want a tractor’; Russian peasant: ‘My neighbour has a goat. Kill my neighbour’s goat’. Infectious happiness is one possible explanation for altruistic acts.

An individual maximising own happiness also maximises the infectious effect of happiness on others. An individual can better maximise own happiness if they recognise the indirect effect of their actions on their own happiness that accrues through the gain in happiness of those in their reference group. Infectious happiness is then partly internalised. In examining the implications for welfare economics, we assume that the individual does not recognise the indirect effects. In that case, infectious happiness, being not internalised at all, can generate an externality. The contrary assumption is explored in the Appendix.

A standard welfare economics argument derived from evidence of the negative effects of relative income on individual happiness is that people work too much. The idea can be traced back to the fable of the bees (de Mandeville, 1723) but there is a modern formalisation (for instance, Layard, 2006: C26-7). Individual *i*, in choosing between work and leisure, does not take into account the negative externality imposed on other individuals. When *i* increases hours worked and therefore income, the reference income of the others is increased and therefore their happiness falls. It might appear that this result could be neutralised if we were to recognise that happiness is infectious. However, it is argued in the Appendix that augmenting the relative income effect with the infectious happiness effect does not alter the result that a socially excessive number of hours is worked. This is because the former is assumed to depend only on income and not on leisure whereas the latter is assumed to depend on happiness, which is affected by both income and leisure.

7. Conclusions

The basic idea of this paper was well expressed 250 years ago in *The Theory of Moral Sentiments*. In the opening pages of that book Smith (1759) argued that it is human nature to derive pleasure from the happiness of others and to suffer from the suffering of others. For instance:

> How selfish soever a man may be supposed, there are evidently some principles in his nature, which interest him in the fortunes of others, and render their happiness necessary to him, though he derives nothing from it except the pleasure of seeing it. Of this kind is pity or compassion, the emotion which we feel for the misery of others, when we either see it, or are made to conceive it in a very lively manner. (Smith, 1759: 11).

The innovation of this paper is to provide economic evidence consistent with that effect. Along with the study referred to above (Fowler and Christakis, 2008), which was able to trace social networks within a small town, our survey is unusual in providing an opportunity to examine the effect of happiness within an individual's reference group on their own happiness. Our estimates are suggestive of positive externalities among interacting individuals which arise from the apparent infectiousness of happiness within the reference group. The results are made more plausible by our use of a methodology designed to identify the causal relationship. The externalities may be greater when the reference group is small, as it is in rural China. The existence of such externalities implies a greater social benefit from local public goods and from the socioeconomic conditions which promote cooperative interaction and fellow-feeling than has previously been generally recognised by economists.

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Appendix 1 - The Welfare Economics of Infectious Happiness

Richard Povey

We examine the implications of infectious happiness for a number of results in welfare economics. The consequences depend crucially upon the assumptions made. Firstly, should the infectiousness externality be included in the social welfare function? We choose to do so, finding the social optimum by maximising the happiness of a representative individual, incorporating all infectiousness and relative income externalities. Secondly, are happiness-maximising agents aware of the infectiousness effects? We initially assume that this is not the case, since it seems plausible that at least some, and possibly most, of the infectiousness effect is unconscious. However, we also briefly consider the impact of conscious infectiousness.

We establish first that the aggregate multiplier effect on happiness will be positive and non-explosive provided that the coefficient of infectiousness, $0 < \beta < 1$. The presence of infectiousness leads to a determinate increase in average happiness within the group. We then consider the implications of the simultaneous presence of infectious happiness and relative income effects, and find that the excess labour supply result holds in a similar manner with or without infectious happiness. Finally, we show that an awareness of the presence of infectious happiness by the individuals affected would lead to a further increase in happiness, through their internalisation of the infectiousness externality, and resulting partial internalisation of other externalities, both negative (relative income effects) or positive (a group public good). This would lead to phenomena such as reduced excess labour supply, greater individual contributions to a public good, and altruistic giving from rich to poor; simply becoming aware of infectious happiness would result in greater happiness.

