How big a problem is noise pollution? A brief happiness analysis by a perturbable economist

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How big a problem is noise pollution?
a brief happiness analysis by a perturbable economist

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Abstract: We approach the question of the costs of everyday residential noise pollution by examining a series of 'happiness regressions.' Following standard approaches, we use a range of socio-economic data to explain respondents' declared level of life satisfaction, and then add perceived noise pollution into the analysis. In the process we replicate the observed patterns from other studies of this type. We find noise to exert a negative and highly significant effect on happiness, approximately of the same order of magnitude as being disabled. Using some rough and ready calculations, we find the monetary equivalent costs of noise pollution to be on the order of €170 per month per household.

Key words: happiness, hedonic regression, noise pollution
JEL codes: R21, R41, Q51

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Introduction

Noise pollution has been a source of concern for doctors, psychologists, and economists for some time. Perhaps due to the broad public policy implications, much of the attention has focussed on noise from roads and especially airports. For example, multiple studies have demonstrated the significant negative physical, psychological and economic effects of chronic aircraft noise exposure (see, for example, Stansfeld et. al. 2005, von Praag and Baarsma 2005). Another, smaller literature studies the determinants of overall residential satisfaction and often, while not focussing on it, includes noise as one of the contributing factors (see, for example, Diaz-Serrano (2006)).

In economics, there is naturally an interest in calculating the costs of noise pollution and comparing these to the costs of noise abatement policies. While the latter exercise is straightforward, there are a number of difficulties associated with summing up the economic and psychological effects of noise. One set of approaches to this problem includes contingent valuation or 'stated choice' methods where subjects are asked to give their willingness-to-pay for alternative levels of different attributes, or are asked to choose between alternative combinations whose monetary equivalence is known to the researchers (see, for example, Galilea and Ortuzar (2005), Wardman and Bristow (2007)). These methods are prone to various forms of strategic bias, however, and thus remain somewhat controversial (see Carson et. al. 2001 for a good review).

Since Walters (1975) it has become more common to use hedonic house price regressions to analyze the relationship between house prices and proximity to noise sources (usually airports) in order to estimate a shadow price of noise from the market data; all else equal, if similar homes sell for less the closer they are to the airport, the conditional difference in price is interpreted as the market discount attributed to the noise problem. The imputed noise costs found by many of these studies are substantial: for example, Nelson (2004) finds a $200,000 house would sell for $20,000 to $24,000 less if exposed to airplane noise.

In theory, with perfect information and free and costless mobility, in equilibrium house prices should completely compensate the noise differentials and the average home-owner should be left observationally indifferent between house X with noise level A and house Y with noise level B. However, von Praag and Baarsma (2005) point out that these assumptions for housing markets are far from realistic as moving costs are relatively high, both economically and socially. Many people who optimally chose a home 10 years ago may find themselves in a suboptimal situation years later for a number of reasons: increases in local traffic, changes in airplane flight paths, or noisy new neighbours next door. Nevertheless, high moving costs combined with the social and psychological costs of re-establishing a social network and leaving one's home of many years[1], many home owners may simply hunker down and stay put. Furthermore, many housing markets are highly regulated with a large amount of

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[1] For example, a home owner may have recently renovated their bathroom using Pietra de Luna natural limestone tiles and be loathe to either trade down or go through the ordeal again.

rationing (such as the market studied by von Praag and Baarsma[2]). If the housing market is not in equilibrium, house prices may not fully compensate for undesirable characteristics and there will be *residual* welfare costs.

A further complication arises when one considers that there may be considerable heterogeneity in individuals' tolerance towards noise. Walters (1975) distinguishes between 'perturbable' and 'imperturbable' people. Arsenio et. al. (2006) indeed does find evidence of self-selection, where those with higher marginal values of noise self select into quieter apartments. In the presence of such heterogeneity, noise tolerant people will be more likely to self-select into noisy areas (taking advantage of the lower prices) which in turn leads to a downward bias in any estimate of the average welfare costs of noise; those closest to the noise source are the least bothered by it! Endogenous selection implies that we cannot necessarily interpret the difference in house prices attributed to noise differentials as the total cost that would be imposed on an average individual exposed to that noise.

A third alternative, adopted here, is to use data from the many 'happiness' or life satisfaction surveys that are now available, many of which ask questions about noise pollution. For example, van Praag and Baarsma (2005) use a combination of life-satisfaction data (including detailed questions on exposure to different kinds of noise), house prices, and actual objective aircraft noise measurements by postcode to estimate the costs of airport noise around Amsterdam airport. As van Praag and Baarsma do not find any relationship between noise and price, all of the costs of airport noise in their case are derived from the happiness survey data.

