A Meta-Analysis of the Willingness to Pay for Reductions in Pesticide Risk Exposure

Chiara M. Travisi, Raymond J. G. M. Florax and Peter Nijkamp

NOTA DI LAVORO 101.2004

JULY 2004

SIEV – Sustainability Indicators and Environmental Valuation

Chiara M. Travisi, *Department of Management Economics and Industrial Engineering, Polytechnic of Milan*
Raymond J. G. M. Florax, *Department of Spatial Economics, Free University and Department of Agricultural Economics, Purdue University*
Peter Nijkamp, *Department of Spatial Economics, Free University and Tinbergen Institute*

This paper can be downloaded without charge at:

The Fondazione Eni Enrico Mattei Note di Lavoro Series Index:
http://www.feem.it/Feem/Pub/Publications/WPapers/default.htm

Social Science Research Network Electronic Paper Collection:
http://ssrn.com/abstract=XXXXXX

A Meta-Analysis of the Willingness to Pay for Reductions in Pesticide Risk Exposure

Summary

The use of environmental policy instruments such as eco-labelling and pesticide taxes should preferably be based on disaggregate estimates of the individuals' willingness to pay (WTP) for pesticide risk reductions. We review the empirical valuation literature dealing with pesticide risk exposure and develop a taxonomy of environmental and human health risks associated with pesticide usage. Subsequently, we use meta-analysis to investigate the variation in WTP estimates for reduced pesticide risk exposure. Our findings show that the WTP for reduced risk exposure is approximately 15% greater for medium, and 80% greater for high risk-levels, as compared to low risk levels. The income elasticity of pesticide risk exposure is generally positive, although not overly robust. Most results indicate that the demand for human health and environmental safety is highly elastic. We also show that geographical differences, characteristics of the survey, and the type safety device (eco-labelling, integrated management, or bans) are important drivers of the valuation results.

Keywords: Pesticide risk, Willingness to pay, Meta-analysis

JEL Classification: D18, H23, I12, Q25

We would like to thank Marco Vighi and Antonio Finizio from the Department of Environmental Sciences, University of Milano-Bicocca, in Italy, for toxicological and ecotoxicological advice, and Erik Verhoef and Henri de Groot from the Department of Spatial Economics, Free University, Amsterdam, The Netherlands, for helpful comments and suggestions. We are also grateful for extensive comments generated by two anonymous reviewers. This research was conducted while Chiara M. Travisi was a researcher at FEEM, Milan. The usual disclaimer applies.

Address for correspondence:

Raymond J. G. M. Florax
Department of Spatial Economics
Free University
De Boelelaan 1105
1081 HV Amsterdam
The Netherlands.
E-mail: rflorax@feweb.vu.nl

1. Introduction

The use of chemical inputs such as fertilizer and pesticides has contributed to an unprecedented growth in agricultural production and productivity. At the same time, the impact of environmental and health risks associated with intensified use of chemicals has increased as well. The available empirical evidence from medical and (eco-)toxicological studies documents the prevalence of non-negligible hazards to human health and to the quality of aquatic and terrestrial ecosystems. Pesticides can, for instance, contaminate drinking water and food crops, and high-dosage pesticide usage in the production of fruits and vegetables can potentially induce serious health hazards to consumers (Pimentel *et al.*, 1992). Poisoning of farmers due to field exposure to pesticides occurs frequently, especially in developing countries (Sivayoganathan *et al.*, 2000). Pesticides belong to the most frequently detected chemicals in water, particularly in groundwater (Funari *et al.*, 1995), and pesticide usage affects the quality and quantity of the flora (Pimentel and Greiner, 1997), mammalian species (Mason *et al.*, 1986), insects (Murray, 1985), and birds (Luhdholm, 1987).

The consumers' awareness for food safety and the social preference to improve the environmental sustainability of agriculture culminate in the design and application of new policy instruments. One such policy instrument is eco-labelling of fresh produce (Govindasamy *et al.*, 1998; Blend and Ravenswaay, 1999), but rules and regulations for the proper use of pesticides and (optimal) pesticide taxes have been designed as well (Swanson, 1998; Mourato *et al.*, 2000; Pearce and Seccombe-Hett, 2000). The availability of detailed and disaggregated monetary estimates of the individual's willingness to pay for pesticide risk reductions is, however, pivotal for a successful implementation of such policies. In the case of eco-labelling, WTP information provides a basis for price differentiation according to the type and severity of pesticide risks involved in the production of produce. In the case of an ecological tax, economic theory shows that a Pigouvian tax requires the eco-tax to be set equal to the marginal value of the negative externalities associated with pesticide usage.