1. Multiplier Effects

Take a group of N individuals. Each individual has a happiness function specified by:

$$H_i = \alpha Y_i - \gamma \bar{Y}_i - \delta L_i + Z_i + \beta \bar{H}_i \tag{6}$$

$Y_i = \ln(y_i)$ is the logarithm of individual i's income. $\bar{Y}_i = \bar{y}_i = \frac{1}{N-1} \sum_{j \neq i}^{N} [y_j]$ is the average income of all other individuals apart from individual i. L_i is individual i's labour supply. $\bar{H}_i = \frac{1}{N-1} \sum_{j \neq i}^{N} [H_j]$ is the average happiness of all other individuals. Z_i is a parameter which includes all other determinants of individual happiness.

In order to establish that the aggregate multiplier effect will be finite and well-defined, we need to find expressions for $\frac{dH_i}{dZ_i}$ and $\frac{dH_i}{dZ_j}$ (where $j \neq i$), the total derivatives of own happiness and others' happiness with respect to an increase in parameter Z_i once aggregate multiplier effects have been accounted for. Totally differentiating (6) yields:

$$\frac{dH_i}{dZ_i} = 1 + \beta\frac{d\bar{H}_i}{dZ_i} = 1 + \frac{\beta}{N-1}\sum_{j\neq i}^{N}\left[\frac{dH_j}{dZ_i}\right] \tag{7}$$

$$\frac{dH_i}{dZ_j} = \beta\frac{d\bar{H}_i}{dZ_j} = \frac{\beta}{N-1}\left(\frac{dH_j}{dZ_j} + \sum_{k\neq j}^{N}\left[\frac{dH_k}{dZ_j}\right]\right) \tag{8}$$

By symmetry we can assume $\frac{dH_k}{dZ_j} = \frac{dH_j}{dZ_i} = \phi$ and $\frac{dH_i}{dZ_i} = \frac{dH_j}{dZ_j} = \psi$, so (7) and (8) become:

$$\psi = 1 + \beta\phi \qquad \phi = \frac{\beta}{N-1}\left(\psi + (N-2)\phi\right) \tag{9}$$

Solving (9) simultaneously yields:

$$\phi = \frac{\beta}{(1-\beta)(N-(1-\beta))} \qquad \psi = \frac{(1-\beta)(N-1)+\beta}{(1-\beta)(N-(1-\beta))} \tag{10}$$

From (10), provided $N \geq 2$ and $0 < \beta < 1$, ϕ and ψ are both positive and finite. It is also always the case that $\phi < \psi$. This means that the impact on individual i's happiness from an increase in their own Z_i is always greater then the impact from an increase in another individual's Z_j. As $\beta \longrightarrow 1^-$,[3] $\phi \longrightarrow \infty$ and $\psi \longrightarrow \infty$. The aggregate multiplier effect therefore only remains non-explosive when $\beta < 1$.[4] Both ψ and ϕ are increasing in β, showing that increased infectiousness causes an increased aggregate multiplier effect. ψ and ϕ determine the multiplier effect on all other parameters as well.[5]

2. Happiness Gain From Infectiousness

It is possible from the specification in (6) to calculate how much of the average individual's happiness is due to the aggregate infectious happiness effect. Assuming an individual with average happiness $\bar{H}$ and who, with infectiousness effects absent, would also have happiness equal to the group average, which we denote by $\bar{V}$, we would have:

$$\bar{H} = \psi\bar{V} + \phi\sum_{j\neq i}^{N}[\bar{V}] = (\psi + (N-1)\phi)\bar{V} = \frac{1}{1-\beta}\bar{V} \tag{11}$$

[3] Meaning that β goes to 1 from below.

[4] Since happiness in human groups does not explode to infinity, we expect a β well below this limit.

[5] For example, where $\gamma = 0$, so that there are no relative income effects, marginal happiness from own income will be $\frac{\psi\alpha}{y_i}$ and the marginal happiness from another's income $\frac{\phi\alpha}{y_j}$.