This paper makes a small contribution to the literature on the welfare costs of noise by using the 'happiness' analysis approach, but taking a step back and asking a more general (and therefore less precise) question about noise pollution than addressed by van Praag and Baarsma. In particular, we consider what, on average, given the existing disequilibrium in housing markets and the actual distribution of perturbable and imperturbable individuals, is the welfare impact of *all* sources of noise pollution? Heterogeneity and self-selection will tend to downward bias our estimate compared to one that measures the impact of an exogenous noise shock, but disequilibrium in the market will tend to push our estimate upwards compared to an estimate based on an optimal allocation. In the end we simply wish to calculate the general welfare (i.e. utility) costs of noise pollution, expressing these as both monetary equivalents and in terms of equivalent welfare trade-offs with other relatively intangible characteristics of peoples' lives.

Data

In order to evaluate the welfare effects of noise we take advantage of a comprehensive stratified random sample survey undertaken by the European Foundation for the Improvement of Living and Working Conditions, set up by the European Council in 1975 to "contribute to the planning and design of better living and working conditions in Europe". The European quality of life survey (EQLS) was carried out in 2003,

[2] The Amersterdam market under study was so far out of equilibrium that von Praag and Baarsma found *no* relationship between noise exposure and price!

covered 28 countries, and involved interviewing 26,000 people. The survey examined a range of issues, such as employment, income, education, housing, family, health, work-life balance, life satisfaction and perceived quality of society. In addition to all the standard socio-economic and housing quality variables, respondents were asked to rank their overall life satisfaction, or happiness as some call it, on a scale of 1 to 10. They were also asked their frequency of exposure to complaint-warranting noise from all sources (from none to very many).

At first blush many economists might rightly be suspicious of surveys asking people how satisfied they are with life. As Di Tella and MacCulloch (2006) so succinctly put it, "economists are trained to infer preferences from observed choices… they watch what people do, rather than listening to what people say" (p. 25). However since the work of Richard Easterlin (1974), the use of life satisfaction, or happiness, survey data has become increasingly common among economists. Despite a few issues[3], numerous studies have shown these rankings to be surprisingly robust over time and across space, and correlated with the right signs to observables that we might expect to affect happiness (for a nice survey see Di Tella and MacCulloch (2006)).

Our primary dependent variable is the average of two answers from (identical) questions in which respondents were asked to rank their overall life satisfaction on a scale from 1 to 10 (see below for a discussion of why we chose to average the two). The mean 'happiness score' in the usable sample was 6.94, with a standard deviation of 1.96.

Our measure of noise is the response to the question of whether, in the area where the respondent lives, there are 'very many', 'many', 'a few', or no reasons to complain about noise. For most of the analysis we classify respondents who answered 'very many' or 'many' as living in a noisy area (***noisy***)[4]. We do not collect any information about the source of the noise, nor do we have any way of objectively measuring the actual decibel level of the offending noise. In the usable sample 1486 people (7.4% of the sample) claimed to have 'very many' complaints about noise, 2060 (10.2%) had 'many', 5427 (27%) had 'a few' and 11,143 (55.4%) people had no complaints about noise.

Our measure of income is after-tax household net monthly income, which respondents categorized into one of 19 possible income brackets (see table A2 in the appendix). Following Layard, Mayraz and Nickell (2008) we assign income to be the mean of each bracket[5] and include both the log of income and the square of the log of income in all our regressions. Other control variables include sex, age, marital status, education, employment status, family size, and various dwelling characteristics. In addition we include a full set of country fixed effects which will control for the average level of happiness within each country due to both observable and unobservable characteristics. Thus all our overall estimates should be interpreted as a weighted

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[3] For example, the bounded nature of the satisfaction ranking can impose an illusion of diminishing marginal returns.
[4] We later parse these out for robustness checks.
[5] For the last open-ended bracket of €4500+ we assign a value of €5000.

average of the *within* country estimates. A full list of all the variables and their definitions is provided in table A1 in the Appendix.

Method

The empirical approach we adopt here is quite straightforward: by including our survey measure of perceived noise pollution in a regression analysis, along with a comprehensive set of control variables that may relate to reported happiness levels, we estimate the marginal effect on reported happiness of different degrees of noise pollution. As we can also measure the effect on happiness of (rough) income level from the same regression, we can then calculate how much income would have to increase/decrease to produce the equivalent effect on reported happiness. We call this derived figure the income-equivalent cost of noise pollution.

This strategy is not novel – for example Clark and Oswald (2002), and Frey, Luechinger and Stutzer (2004) adopt just such an approach for valuing life events such as marriage, illness or unemployment, or terrorism, respectively. Furthermore, our strategy is quite a bit simpler than in van Praag and Baarsma (2005), who isolate the utility-compensation costs of *objective* increases in aircraft noise, controlling for other factors that affect perception of noise.