The multidimensionality of pesticide risks implies that potential tradeoffs exist in correcting for different types of impacts. The relative importance of each pesticide risk, as measured by the individuals' WTP for declined risk exposure, is therefore crucial in the price setting and tax determining behaviour of producers and the government.[1] In this paper, we present a statistical summary of WTP estimates for reduced pesticide risk exposure taken from the empirical economic literature. We use meta-analysis as a statistical tool to analyse the variation in the estimated WTPs associated with the impacts of pesticide risk on human health and the environment. Meta-analysis is a form of research synthesis in which previously documented empirical results are combined or re-analysed in order to increase the power of statistical hypothesis testing. Some proponents maintain that meta-analysis can be viewed as quantitative literature review. Others assert that meta-analysis can be used to pinpoint aspects critical to the future development of theory (Stanley, 2001).

This paper is organized as follows. In Section 2, we discuss the theoretical underpinnings of risk valuation and review the food safety and environmental benefits literature. We also introduce a taxonomy of WTP measures according to different types of risks. In Section 3, we present an exploratory assessment of empirical WTP values for different pesticide risk impacts. Section 4 gives an overview of potential determinants for differences in WTP values, where the differences are related to theory, behavioural aspects and/or the research design of the underlying studies. In Section 5, we analyse the empirical WTP estimates by means of a meta-regression in order to account for potential differences in a multivariate framework. Section 6 provides conclusions.

2. Valuation of pesticide risks

The implicit value of pesticide risk should reflect preferences of the economic actors exposed to the risk. These actors include producers applying pesticides in production processes, and consumers of products that have been produced using pesticides, as well as the more general group of consumers of use and non-use 'services' from the environment. The monetary value of a decrease in pesticide usage and the associated hazards can be expressed as the aggregate individuals' willingness to pay for pesticide risk reduction or, alternatively, the willingness to accept (WTA) a compensation for exposure to increased pesticide risk levels. WTP (and WTA) values hence reflect preferences, perceptions and attitudes toward risk of the economic actors affected by the decision to lower

[1] Note that a Pigouvian tax equals the aggregate marginal damage only if evaluated at the efficient pollution level. We also implicitly assume that a first-best world is considered.

prevailing levels of pesticide usage, implying that the WTP for a risk decrease can differ among different hazardous situations (Sjoberg, 1998, 2000).

The risk valuation literature typically assumes that preferences can be represented by continuous and smooth utility functions, and that the total WTP is a strictly increasing concave function of the level of risk reduction (Grossman, 1972; Jones-Lee, 1976). There is strong empirical support for these assumptions, although they are occasionally refuted as well (see, e.g. Smith and Desvouges, 1987). The downward-sloped relationship between the marginal WTP and the risk of experiencing a situation with detrimental effects of pesticides usage can conveniently be interpreted as a demand function for health or environmental quality. The impacts of pesticide usage can be interpreted in terms of health risks and/or the risk of environmental degradation due to, for instance, increased contamination of soil and water resources, reduction in farmland biodiversity, and loss of natural habitats. Obviously, the WTP estimate depends on both the initial risk level and the change in the level of pesticide risk at stake. de Blaeij *et al.* (2003) observe that the dependence of the marginal WTP on the initial risk level and the level of risk reduction has often been disregarded in the empirical risk valuation literature. The latter is, however, only warranted if the demand function is close to horizontal at low risk levels.

The WTP (or WTA) concept can be empirically measured using stated or revealed preference techniques. Both stated and revealed preference approaches have their pros and cons. The analysis of revealed preference data is often hampered by lack of data on the choice-set considered by the actor, and the actor's perception of risks. Moreover, econometric difficulties, such as multicollinearity, can severely hamper the estimation of trade-offs between money outlays and health improvements. These problems can be circumvented by the use of stated preference techniques, although the answers of respondents can then depend rather strongly on the way in which contextual information is presented. Moreover, non-use values of pesticide risk reduction can only be captured by stated preference techniques. A more general issue, relevant to both techniques, is that many respondents may have cognitive difficulties handling information about uncertainty, because real-life risk changes tend to be very small in magnitude. An advantage of the stated preference approach is that the information provided during the interview can help guiding the respondent to a proper understanding of the 'good' being valued, and of the breadth of the implied health improvement (Slovic, 1987).[2]

Over the last two decades, an extensive empirical economic literature on pesticide risk valuation has emerged. The WTP estimates available in this literature typically refer to negative side effects on human health, and to damage to environmental agro-ecosystems. Historically, the literature has been driven by the interest in human rather than environmental effects of pesticide risk management, and the literature therefore focuses primarily on the valuation of health effects on consumers and farmers (see, e.g. Roosen *et al.*, 1998; Blend and Ravenswaay, 1999; Fu and Hammitt, 1999; Wilson, 2002). Considerably fewer studies address the ecological dimension of pesticide risk (see, e.g. Higley and Wintersteen, 1992; Mullen *et al.*, 1997; Lohr and Higley, 1999; Foster and Mourato, 2000; Brethour and Weersink, 2001; Cuyno *et al.*, 2001).