So, average happiness is increased by a factor of $\frac{1}{1-\beta}$ through the aggregate infectiousness effect, and, as is obvious from (6), the proportion of individual happiness which is due to the infectiousness effect is β. The percentage increase in happiness due to the infectiousness effects will be $(100)\left(\frac{\beta}{1-\beta}\right)\%$. Given the empirical estimates for β of roughly 0.3 to 0.33, the implied increase in average happiness is therefore in the range of 43-50%.

3. Excess Labour Supply

The excess labour supply effect continues to hold equally strongly with infectious happiness. Although at first sight it might seem that infectious happiness provides a positive externality from additional income earned by each individual which could offset the negative relative income externality, this is not in fact the case. This is because although infectiousness does increase the marginal social benefit from increased earned income, it also increases the marginal social cost proportionately, since both the happiness from income and the loss of happiness from work go through the multiplier. The 'envy' effects are similarly scaled up in proportion to the marginal happiness from income. Therefore, the mere presence of the multiplier (without consciousness of it) cannot neutralise the relative income externality.

If happiness-maximising individuals are unaware of infectiousness effects, then $\bar{H}_i$ from (6) will be treated as constant, and will therefore drop out in the first order condition. Setting $\frac{dy_i}{dL_i} = w$ (where w is the real wage), and totally differentiating (6), gives us:

$$\frac{dH_i}{dL_i} = w\frac{\alpha}{y_i} - \delta = 0 \tag{12}$$

Since by symmetry all individuals will choose the same level of earned income, this first order condition can be rearranged to give the privately optimal earned income level y°:

$$y^{\circ} = \frac{w\alpha}{\delta} \tag{13}$$

The socially optimal outcome can be found by taking a representative individual's happiness function, and internalising the externality to give the following first order condition:

$$\frac{dH}{dL} = \psi\left(w\frac{\alpha}{y} - w\gamma - \delta\right) + \phi(N-1)\left(w\frac{\alpha}{y} - w\gamma - \delta\right) = 0 \tag{14}$$

$$y^{*} = \frac{w\alpha}{\delta + w\gamma} \tag{15}$$

There is excessive privately earned income, with the effect being greater the greater is the relative income effect coefficient γ. The levels of privately and socially optimal labour supply would be the same with infectious happiness as they would be with no infectious happiness (i.e. where $\beta = 0$), since setting $\psi = 1$ and $\phi = 0$ would not change (13) or (15).

4. Conscious Infectiousness

If individuals were to became aware of the infectiousness externality, the result above would be subtly altered. Individuals would now take into account the indirect impact of their actions on their own happiness through changes in the happiness of others incorporated into their happiness function via the β parameter. They would work less than if there were no infectiousness effects.[6] Conscious infectiousness would also would lead to higher individual contributions to a group public good[7] and could lead to altruistic transfers from rich

[6] Assume now that individuals are aware of the infectiousness effects, and incorporate them into their own-happiness maximisation decision. Totally differentiating (6), using (10), gives the following first order condition for privately optimal labour supply in a symmetric non-cooperative Nash equilibrium:

$$\frac{dH_i}{dL_i} = \psi\left(w\frac{\alpha}{y_i} - \delta\right) + \phi\left(-\frac{w}{N-1}\sum_{j\neq i}^{N}[\gamma]\right) = 0 \tag{16}$$

Solving (16) yields the following for privately optimal earned income:

$$y^{\circ} = \frac{w\alpha}{\delta + w\frac{\phi}{\psi}\gamma} \tag{17}$$

$\frac{\phi}{\psi} = \frac{\beta}{(1-\beta)(N-1)+\beta}$ is increasing in β, decreasing in N and is always positive but less than 1. This means that there is always some 'overwork' but that greater infectiousness and a smaller group size can reduce and partially offset the inefficiency. The intuition for this is that since the infectiousness effect depends upon the *average* happiness of the other members of the group, a larger group effectively dilutes the internalisation of the relative income externality.