While the estimation strategy may be uncomplicated, it is not unproblematic. Ideally we would measure reported happiness before and after the exogenous introduction of different objective degrees of noise pollution in the same individuals. However our data is purely cross sectional, we measure perceived, not actual, noise levels, and the sources of that noise are not necessarily exogenous (for example, road noise may have existed when the respondent moved to their home). If there are unobservable characteristics that are correlated both with reported noise and with reported happiness levels (for reasons unrelated to the noise), then there could be omitted variable bias. Furthermore, if lower levels of happiness make people particularly sensitive to noise, there could be endogeneity bias[6]. Finally, there are also a number of issues with the estimation of elasticity of happiness with respect to income, which we discuss below.

As the dependent variable, a reported level of happiness, is a reported rank from 1 to 10, the standard estimator used in the literature is an ordered probit (O-probit). However the EQLS survey asked (in identical fashion) respondents to rank their happiness levels from 1 to 10 *twice* during the course of the survey, presumably for

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[6] However, preference heterogeneity by itself is not a problem here. For example, 'perturbable' people may both report more noise and lower happiness, but as long as the lower happiness is due to the fact that they are more perturbed by noise, then as long as we are consistent in interpreting our results as the effect on happiness of perceived noise (not actual noise), our results will not be biased and will in fact capture the overall *average* impact on happiness of the noise that is actually out there on the actual distribution of perturbable and imperturbable people, whatever that may be.

strategic reasons. Thus we have two highly correlated, but often non-identical, happiness rankings for each individual. Averaging these two responses should give us a more robust measure, but it also results in a variable with 19 possible values rather than 10. Thus it was not obvious whether ordered probit or simple OLS would be more suitable.

To further investigate we ran a number of basic happiness regressions using all three measures of happiness and both O-probit and OLS regressions. Results were quantitatively and qualitatively extremely similar regardless of whether we used the first happiness measure, the second happiness measure or the average of the two. They were also similarly comparable whether we used an O-probit or an OLS estimator. Furthermore, we found that the proportional log ratios assumption was rejected for the O-probit specification. One solution is to use a generalized ordered logit (GO-logit) instead, but we found that the GO-logit approach became extremely difficult to estimate and complex to interpret with so many possible outcomes.

Other studies have also examined the question of the most appropriate estimation method for the typical (ranking from 1-10) happiness data. Lu (1999) examines the question of using O-logit or OLS specification in the context of ordered residential satisfaction data. Although he finds the former preferable on first principles, in practice Lu also finds the results derived from the two approaches are the same. Thus our preferred estimation approach is to use the more robust average of the two happiness measures as the dependent variable with a robust OLS estimator[7].

Results

a. Estimating happiness regressions

Table 1 presents the results from our 4 primary happiness regressions. All four regressions control for country fixed effects (not reported) and report robust standard errors in parentheses. We follow the happiness literature for guidance on our basic set of control variables, and their choice is intuitive (a list of all control variables and definitions is included in the appendix).

Column (1) presents the baseline, classic happiness regression. All signs are intuitive and we replicate several interesting patterns reported in the literature. In particular, we find a very strong and extremely significant happiness effect of income: richer people are happier, although there is a diminishing marginal impact as income increases.

However there are several important caveats associated with the estimates of the effect of income on happiness. First, this is a cross sectional relationship – that a rich person is happier than a poor person does not automatically imply that the poor person would be made equally happy if they too were as rich. For example, it could be that what really matters is *relative* wealth. In fact, it is much harder to detect an effect of increasing income on happiness in a time series analysis (the famous Easterlin

[7] As mentioned above, none of our results seem at all sensitive to this choice.

Paradox[8]), although recently Stevenson and Wolfers (2008) present evidence that there is indeed such an effect.

Second, the relationship could be endogenous – happier people could earn more income (see, for example, Oswald and Powdthavee (2007)) - which could bias our estimates upwards or downwards. Third, omitted variables arguably bias the income coefficient on income downwards. For example, if higher income requires greater effort, but we do not control for (happiness reducing) effort in the analysis, we will under-estimate the degree to which an income increase uncompensated by effort would raise happiness[9].

Figure 1 presents the estimated relationship between happiness and income from our analysis. A striking feature of this curve is the very steep relationship between increasing income and increasing happiness at the lower ends of the socio-economic scale, with a significant flattening out at relatively moderate income levels. This sharply diminishing marginal utility of income could derive either from true declining marginal utility of money, some natural upper bounds on human life satisfaction, or be at least partially an artefact of the boundedness of the happiness rankings and the method of estimation[10].