The food safety literature centres on the valuation of human health risks associated with the presence of pesticide residues in food, typically using stated preference approaches. Most studies refer to the US, given the importance of food safety policy there (see, e.g. Misra *et al.*, 1991; Ravenswaay and Hoehn, 1991a,b; Baker and Crosbie, 1993; Eom, 1994; Buzby *et al.*, 1995; Roosen et al., 1998). Occasionally, the valuation concerns a cost-benefit analysis of the reduction or ban of a specific pesticide compound (Bubzy *et al.*, 1995; Roosen *et al.*, 1998). Alternatively, the valuation is more marketing-oriented and focuses on consumers' WTP for certified residues-free produce or fresh products certified for integrated pest management (see, e.g. Misra *et al.*, 1991; Ravenswaay and Hoehn, 1991a; Ott, 1990; Baker and Crosbie, 1993; Eom, 1994; Blend and Ravenswaay, 1999).

More recently, the study of pesticide risks extends to pesticide health risks for farmers (Wilson, 2002). Higley and Wintersteen (1992), Mullen *et al.* (1997), and Brethour and Weersink (2001) extend the focus of the pesticide risk literature by including the valuation of changes in integrated pesticide risk management on the environment in addition to considering acute and chronic human toxicity for farmers.[3] Their environmental categories include ground and surface water, aquatic

---

[2] Stated preferences can be generated using the contingent valuation technique, choice experiments (i.e., conjoint analysis, contingent ranking or choice modelling), or the health-state utility approach (see de Blaeij, 2003, for details).

[3] Brethour and Weersink (2001) actually use a simple value transfer approach and extrapolate their estimates from the WTP-values of Mullen *et al.* (1997). These results are therefore not included.

species, avian species, mammals, and arthropods. Cuyno *et al.* (2001) improve on this approach in order to avoid double counting by distinguishing fewer environmental categories corresponding to non-target organisms at risk. Finally, Foster and Mourato (2000) and Schou *et al.* (2002) combine the analysis of human health effects and the environment by employing contingent ranking techniques to determine the WTP for the reduction of human health effects, and loss of farmland biodiversity.

Human health deterioration and environmental degradation caused by pesticide usage are intrinsically heterogeneous because targets, exposure mechanisms, and endpoints vary. In order to facilitate the interpretation of the empirical results in the literature, we use a taxonomy of available WTPs for pesticide risk reduction. Figure 1 provides a schematic overview in which we increase the detail of the classification up to the definition of sub-sets of risk reduction benefits with analogous targets and endpoints.

< Figure 1 about here >

In Figure 1, the class referring to environmental degradation includes WTPs of pesticide risk reduction with respect to various non-target ecosystems. The term non-target ecosystems is used to indicate all living organisms that can be reached and spoiled by pesticides, with the exception of pests specifically intended to be destroyed by the pesticide applications. We distinguish two different targets, aquatic and terrestrial ecosystems, and within those ecosystems, several different types of non-target organisms.

WTP estimates concerning the reduction of pesticide hazards for human health refer either to direct effects on farmers, or to effects on consumers due to the ingestion of produce that contains pesticide residues. Pesticide hazards for farmers are typically related to direct contact with pesticide compounds or to field exposure, whereas detrimental health effects on consumers may be caused by pesticide residue in produce, specifically in fresh fruits and vegetables. In both cases, WTPs can be related to either acute or chronic health effects, caused by pesticide poisoning and long-lasting exposure to low concentrations of pesticides, respectively. The risk of developing cancer is considered explicitly in some studies, although with different specifications. Cancer hazard associated with ingestion of pesticide residues is frequently directly evaluated (that is, it is explicitly mentioned in the valuation question), whereas the hazard related to field exposure is oftentimes analysed indirectly by characterising chronic risks using information deduced from cancerogenity and teratogenesis tests.