As β increases, the privately optimal level of earned income becomes closer to the socially optimal level. However, only as $\beta \longrightarrow 1^{-}$ will the privately optimal earned income level become first-best. Given that $\beta < 1$, as $N \longrightarrow \infty$ the outcome becomes just as inefficient as with no infectiousness. This is because when the number of individuals becomes large, the *average* relative income effect on each of them from an increase in *one* individual's income becomes negligible.

The intuition for why the infectious happiness effect is never sufficient to fully offset the relative income externality can be seen from the fact that both ψ and ϕ are increasing in β. Although as $\beta \longrightarrow 1$, $\phi \longrightarrow \psi^{-}$, both ψ and ϕ also simultaneously go to infinity. As long as $\phi < \psi$, the weighting on each other individual in an individual's happiness function is less than the weighting on onesself.

[7] We assume that each individual can contribute one unit of the public good with one unit of labour supply, and that one unit of the public good contributes one unit of income to *every* individual. Letting G_i be the individual contribution to the public good, setting $\frac{dL_i}{dG_i} = 1$ and $\forall_j : \frac{dy_j}{dG_i} = 1$, and using the fact that $\forall_i : y_i = y$ in a symmetric non-cooperative Nash equilibrium, we have the following first order condition for privately optimal contribution:

$$\frac{dH_i}{dG_i} = \psi\left(\frac{\alpha}{y_i} - \gamma - \delta\right) + \phi\left(\sum_{j\neq i}^{N}\left[\frac{\alpha}{y_j} - \gamma\right]\right) = 0 \qquad y^{\circ} = \frac{\alpha\left(1 + \frac{\phi}{\psi}(N-1)\right)}{\gamma\left(1 + \frac{\phi}{\psi}(N-1)\right) + \delta} \tag{18}$$

The first order condition for socially efficient provision of the group public good, meanwhile, will be (using a representative individual's happiness function, denoting the simultaneous contribution by G):

$$\frac{dH}{dG} = (\psi + \phi(N-1))\left(\frac{N\alpha}{y} - N\gamma - \delta\right) = 0 \qquad y^{*} = \frac{\alpha N}{\gamma N + \delta} \tag{19}$$

Since $\left(1 + \frac{\phi}{\psi}(N-1)\right) = \frac{(N-1)+\beta}{(1-\beta)(N-1)+\beta}$ is always less than N and increasing in β, there is always underprovision of the group public good, but the inefficiency is ameliorated as the infectiousness of happiness increases. Again, the first-best outcome is only achieved as $\beta \longrightarrow 1^{-}$.

group members to poorer ones[8]. Awareness of infectiousness would be happiness-increasing. However, none of these cases would yield the first-best level of happiness, given exogenously-determined α, β, γ and δ parameters. The policy problems posed by excess labour supply and the underprovision of public goods by voluntary individual effort would therefore remain, but would be less severe in a smaller group with greater infectiousness.

[8]Allowing individual i to transfer income to individual j by letting $\frac{dy_i}{dy_j} = -1$, and totally differentiating the expression for H_i from equation (6) using (10), gives the following first order condition for an altruistic transfer from individual i to individual j that maximises i's utility.

$$\frac{dH_i}{dy_j} = \psi\left(-\frac{\alpha}{y_i} + \frac{\gamma}{N-1}\right) + \phi\left(\frac{\alpha}{y_j} - \frac{\gamma}{N-1}\right) = 0 \tag{20}$$

(20) can be rearranged to yield the following:

$$\frac{y_i}{y_j} = \frac{\psi}{\phi}\left(1 - \frac{\gamma}{\alpha(N-1)}y_i\right) + \frac{\gamma}{\alpha(N-1)}y_i \tag{21}$$

Since $\frac{\psi}{\phi} > 1$, then provided that $y_i < \frac{\alpha(N-1)}{\gamma}$, it will be the case that $\frac{y_i}{y_j} > 1$. Under this condition, since $\frac{\psi}{\phi} = \frac{N-1}{\beta} - (N-2)$, the ratio of income of the donor (i) to the donee (j) is increasing in N and decreasing in β. Altruistic giving will be greater, and income ratios closer to equal, the smaller is the group and the higher is β. As $\beta \longrightarrow 1^-$, $\frac{\psi}{\phi} \longrightarrow 1$ and $\frac{y_i}{y_j} \longrightarrow 1$.