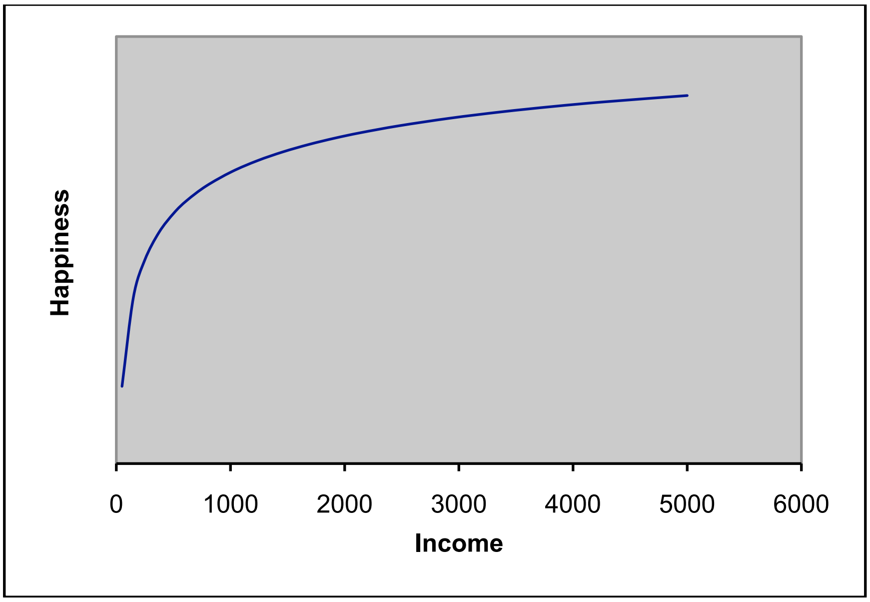

Figure 1: the estimated conditional relationship between household monthly income (€) and life satisfaction

At first glance, these results from a cross section of European countries seem to contrast sharply with results from the U.S. General Social Survey, as reported in

[8] See Easterlin (1974), Stevenson and Wolfers (2008)
[9] We thank Guy Mayraz for this insightful comment.
[10] Perhaps a result of either endogeneity or omitted variable bias discussed above. For example, if higher income jobs require proportionally more effort this could bias the coefficient downwards as income increases.

Layard, Mayraz and Nickell (2008) and reproduced here in Figure 2. In the U.S., it seems the curve remains steep over a much broader range of incomes.

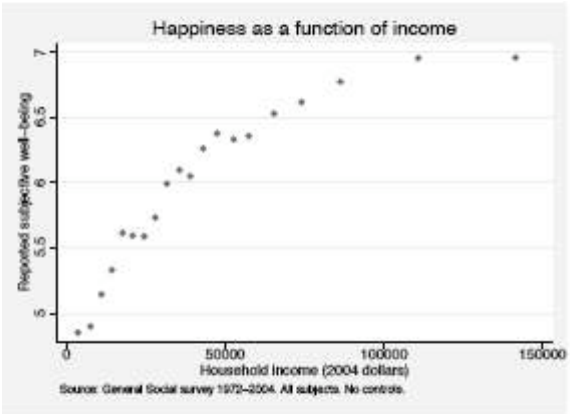

Figure 2: the estimated U.S. relationship between income and well being (no controls) **Source:** Layard, Mayraz, and Nickell (2008)

There are several things to keep in mind before jumping to conclusions. First, figure 1 presents a *conditional* relationship – we are controlling for education, health and other desirable attributes that tend to be highly correlated with income and arguably constitute the primary mechanisms through which income affects subjective well being. Figure 2 presents the unconditional correlation without controls. However, the unconditional estimates from the EQLS data (not reported) are not much different from the conditional ones, and the plots look almost indistinguishable to the eye.

A more likely explanation for the different shapes in figures 1 and 2 is the metric of 'well being' used in the U.S. General Social Survey. Unlike the EQSL, which uses a ranking of life satisfaction from 1 to 10, the U.S. survey presents respondents with only three levels of well being to choose from. This lack of correspondence between the dependent variables makes a direct comparison of the slope coefficients very difficult. However, estimating the slope will become important if we are to be able to calculate a compensating payment for lost satisfaction due to noise pollution, so it is a question which requires careful scrutiny.

Layard *et. al.* (2008) do just this; they analyze the EQLS, as well as seven other 'happiness' datasets, in order to estimate an elasticity of marginal utility with respect to income, which they denote ρ. Given the focus of their research, in order to focus on 'permanent income' they restrict their analysis to those between the age of 30 and 55, and delete the top and bottom 5% of outliers. Despite the difference in the samples, as with our analysis, Layard *et. al.* find that both log_income and (log_income) squared have explanatory power[11], and thus reject the hypothesis that happiness depends only linearly on the log of income (i.e. ρ=1). Layard *et. al.* go on then to estimate ρ using maximum likelihood, and their results suggest values of ρ that are reassuringly similar across countries and time and fall into the region of 1.19-1.34 with an overall average of 1.26. Although we do not directly estimate ρ ourselves, we can use these Layard et.