3. Exploratory meta-analysis

Meta-analysis is essentially the 'analysis of analyses' (Hunter and Schmidt, 1990) and has a long tradition in experimental medicine, biomedicine and experimental behavioural sciences, specifically in education and psychology. Its use in the experimental sciences has evoked a growing literature on appropriate statistical techniques (see Cooper and Hedges, 1994, for a review), geared towards the combination of effect sizes across studies in order to increase statistical power of hypothesis testing. Effect sizes are statistical summary indicators such as standardised differences in means of experimental and control groups, correlations, and odds-ratios.

These types of effect sizes are rather different from the typical quantitative measures used in economic research. Although substantial parts of economics are quasi-experimental rather than experimental, and meta-analysis was initially developed for experimental disciplines, economists increasingly start using meta-analysis in quasi- or non-experimental contexts (Stanley, 2001). Meta-analysis constitutes a systematic framework for the synthesis and comparison of previous studies, because it systematically exploits existing empirical results to produce more general results by focussing on a joint kernel of previously undertaken research (Florax *et al.*, 2002). The use of meta-analysis in economics originated in environmental economics, and was to a considerable extent driven by the need to attain clarity about WTP estimates for non-marketed environmental goods, and the associated differences in valuation techniques (see Smith and Pattanayak, 2002). By now, there is a considerable meta-analysis literature in environmental economics, and the technique proliferates to other areas, such as labour economics, industrial organisation, and macroeconomics (Florax, 2002a).

Apart from Nijkamp and Pepping (1998), who focus on the effectiveness of pesticide price policies, no meta-analysis on pesticide usage exists.[4] Most meta-analyses in economics employ meta-regression.[5] In our case, the meta-regression analysis centres on identifying the relationship between the WTP for a decline in pesticide threats, and theoretical and behavioural differences towards pesticide risk as well as differences in the research design of the underlying studies. Typical moderator variables therefore include the baseline risk level, risk attitudes and perceptions of respondents, the source and nature of the risk data, and research design characteristics.

Meta-analysis can, however, also be used to combine effect sizes. We therefore first focus on deriving a combined WTP estimate for the different types of risks distinguished in Figure 1, and we assess whether the WTP estimates can be viewed as a homogeneous or heterogeneous sample by means of meta-regression analysis. In the remainder of this section we discuss the literature retrieval process, and we explore the meta-dataset. Subsequent sections discuss the prime determinants of WTP values for reduced pesticide risk exposure, and provide the results of the meta-regression analysis.

The literature retrieval process comprises checking several economic databases (among others EconLit), reference chasing, and approaching key scholars in the field. Several keywords, such as 'willingness to pay', 'pesticide', 'food-safety', 'environmental risk', and 'human health risk' were used in order to cover the multidimensionality of pesticide risks. This resulted in a set of slightly more than 60 studies, a subset of 27 of which contains monetary estimates. Several of these studies do, however, not provide usable WTP estimates. Specifically, in some studies the estimates are expressed as a probability of WTP (see, e.g. Owens *et al.*, 1997; Thompson and Kidwell, 1998; Huang, 1993). Others use the cost of illness approach (see Crissman *et al.*, 1994; Pingali *et al.*, 1994), or they use a hedonic approach to estimate shadow values and only report the mean elasticity for various impacts of herbicides (see Beach and Carlson, 1993; Söderqvist, 1998). As a result, the meta-analysis is concerned with only 15 studies, from which we derive 331 observations.

< Table 1 about here >

---

[4] See also van den Bergh *et al.* (1997) for more extensive results.

[5] See Florax (2002a) for an overview of methodological problems in meta-regression analysis.

A listing of the studies and their main characteristics is presented in Table 1. The studies have been published during the 1990s and early 2000s, and predominantly deal with the US. Most observations (> 230) refer to human health, of which approximately one-fifth is concerned with farmers and the rest with consumers, in particular with the unspecified general health hazard. Approximately one-third of all observations refer to detrimental effects on ecosystems, with slightly more observations pertaining to aquatic as compared to terrestrial ecosystems.

Table 1 shows that comparing effect sizes for different target types, countries and time-periods comes with operational problems, because the effect sizes have to be transformed to a common measurement unit, and a common currency in prices of a given year. The latter two transformations are straightforward, but the transformation to a common measurement unit necessitates the use of approximations. The standardised effect size T is derived from the original effect size reported in the primary study as $T = c \cdot t \cdot m_i \cdot \widetilde{T}_i$, where $\widetilde{T}_i$ is the original effect size in a specific measurement unit and a given currency of a specific year, and T is the marginal WTP per person, per year, for a given reduction in pesticide risk exposure, in US dollars of 2000. The transformation factors m_i depend on the measurement unit of the underlying studies. In order to standardise the data, information about average household size, annual per capita consumption of produce, annual number of pesticide treatments, and rural density are taken from the original studies or from official national statistics. The transformation factors t and c are operationalized as a GDP deflator, and a Purchasing Power Parity (see the Appendix for details). From here on, all WTP figures are presented as standardised effect sizes using the above definition.