When $\beta < 1$, as $N \longrightarrow \infty$, $\frac{y_i}{y_j} \longrightarrow \infty$; altruistic giving is diluted in a large group. The intuition for this is that since individual happiness depends upon the average income in the reference group, a larger reference group reduces the incentive to give up income to any given individual. This reflects the standard phenomenon of income redistribution becoming a public good in a large group whose members dislike income inequality.

Table 1
Happiness functions including mean village happiness

	(1)	(2)	(3)
Personal variables			
Age (years)	-0.010743	-0.01221	-0.012261*
Age squared	0.000167**	0.000168*	0.000165**
Male (sex)	-0.065749**	-0.059325*	-0.04128
Married	0.131049*	0.137342	0.206390*
Divorced	-0.391229*	-0.586712**	-0.465230*
Widowed	-0.242822**	-0.183981	-0.080847
Ethnic minority dummy	0.095290***	0.040600	0.026346
Education (years)	0.005764	-0.004051	-0.00196
In good health	0.409144***	0.319755***	0.278667***
In a good mood	0.554933***	0.432448***	0.382372***
Economic variables			
Log of per capita household income 2002 ('000 Yuan)	0.159411***	0.104149***	0.063553***
Working hours ('00 per year)	-0.003476***	-0.002812*	-0.001604
Net wealth ('000 Yuan)	0.001764***	0.001101***	0.000916**
Village variables			
Satisfaction with clinic		0.061738***	0.043334**
Extent to which spokesman represents interests		0.040108**	0.039122***
Degree of harmony among lineages		0.042761*	0.030603
Degree of harmony in village		0.085734***	0.067849***
Household income much above village average		0.250374***	0.270873***
Household income above village average		0.135409***	0.192013***
Household income below village average		-0.346064***	-0.325974***
Household income much below village average		-0.967825***	-0.895177***
Average village happiness	0.586085***	0.495157***	0.399491**
County dummies			Yes
Constant	-0.786243**	-0.377767	0.371381
R-squared	0.218	0.301	0.389
Number of observations	8872	7528	7528

Notes:
1. Dependent variable: happiness score based on cardinal values assigned to qualitative assessments as follows: very happy=4; happy=3; so-so=2; not happy=1 and not at all happy=0.
2. Independent variables with cardinal values assigned to qualitative assessments so that a higher value denotes greater intensity: : satisfaction with clinic, extent to which spokesman represents interests; level of harmony among villagers, level of harmony among lineages.
3. The omitted categories in the dummy variable analyses are: female sex; married; not healthy; in normal or worse than normal mood; household at average village income.
4 ***, **, and * denote statistical significance at the one per cent, five per cent and ten per cent levels respectively.
5. Model (3) has been clustered at village level for robust standard errors.

Table 2
Happiness functions including mean village happiness, income and education

	(1)	(2)	(3)
Personal variables			
Age (years)	-0.009574	-0.010815	-0.011293*
Age squared	0.000154**	0.000152*	0.000154**
Male (sex)	-0.066747***	-0.060696**	-0.040937*
Married	0.118787*	0.129626	0.193875**
Divorced	-0.446661***	-0.650795***	-0.527283**
Widowed	-0.267171***	-0.210874*	-0.109677
Ethnic minority dummy	0.102671***	0.044364	0.033835
Education (years)	0.005839*	-0.003914	-0.002223
In good health	0.407708***	0.317900***	0.276919***
In a good mood	0.554136***	0.431780***	0.380692***
Economic variables			
Log of per capita household income 2002 ('000 Yuan)	0.163797***	0.108125***	0.067473***
Working hours ('00 per year)	-0.003524***	-0.002842**	-0.00146
Net wealth ('000 Yuan)	0.001735***	0.001085***	0.000941***
Village variables			
Satisfaction with clinic		0.061340***	0.039508***
Extent to which spokesman represents interests		0.040746***	0.041512***
Degree of harmony among lineages		0.041283**	0.028144*
Degree of harmony in village		0.086883***	0.069544***
Household income much above village average		0.255812***	0.272839***
Household income above village average		0.137947***	0.193466***
Household income below village average		-0.339410***	-0.318956***
Household income much below village average		-0.968218***	-0.890759***
Average village happiness	0.601122***	0.553546***	0.510743***
Average village income	-0.071755	-0.281117	-0.610389*
Average village education	0.002639	0.007607	-0.004289
County dummies			Yes
Constant	-0.756091*	-0.120021	1.308936*
R-squared	0.217	0.300	0.390
Number of observations	8694	7375	7375