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[11] Although Layard *et. al.* (2008) find a much less significant coefficient on the squared log of income for the EQLS data, which is probably due to their much narrower data set.

al. results to compare against our own direct utility-compensating estimates as a robustness check (see discussion below and table 2).

Another interesting relationship that has drawn some attention recently is the correlation between happiness and age. Thus, following some recent research (see, for example, Yang Yang (2008), Oswald and Blanchflower (2008)), we also control for age, age-squared and age-cubed. Mirroring the findings of others, we find a striking dip in happiness around middle age, which then heads upwards again as people age further[12]. This relationship holds true controlling for health, income, marital status, country of residence, etc. and has received quite a bit of interest from sociologists, psychologists and economists in the last year. Figure 3 illustrates this estimated cubic inverted-U relationship from our baseline regression.

Figure 3: the estimated conditional relationship between reported life satisfaction and age

In Column (2) we introduce our noise variable, ***noisy***, to the baseline regression. Respondents who report 'very many' or 'many' reasons to complain about noise in the area where they live are much less happy than others, and this is highly statistically significant. The coefficient estimate of -0.260 is similar in magnitude to reported effects of noise on housing satisfaction by Diaz-Serrano (2006)[13], and approximately of the same order of magnitude as the coefficient on being disabled (≅0.30). In column (3) we parse out our ***noisy*** variable into its component parts: ***noise1***

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[12] Thank goodness.

[13] Diaz-Serrano reports 12 country-specific regressions explaining 'satisfaction with housing' (also ranked from 1-10) from the European Community Household Panel from 1994-2001, split between owners and renters, for a total of 24 regressions. Coefficient estimates on 'neighborhood noise' ranged from a highly significant -0.348 (renters in the UK) to an insignificant -0.004 (owners in Italy). The overall (unweighted) average 'noisy neighborhood' coefficient is -0.182. Excluding the apparently imperturbable countries of Ireland and Italy, where noise is not statistically significant, yields and estimate of -0.219.

corresponds to 'very many' noise complaints, ***noise2*** 'many', and ***noise3*** denotes only 'a few' complaints (the excluded category is 'no complaints'). As expected, the coefficients on the three variables declines monotonically from -0.382 (worse than being disabled!) for the most noise to -0.234 for relatively fewer complaints.

In column (4) we consider whether our noise variable could be proxying for other characteristics of the respondent's dwelling. For example, poorly constructed housing can lack acoustic insulation, causing more noise complaints, as well as decrease happiness more directly. Thus in regression (4) we control for the state of the dwelling: whether it is considered too small, how high the density (family size/number of rooms) is, whether it is in bad shape (with rot or no indoor plumbing), and whether the respondent owns the property, privately rents or lives in public housing. Once we have controlled for all these housing factors, the magnitude of the coefficient estimate on ***noisy*** falls to -0.196, but is still negative and highly statistically significant.

Finally, it is interesting to note that in regression (1) ***Urban*** is negative and significant. However, once we control for noise pollution in regressions (2)-(4), the significance of this variable disappears, and even switches signs to positive in regression (3) when noise is more disaggregated. Thus it seems that a primary disutility of living in urban areas comes from noise pollution – and in fact people are indifferent between rural and urban areas once noise is taken into account.

b. Utility compensating income estimates

We have found noise pollution to have a relatively large and statistically significantly negative effect on life satisfaction. However we would also like to calculate the monetary equivalent impact: by how much would income have to increase to compensate for the negative effect on happiness that noise pollution creates?

Taking our coefficient estimates from regression (2) on ***log income*** and square of ***log income*** we get our partial happiness function:

$$H = 0.745\ln(i) - 0.0302\ln^2(i) \qquad (1)$$

where H denotes our happiness score and i denotes income.

We take the derivative of H with respect to i to find the slope:

$$\frac{\partial H}{\partial i} = \frac{0.745 - 0.0604\ln(i)}{i} \qquad (2)$$

Clearly, the income required to compensate an individual for a loss of happiness due to noise pollution (or anything else) will vary with that individual's income. In the case of noise, our estimate for the loss life satisfaction associated with having 'many' or 'very many' complaints about noise ranged from 0.196 to 0.260 'units' of happiness. Table 2 presents the required compensatory income to offset the (conservative) 0.196 unit loss of happiness for each of the 19 income levels in the EQLS survey. The amount varies from €19/month for the lowest income bracket, up to a staggering €4200 for the top group.