< Figure 2 about here >

The top graph in Figure 2 shows that the number of WTP estimates drawn from the studies varies between 1 and 115. Within studies, the distribution of estimates is as a rule rather even, except for the study by Hammitt (1993), which has a very skewed distribution (the median is substantially smaller than the mean). This also carries over to the overall distribution of estimated WTP values for all studies. The mean WTP for reduced pesticide risk exposure is US$ 122 per person, per year (in prices of the year 2000), and the median is US$ 16, but the overall standard deviation is rather high at US$ 208. The mean WTP value may not necessarily be a meaningful indicator because it assumes that no significant differences in means exist across different target types. In addition, it ignores the conceptual difference in targets and endpoints as described in the taxonomy of pesticide risks (see Figure 1).

We therefore graphically present the range of estimates for human health and environmental risks, categorised according to the taxonomy in target types, in the bottom graph of Figure 2. It is obvious that the distributions for the different target types are sometimes rather skewed. However, the most striking result is that the mean WTP for impacts on aquatic and terrestrial ecosystems, and for health effects of farmers seem to be very similar, with the exception of the valuation of increased biodiversity through a reduced pesticide risk exposure. The mean WTPs for the impact of reduced pesticide risk exposure on consumer health are substantially smaller, but at the same time, these distributions are very skewed.

In sum, the exploratory analysis indicates that the WTPs for pesticide risk reduction are rather homogeneous. The mean WTP for a reduction in pesticide risk exposure is very similar for health effects for farmers (US$ 262), and the impact on aquatic (US$ 289) and terrestrial ecosystems (US$ 246) excluding biodiversity (US$ 14). The latter seems to constitute a separate category. Similarly, the mean WTP for a reduction in negative health effects for consumers (US$ 42) is very different. One should note, however, that it is not necessarily meaningful to compare mean WTPs per target type, because such a comparison ignores differences in, for instance, research design, the initial risk level, the change in the risk level, and income. Moreover, the WTP values vary greatly about the mean, and they have been measured with varying precision.

4. Potential determinants of WTP variation

The meta-analysis therefore focuses on explaining the variation in WTP estimates by means of a multivariate meta-regression. In the meta-regression the standardised WTP measure is the dependent variable, and variables related to theoretically expected differences, methodological issues, and differences in the study setting are used as explanatory variables. In the next section we discuss the relevant econometric issues, and present the empirical results. This section provides an overview of potentially important explanatory factors that can be derived either from sample information or from outside data sources.

The dependent variable in the analysis is the standardised WTP estimate for the reduction and prevention of pesticide risk exposure, which ranges from –26 to 1375 US$ per person, per year.[6] In total, there are 331 observations, of which 15 (taken from Hammitt, 1993) are negative. Because the negative values are theoretically implausible and the heteroscedasticity inherent in a meta-analysis is generally mitigated by a semilog specification, we exclude the negative values. The meta-analysis is therefore based on 316 positive observations, with a mean and median of US$ 136 and 17, respectively.

Potentially relevant explanatory factors, usually called moderator variables (Sutton *et al.*, 2000), can be derived from three different sources. Theoretical models of individual rationality suggest WTP-risk tradeoffs, and factors related to the study design process pertaining either to methodological issues or to the specific study setting (time period considered, geographical location, etc.) may induce systematic variation. We briefly discuss the relevant variables and operationalizations.

The main distinction among target types in the taxonomy provided in Figure 1 refers to human health deterioration and degradation of the environment. This distinction can also be interpreted as distinguishing between private and public effects of reduced pesticide risk exposure. Microeconomic choice theory underlying WTP estimation predicts the WTP for private goods to be relatively higher, because of free-riding behaviour inherent in collective welfare improvements (Johannesson *et al.*, 1996). In the empirical analysis, we use dummy variables to assess and control for heterogeneity according to target types.

[6] A fairly small number of primary studies reports trimmed rather than ordinary mean WTP-values (i.e., the mean of a middle group of a series of individual estimates), because trimmed means are less sensitive to outliers, and trimming reduces the distance between the mean and the median of the distribution of individual WTP values (see also de Blaeij *et al.*, 2003).