Notes:
1. Dependent variable: happiness score based on cardinal values assigned to qualitative assessments as follows: very happy=4; happy=3; so-so=2; not happy=1 and not at all happy=0.
2. Independent variables with cardinal values assigned to qualitative assessments so that a higher value denotes greater intensity: : satisfaction with clinic, extent to which spokesman represents interests; level of harmony among villagers, level of harmony among lineages.
3. The omitted categories in the dummy variable analyses are: female sex; married; not healthy; in normal or worse than normal mood; household at average village income.
4 ***, **, and * denote statistical significance at the one per cent, five per cent and ten per cent levels respectively.
5. Models (2) and (3) have been clustered at village level for robust standard errors.

Table 3
Happiness functions including mean village happiness, with income instrumented

	(1)	(2)	(3)
Personal variables			
Age (years)	-0.019990*	-0.022139**	-0.023795**
Age squared	0.000216**	0.000249**	0.000269**
Male (sex)	-0.016111	-0.06053	-0.062668
Married	-0.392170**	-0.487417*	-0.482616***
Widowed	-0.933376**	-0.813357**	-0.810942**
Ethnic minority dummy	0.286060***	0.117418	0.119104*
Education (years)	-0.016646*	-0.015836*	-0.015085*
In good health	0.384371***	0.320797***	0.319241***
In a good mood	0.493580***	0.410606***	0.407749***
Economic variables			
Log of per capita household income 2002 ('000 Yuan)	0.966417***	0.565862*	0.556639**
Working hours ('00 per year)	-0.009055***	-0.004244	-0.004042
Net wealth ('000 Yuan)	-0.003977**	-0.002103	-0.002036
Village variables			
Satisfaction with clinic		0.074508***	0.075963***
Extent to which spokesman represents interests		0.032153**	0.032285***
Degree of harmony among lineages		0.032911	0.027458
Degree of harmony in village		0.073663***	0.078289***
Household income much above village average		0.202061**	0.198107**
Household income above village average		0.094895**	0.095623**
Household income below village average		-0.247153***	-0.244418***
Household income much below village average		-0.816295***	-0.813069***
Average village happiness	0.639847***	0.481927***	0.525198***
Average village income			-0.073401
Average village education			-0.066494
Constant	-5.820140***	-2.709769	-2.129702
R-squared	-0.133	0.175	0.181
Number of observations	5198	4511	4418
Exclusion restrictions used	Father's years of education; spouse's years of education	Father's years of education; spouse's years of education	Father's years of education; spouse's years of education
Significance of exclusion restrictions in first stage equation			
Father's years of education	**	*	**
Spouse's years of education	***	***	***
F-test of excluding instruments (P-val)	0.0000	0.0002	0.0000
Sargan/Hansen J test for overidentification of all instruments (P-val)	0.8826	0.6815	0.4974
Anderson Rubin test of joint significance of endogenous regressors in main equation, F test (P-val)	0.0004	0.1100	0.0655

Notes:
1. Dependent variable: happiness score based on cardinal values assigned to qualitative assessments as follows: very happy=4; happy=3; so-so=2; not happy=1 and not at all happy=0.
2. Independent variables with cardinal values assigned to qualitative assessments so that greater intensity is represented by a higher value are: satisfaction with clinic, level of harmony among villagers, level of harmony among friends,
3. The omitted categories in the dummy variable analyses are: female sex; married; employed or labour force non-participant; not healthy; in normal or worse than normal mood; current living standard the same as five years ago.