There are several interesting points to note. First, the general relationship outlined in table 2 is not overly sensitive to the choice of functional form for the happiness-income parameterization. In separate robustness checks using level income brackets (1-19), dividing the sample into three income groups, and allowing separate intercepts and slope coefficients for each, we found very similar results (not reported but available upon request).

Second, taking the compensation amounts presented in table 2 as the amount required to compensate for *noise pollution* assumes that a noisy environment reduces happiness in equal amounts for all income cohorts. For wealthy people, spending to reduce noise pollution is a good deal in happiness terms, so we would expect them to 'buy' themselves out of a lot of the noise (and other) problems that less wealthy individuals face. In fact, if we break up the noise variable, ***noisy***, by income bracket, we find that the wealthiest third do not suffer[14] from noise (even if they complain about it), suggesting that what they consider to be 'noise' is not the same as it is for the lower income classes.

If we thus omit the top third of the income scale from consideration (they do not suffer from noise pollution!), we are still faced with implausibly high compensation rates for the middle income group. This of course is simply a direct result of the sharp flattening out of the estimated happiness-income curve. However, given our suspicion that the income coefficient may be biased downward (due to omitted effort) we may arguably justify adopting the more liberal estimates from the lower income cohorts. Moreover, it is probably politically and possibly ethically infeasible to consider making larger compensation payments to wealthier individuals for noise pollution (although this is routinely done in wrongful death cases, for different reasons). Thus on the basis of our results for the lowest third of income levels (taking the average of the six lowest brackets), given the estimates for the (conservative) utility costs of noise from regression (4) we adopt a very rough estimate of a monetary equivalent cost of relatively severe noise pollution to be on the order of €167 per month for a household.

Finally, as we have discussed above, Layard, Mayraz and Nickell (2008) calculate the elasticity of happiness with respect to income (ρ) for 8 different data sets, and column 4 of table 2 presents the implied compensation for each income bracket from their mean overall estimate of ρ, 1.26. As is apparent, the Layard *et. al* estimates are higher than ours. Perhaps this is to be expected as their estimate for the EQLS of $\rho=1.19$ was the lowest of all the datasets. However, estimates of the compensating income required at $\rho=1.19$ are still slightly higher than ours[15].

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[14] The coefficient on ***noisy*** for the top 6 income brackets was -0.07 with a robust t-statistic of -1.01. Full results available upon request.

[15] Recall that they used an abbreviated sample, omitting outliers and including only those between the ages of 30 and 55. In addition they used direct maximum likelihood estimation on a slightly different functional form.

Discussion

This paper presents a simple empirical exercise to raise awareness of a simple point: although it may seem unimportant to some, noise pollution can have a serious detrimental affect on people's life satisfaction. We approach this problem by examining a series of 'happiness regressions' in which we use a range of socio-economic data to explain respondent's declared level of life satisfaction on a scale from 1 to 10. In the process we replicate the observed patterns from other studies of this type. For example, we find decreasing marginal utility of income and a significant inverse-U shape in the relationship between age and happiness.

Our primary focus is the impact of noise pollution on this overall life satisfaction measure. Furthermore, if possible we would like to compare the happiness cost of noise to the happiness benefit of income. From this comparison we can then generate an estimate of the monetized cost of noise pollution as an alternative to more standard hedonic approaches based on market prices. In particular, while a number of other studies have used hedonic methods to monetize the costs of traffic and airport noise (which are substantial), this paper makes a stab at monetizing the costs of everyday neighbourhood noise of *all* types (even imaginary noise!).

In the process of generating our estimates we confront some significant hurdles in dealing with the 'happiness' data that is now routinely collected in many surveys. In particular we find a severe decline in the marginal impact of income on happiness even at very moderate levels of income. While this could be a true reflection of people's underlying preferences, it may also be due to endogeneity, reflect a downward bias from omitting a measure of 'effort' from the analysis, or be an artefact of the bounded nature of the happiness rankings themselves. At any rate, taken at face value a low elasticity of happiness with respect to income automatically implies that quite large monetary transfers must be made to compensate a given fall in 'happiness,' leading to implausible and infeasible estimates of the value of noise abatement for higher income individuals.

However our results also suggest that higher income households make those trade-offs they see as worthwhile and 'buy' themselves out of serious noise problems[16]. Among the wealthiest cohort of our sample, even those having 'many' or 'very many' reasons to complain about noise did not experience lower happiness by a statistically significant amount as a result, suggesting that their perception of noise is quite different from those with less income.

In the end, we adopt the estimates from the bottom third income cohort of the sample. For this group, we estimate that the monetary equivalent of relatively severe noise pollution would be on average about €167 per month per household. Clearly these are large costs which, if taken at face value, can easily justify significant investment in noise abatement policies and infrastructure.