A simple expected utility framework can be used to describe how individuals are willing to trade wealth for increases or decreases of health risks, under the conventional assumption that the estimated marginal valuation of a risk decline increases with an increase in the baseline risk level, with the absolute size of the risk reduction, and with the baseline income (Grossman, 1972; Jones-Lee, 1976; Hammitt, 2000). Previous meta-analyses on the valuation of health hazards have found significant and positive correlations between the risk level and income, and a negative correlation with risk decline (Miller, 2000; Mrozek and Taylor, 2002; de Blaeij *et al.*, 2003). In our meta-analysis, the heterogeneity in classifying risk as well as the different varieties of risk considered in the primary studies require a careful operationalization of the abovementioned concepts. First, in order to make the studies comparable, the information on the baseline risk has to be expressed in a discrete three-step variable (ultimately transformed into three different dummy variables) identifying a low, medium and high baseline risk. Second, in virtually all studies the risk reduction equals the change from the baseline risk level to zero, and it can hence not be identified separately.[7] Finally, due to the lack of a complete data series on the baseline income level for all the original studies, we include this determinant in the analysis using exogenous information on GDP per capita levels for countries (World Bank, 2002).

An important methodological difference between the studies concerns the valuation technique. Approximately 40 percent of the observations are contingent valuation measures. A similar percentage is derived using a revealed preference method, and approximately 20 percent employs some variant of choice experiments (either conjoint analysis, contingent ranking, or choice modelling). The well-known expectation is that stated preference studies exhibit higher WTP estimates as compared to revealed preference studies (see, e.g. List and Gallet, 2001).

Another potentially relevant source of variation relates to the subjective nature of the WTP estimates and the related issue of the individual's perception of risk. The sociological and psychological risk perception literature shows that individuals have difficulty dealing with uncertain

[7] The only studies for which precise continuous information on the baseline risk and the risk decline is available are the studies on the relation between pesticide exposure and cancer (Buzby *et al.*, 1995; Eom, 1994; Fu *et al.*, 1999). A detailed explanation of the operationalization of the baseline risk level is given in the Appendix.

events with a low probability of occurrence. Individuals also find it hard to accurately perceive actual risks on the basis of expert information or news coverage (Viscusi and O'Connor, 1984; Slovic, 1987). The individual's perception of risk is therefore influenced by the nature and quality of the available risk information, and the degree to which subjective perception problems occur. In the meta-analysis we can assess the importance of some of these perception difficulties, although only for stated preference studies. We experiment by including dummy variables controlling for the type of risk information provided to respondents in the valuation surveys. Specifically, we can control for differences in the type of risk scenario presented to the respondents (i.e., an actual, potential or implicit scenario), differences in the source of pesticide risk (one specific pesticide or pesticides in general), the health risk vehicle (one specific fresh food, or fresh food in general), and differences in the type of safety enhancing measure proposed (adoption of Integrated Pest Management versus eco-certification of food commodities or a ban on particular pesticide compounds). In addition, we can include information regarding the type of payment vehicle (price premium, separate billing, or yield loss), which type of interview was performed (mail versus face-to-face), and whether pre-tests and controls for biases were adopted. Finally, with respect to all types of studies we can potentially distinguish ex ante from ex post risk and general risk.

It is also well known that the respondent's socio-demographic characteristics are important with respect to risk perception and willingness-to-pay attitude (Huang, 1993; Govindasamy *et al.*, 1998; Sjoberg, 2000). Complete socio-demographic profiles can however not be derived from the information available in the primary studies. We therefore experiment including dummy variables indicating which stakeholders were interviewed in the valuation survey (farmers, consumers, or both), and include dummy variables referring to the geographical location of the study.

5. Meta-regression variants and estimation results

The number of potentially relevant control variables determined in the preceding section is too large to be useful because, given the operationalization of most variables as dummy variables, prohibitive multicollinearity results. We therefore use a somewhat restricted set of control variables in the meta-regression analysis.

The initial step in the meta-regression is to assess the heterogeneity of effect sizes with respect to the different target types, controlling for differences in the risk level and the hypothesised risk change.[8] We use an *F*-test to assess how much heterogeneity among target types needs to be taken into account using a weighted least squares (WLS) estimator. A meta-analysis is intrinsically heteroscedastic because the effect sizes are commonly taken from studies with differing numbers of observation. As a result the estimated standard errors are different. Unfortunately, estimated standard errors are only available for a small part of the dataset (89 observations). We therefore use the number of observations of the underlying studies as a proxy to account for the precision with which the effect sizes have been estimated (see also Dalhuisen *et al.*, 2003). The sample size of the primary studies ranges between 21 and 1157 observations.[9]

We start with a simple specification in which the log of the estimated standardised WTP is modelled as a linear additive function of the usual constant term, the different target types (with general health effects for consumers as the omitted category), the baseline risk level (with low risk as the omitted category), and the log of per capita income as explanatory variables.