4. ***, **, and * denote statistical significance at the one per cent, five per cent and ten per cent levels respectively.
5. Instrumented variables regression results are generated using the Baum et al. (2003), ivreg2.ado programme for Stata.
6. The instrumented equations contain fewer observations because information relating to one of the exclusion restrictions, spouse's education, is available only for respondents who are the heads of their households and who are married or widowed. Hence a coefficient for the variable divorced cannot be estimated.

Table 4
Happiness functions including mean village happiness and income, with income instrumented using the Hausman-Taylor approach

	Instrumented/ instrument	(1)	(2)
Personal variables			
Age (years)	‡‡	-0.016899***	-0.018314***
Age squared	‡‡	0.000211***	0.000236***
Male (sex)	‡‡	-0.018508	-0.023933
Married	‡‡	0.236140***	0.234544***
Divorced	‡‡	-0.600850***	-0.642441***
Widowed	‡‡	-0.048728	-0.080989
Ethnic minority dummy	‡‡	0.144429**	0.132368**
Education (years)	†	-0.002256	0.001262
Unemployed	†	-0.087696	-0.079387
In good health	†	0.221562***	0.258365***
In a good mood	‡‡	0.331675***	0.383160***
Lived out	‡‡	0.005024	0.013243
Economic variables			
Log of per capita household income 2002 (‘000 Yuan)	†	0.047117***	0.078728***
Working hours (’00 per year)		-0.000435	0.000116
Net wealth (‘000 Yuan)	†	0.000249	0.001053***
Attitudinal variables			
Big increase	†	0.066812*	0.122793***
Small increase	†	0.019524	0.036944
Decrease	†	-0.093970**	-0.101106**
Better	†	0.193542***	0.274361***
Worse	†	-0.113986***	-0.200985***
Family is important	†	0.027584	0.025987
Friends are important	†	0.048739***	0.050204***
Religion is important	†	0.013527	0.017024*
Money is important	‡‡	-0.014439	-0.023932**
Village variables			
Phone	†	0.017622	0.071911***
Satisfaction with clinic	†	0.018987*	0.023277**
Extent to which spokesman represents interests	†	0.049102***	0.054928***
Degree of harmony among lineages	†	0.016841	0.017001
Degree of harmony in village	†	0.050869***	0.047897***
Household income much above village average	†	0.226895***	
Household income above village average	†	0.167193***	
Household income below village average	†	-0.311163***	
Household income much below village average	†	-0.826971***	
Average village happiness	†	0.247684***	0.203222**
Average village income	†		-0.171697
Total village population at end 2002 (‘00s)		-0.000617	-0.002732
Hilly terrain	†	-0.28125	-0.199636
Mountainous terrain	†	-0.648569***	-0.723691***
Constant		0.896808**	1.889870*

Number of observations	6979	6979
Sargan test for overidentification of all instruments (P-val)	0.7610	0.5065

Notes:
1. Dependent variable: happiness score based on cardinal values assigned to qualitative assessments as follows: very happy=4; happy=3; so-so=2; not happy=1 and not at all happy=0.
2. Independent variables with cardinal values assigned to qualitative assessments so that greater intensity is represented by a higher value are: satisfaction with clinic, level of harmony among villagers, level of harmony among friends,
3. The omitted categories in the dummy variable analyses are: female sex; married; employed or labour force non-participant; not healthy; in normal or worse than normal mood; current living standard the same as five years ago.
4. ***, **, and * denote statistical significance at the one per cent, five per cent and ten per cent levels respectively.
5. Instrumented variables regression results are generated using Stata's xtivreg command. The Sargan test results for overidentifying restrictions were generated using the xtoverid.ado programme (see Baum et al. 2006)
6. Instrumented variables are denoted by the symbol †. Variables used as instruments are those denoted by the symbol ‡‡; the means of these instruments; and, the mean deviations of all the instrumented variables (denoted by †) other than those of the two variables of interest, average village happiness and average village income.