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[16] This strategy turns out to be much more difficult in extraordinarily expensive cities, such as central London.

The question of whether it is reasonable to adopt these estimates at face value is interesting. Van Praag and Baarsma (2005) find that an Amsterdam-area household with monthly income of €1500 would require (monthly) compensation of €57 for an increase in aircraft noise from 20 to 40 *Ku*. As mentioned earlier, Nelson (2004) finds a US$200,000 house would sell for $20,000 to $24,000 less if exposed to airplane noise. $24,000 amortized over 20 years at 4% comes to about $145/month. Galilea and Ortuzar (2005) use a stated preference approach and find a (conservative) estimate of willingness-to-pay (WTP) of US$2.12 per decibel (dB(A)) per month. Double glazing reduces noise levels by approximately 30 dB(A), so their results suggest a WTP of $64/month to reduce noise to a degree equivalent to that achieved by double glazing.

It is difficult to see how to directly compare these disparate estimates, but the general order of magnitude does not seem too out of line with our results. Other studies have focussed on single sources of noise, whereas here we attempt to capture the effect of all sources of irritating neighbourhood noise. Furthermore, one could argue that, due to endogeneity and omitted variable bias of the income coefficient as discussed above, our results should be interpreted as constituting an upper bound of the effect of noise on happiness. On the other hand, psychological studies suggest that people often under-predict how unhappy a future bad event will make them (see Gilbert (2006)), suggesting in turn that the WTP estimates be considered lower bounds[17]. In sum, then, our primary conclusion is that noise pollution seems to be a cause of significant personal dissatisfaction (especially in urban areas) and that this disutility is not wholly immune from quantification. Clearly, more research would be welcome.

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[17] Many thanks to Guy Mayraz who helpfully pointed this out.

Tables

Table 1: Happiness OLS Regressions

VARIABLES	(1) LHS = Happy	(2) LHS = Happy	(3) LHS = Happy	(4) LHS = Happy
Noisy		-0.260***		-0.196***
		(0.0322)		(0.0322)
Noise1			-0.382***	
			(0.0507)	
Noise2			-0.321***	
			(0.0398)	
Noise3			-0.234***	
			(0.0265)	
Urban	-0.0476**	-0.0206	0.00554	-0.00308
	(0.0236)	(0.0238)	(0.0240)	(0.0241)
Sex	-0.132***	-0.131***	-0.133***	-0.127***
	(0.0239)	(0.0238)	(0.0238)	(0.0236)
Age	-0.116***	-0.115***	-0.113***	-0.106***
	(0.0175)	(0.0175)	(0.0175)	(0.0174)
Age^2	0.00195***	0.00193***	0.00190***	0.00163***
	(0.000354)	(0.000354)	(0.000354)	(0.000353)
Age^3	-9.32e-06***	-9.27e-06***	-9.12e-06***	-7.18e-06***
	(2.23e-06)	(2.23e-06)	(2.23e-06)	(2.22e-06)
Log income	0.736***	0.745***	0.759***	0.714***
	(0.103)	(0.102)	(0.102)	(0.102)
$(\text{Log income})^2$	-0.0292***	-0.0302***	-0.0312***	-0.0333***
	(0.00790)	(0.00790)	(0.00789)	(0.00789)
Family size	-0.0241**	-0.0242**	-0.0251**	0.0266**
	(0.0107)	(0.0107)	(0.0107)	(0.0123)
Married	0.575***	0.574***	0.574***	0.563***
	(0.0339)	(0.0338)	(0.0338)	(0.0339)
Single	0.109**	0.107**	0.106**	0.0867*
	(0.0456)	(0.0455)	(0.0454)	(0.0454)
University	0.215***	0.214***	0.221***	0.183***
	(0.0297)	(0.0297)	(0.0297)	(0.0296)
Employed	-0.139*	-0.138*	-0.147*	-0.125
	(0.0837)	(0.0833)	(0.0832)	(0.0816)
Unemployed	-0.789***	-0.787***	-0.798***	-0.730***
	(0.0965)	(0.0962)	(0.0961)	(0.0944)
In School	0.0177	0.0188	0.0174	-0.0116
	(0.0852)	(0.0848)	(0.0847)	(0.0828)
Retired	0.00195	0.00515	-0.00129	0.0289
	(0.0919)	(0.0916)	(0.0914)	(0.0898)
Housewife	-0.111	-0.104	-0.118	-0.0704
	(0.0940)	(0.0936)	(0.0935)	(0.0919)
Disabled	-0.322**	-0.320**	-0.332***	-0.262**
	(0.126)	(0.126)	(0.125)	(0.125)
Healthy	0.802***	0.795***	0.789***	0.757***
	(0.0296)	(0.0295)	(0.0295)	(0.0293)
Unhealthy	-0.881***	-0.873***	-0.869***	-0.853***
	(0.0487)	(0.0487)	(0.0486)	(0.0486)

Table 1 (cont.)