< Table 2 about here >

Table 2 shows, taking into account differences in the associated risk level (which is equivalent to the hypothesised change in the risk level) and per capita income, that the different target types can be grouped into two larger groups in addition to cancer risk and loss of biodiversity. The first group containing acute and chronic health effects on farmers as well as effects on the aquatic and terrestrial ecosystems, the latter excluding loss of biodiversity, has a significantly higher WTP as compared to

---

8 From here on we generally refer to the baseline risk only, although it should be noted that the variables LOWRISK, MEDRISK, and HIGHRISK refer to both the baseline risk as well as the risk reduction (see Section 4).

9 Note that it is common in meta-analysis to use the reciprocal of the sampling variance as weights in order to give the estimated effect sizes that have been measured with the greatest precision most weight (see, e.g. Sutton *et al.*, 2000). As the variance is by and large inversely related to the number of observations of a study, we use the number of observations of the original studies as weights. In addition to weighting we use White-adjusted standard errors, because the Breusch-Pagan test for heteroscedasticity shows that the error variance is not constant.

the omitted category (that is, general health effects on consumers). The second group of target types exhibits a WTP that is not significantly different from general health effects on consumers, and comprises general health effects on farmers, and acute and chronic effects on consumers. The in-between WTPs for two individual target types, specifically for cancer risk and loss of biodiversity, are significantly higher than for general health effects on consumers. An F-test on these combined restrictions on the parameters across the different target types, resulting in four aggregate target types, shows that the restrictions cannot be rejected. Table 2 also shows that the WTP for reduced exposure to pesticide risk is significantly positively correlated with the baseline risk level. The estimated income elasticity is approximately 0.63, but the elasticity is significantly different from zero only in the restricted specification.

Before we continue with more elaborate fixed effects models, we perform a meta-regression in which we assume that unobserved heterogeneity can be modelled using random effects. The strict assumption underlying the meta-model of Table 2, amounting to the population effect size varies only for different baseline risk levels, the four target types, and according to income, can then be relaxed. From a multitude of specifications with random effects for different characteristics (see Rosenberger and Loomis, 2000), we choose three obvious candidates. In one specification we assume unobserved heterogeneity between studies, and in the others between target types and between different estimation methods used in the underlying studies (CVM, choice experiments, and revealed preferences). The random effects model is an attractive specification because it assumes that the population effect sizes for different studies (or target types, or methods, for that matter) are randomly drawn from a normal distribution. The results are therefore easier to generalize to the larger population, and the specification is such that substantially higher degrees of freedom are left. Finally, as result of the incorporation of random study effects (or, alternatively, target type and method effects), the error variance-covariance matrix has a block-diagonal structure with non-zero covariances, which is very similar to a specification that allows for dependence between measurements sampled from the same primary study – or, alternatively, from the same target type, or using the same method (see Florax, 2002b). The results, again weighted for the precision with which the WTP has been measured in the underlying studies, are presented in Table 3.

< Table 3 about here >

Table 3 shows that for all specifications, the corresponding Lagrange Multiplier (LM) tests indicate preference for a fixed or random effects specification over a specification without such effects. The Hausman test results point to preference for the random over the fixed effects specification when the random effects refer to studies or methods, but the fixed effects model is preferable for the specification with random target types. The marginal effects for changes in the baseline risk level are by and large comparable in size to the WLS results in Table 2, except for the random effects model based on different target types, in which they are higher. The correlation with income is comparable to the earlier results for the model with random method effects. For the model with random study effects, the income elasticity is negative – which is implausible, and for the model with random target types the income elasticity is lower than for the WLS results in Table 2.

Although the random effects model is based on an attractive estimator because of its less restrictive assumptions, the downside is that the estimator leads to bias in the coefficient estimates if the random effects are correlated with the other regressors.[10] This is actually very likely in this case because studies, target types, and methods are correlated with the risk levels and/or the level of GDP per capita. For this reason, and because the Hausman test for the model with target types points to the fixed effects model as the preferred specification, we return to the linear, additive specification using fixed effects to characterise differences between studies. From the large set of potential moderator variables presented in Section 4, we typically use those variables that provide information on the survey design of stated preference studies and on socio-demographic characteristics, at the same time avoiding undue multicollinearity.