VARIABLES	(1) LHS = Happy	(2) LHS = Happy	(3) LHS = Happy	(4) LHS = Happy
Small				-0.200***
				(0.0312)
Bad shape				-0.385***
				(0.0287)
Density				-0.181***
				(0.0311)
Owner_occupied				0.0791
				(0.0519)
Rent_private				-0.150**
				(0.0602)
Rent_public				-0.0153
				(0.0602)
Constant	5.248***	5.231***	5.245***	5.719***
	(0.431)	(0.431)	(0.430)	(0.429)
Observations	**20113**	**20113**	**20113**	**20016**
R-squared	**0.346**	**0.349**	**0.351**	**0.363**

Notes:
*** p<0.01, ** p<0.05, * p<0.1
Robust standard errors in parentheses
all regressions include country fixed effects (not reported)

Table 2: Utility compensating income transfers

Mean monthly household income (€)	Slope of the happiness-income curve (dH/di)	Necessary income transfer to compensate for 0.196 happiness units (€/month)	Layard et. al. (2008) estimate of compensation for ρ=1.26 (€/month)
50	0.010174	19	27
150	0.002949	66	108
250	0.001646	119	206
375	0.001032	190	343
505	0.000731	268	499
617	0.000579	339	643
787	0.000435	451	873
1012	0.000323	606	1199
1237	0.000255	770	1544
1462	0.000209	940	1906
1687	0.000176	1116	2283
1912	0.000151	1298	2673
2137	0.000132	1486	3075
2475	0.000110	1777	3700
2925	8.989E-05	2180	4566
3375	7.535E-05	2601	5469
3825	6.451E-05	3038	6403
4274	5.616E-05	3490	7364
5000	4.611E-05	4250	8973

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Appendix

Table A1: The EQLS variables used in the analysis are:

Variable Name	Variable Definition
Happy	The average of the two responses ranking overall life satisfaction on a scale from 1-10
sex	Sex=1 if respondent is male
age	Age of the respondent
income	Net household monthly income bracket (see table A2)
Famsize	Household size
married	Respondent is married
Single	Respondent is single
University	Highest level of education attained is university
emp	Respondent is employed
Unemp	Respondent is unemployed
Inschool	Respondent is currently in education
Retired	Respondent is retired
Housewife	Respondent is a housewife
Disabled	Respondent is classified as disabled
healthy	Respondent reports health to be excellent, very good, or good
unhealthy	Respondent reports health as poor
urban	Respondent lives in a city, city suburb, or a medium to large town
Noise1	there are 'very many' reasons to complain about noise in the area where the respondent lives
Noise2	there are 'many' reasons to complain about noise
Noise3	there are 'a few' reasons to complain about noise
Noisy	noise1=1 or noise2=1
small	Respondent's dwelling is short on space
badshape	Respondent's dwelling has rot in windows, doors or floors, damp or leaks, or lack of indoor flushing toilet
den	Density = family size / number of rooms
ownerocc	Respondent is an owner-occupier of dwelling
rentpriv	Respondent is a private renter of dwelling
rentpub	Respondent rents from the state (i.e. public housing)

Excluded categories include:
Employment status: Other
Marital status: Divorced or Widowed, don't know/no answer
Ownership status: accommodation is provided free, Other, Don't Know
Health: 'health is fair' and 'don't know'
Education: highest level of education attained is primary or secondary

Appendix (cont.)

Table A2: Income brackets

Income is net monthly household income, divided into 19 non-uniform brackets:

Value	Income bracket
1	Less than 100 euro
2	100 to 199 euro
3	200 to 299 euro
4	300 to 449 euro
5	450 to 559 euro
6	560 to 674 euro
7	675 to 899 euro
8	900 to 1124 euro
9	1125 to 1349 euro
10	1350 to 1574 euro
11	1575 to 1799 euro
12	1800 to 2024 euro
13	2025 to 2249 euro
14	2250 to 2699 euro
15	2700 to 3149 euro
16	3150 to 3599 euro
17	3600 to 4049 euro
18	4050 to 4499 euro
19	4500 euro or more

Table A3: Countries in EQLS Sample

Austria	Italy
Belgium	Latvia
Bulgaria	Lithuania
Cyprus	Luxembourg
Czech Republic	Malta
Denmark	Netherlands
Estonia	Poland
Finland	Romania
France	Slovakia
Germany	Slovenia
UK	Spain
Greece	Sweden
Hungary	Turkey
Ireland	Portugal