< Table 4 about here >

[10] There has been an extensive discussion on whether fixed or random effects models are the most appropriate for meta-analysis (see Sutton *et al.*, 2000), although it should be noted that the meaning of the terms 'random' and 'fixed' is slightly different in the methodological meta-analysis literature as compared to the standard econometric terminology of economists (see Florax, 2002b).

The specifications presented in Table 4 distinguish between different target types, baseline risk levels, and income, as before. In addition, we include dummy variables related to geographical location (non-US countries versus the US), the valuation method (revealed vs stated preferences), the type survey (face-to-face vs a mail-in survey, stratified sampling vs sampling of either consumers or farmers, and a quality check labelled 'Bias control'), risk perception (general vs ex ante or ex post risk, and a potential scenario vs an actual or implicit scenario), the payment vehicle (yield loss vs separate billing or a price premium), and the type safety device (integrated pest management and a ban on specific pesticides, with eco-labelling as the omitted category).

The results are weighted least squares estimates, and the different specifications pertain to different groupings of the target type dummies. In specification I, we use a very broad level of aggregation into four target types: the aquatic ecosystem, the terrestrial ecosystem, health effects on farmers, and health effects on consumers (omitted category). Specification II is based on an initial regression with 14 different target types, and the subsequent re-estimation in which target types with a similar-sized coefficient are aggregated and treated as one group, labelled 'other targets'.[11]

Table 4 raises a number of interesting issues. As far as differences between target types are concerned, the large standard errors for these variables show that target types and study characteristics are strongly correlated. This (multi)collinearity makes that the extent to which fixed study effects can be added is limited, implying that much more primary research is still needed, with subsequent pay-offs for the effectiveness of meta-analysis. Notwithstanding this practical constraint, we see, however, that the marginal effects of increasing the baseline risk level are largely unaffected by the different specifications. Going from low to medium and high risk levels increases the WTP by approximately 15 and 80%, respectively. The income elasticity is substantially higher as compared to the results in Tables 2 and 3, and it is greater than one and statistically significant. Even with the correction for income differences, the WTP for reduced pesticide exposure is higher in countries outside the US than within the US. The table also shows that important characteristics of the survey design in stated preference studies have an impact on the WTP. In our sample, revealed preference

[11] The target types are identified in Figure 1 and Table 2. Results are not shown here for reasons of space, but available from the authors upon request.

studies do not lead to substantially lower valuations. Finally, although risk perception and the type of payment vehicle do not have a significant influence, the results show that integrated pest management is valued higher than eco-labelling or pesticide bans.

6. Conclusion

The unprecedented growth of productivity in agriculture is closely related to the increased use of chemical inputs such as fertilizer and pesticides. As an important side-effect chemical inputs in agricultural production evoke non-negligible hazards for human health and the quality of aquatic and terrestrial ecosystems. Food safety and environmental sustainability of agriculture have been promoted using policy instruments such as eco-labelling, pesticide bans, integrated pest management, and pesticide taxes. Preferably, such policy measures should be related to the individuals' willingness to pay for reduced pesticide risk exposure.

We review the pesticide risk valuation literature, and show that substantial information on individual's WTP for reduced pesticide risk exposure is available. The literature is, however, very diverse. It provides WTP estimates not only for various human health risks, but also for the risk of environmental degradation. We develop a taxonomy of the different effects of pesticide risk exposure, distinguishing effects on farmers, consumers, the aquatic and the terrestrial ecosystem, including more detailed target types per category.

Subsequently, we retrieve over 60 studies dealing with pesticide risk exposure, eventually leading to 316 usable individual WTP assessments sampled from 15 studies containing monetary estimates. The studies are predominantly concerned with general health effects on consumers, to a considerable extent addressing the situation in the US, although approximately one-third of the studies deal with environmental degradation, and health effects for farmers are covered as well. We present mean and median effects of the different pesticide risks, both by target type and by study.

We use a meta-regression framework to account for inherent differences in the WTP values for reduced risk exposure. We find strong evidence for the WTP for reduced risk exposure to increase with approximately 15% and 80% in going from low to medium and high risk-exposure levels, respectively. The results for the income elasticity of the WTP for reduced risk exposure vary across specifications, but seem to indicate that the income elasticity is positive and the relationship is elastic. Finally, the results also show that differences across studies, in terms of geographical location and pivotal characteristics of the research design (specifically, the type survey and type safety device), are important drivers of the valuation results.

The results of our meta-analysis also reveal that it is still too early for a meta-analysis to be able to provide a consistent and robust picture of the large range of WTP assessments across different target types. Given the intrinsic heterogeneity in effects of pesticide usage across different target types (food safety, health effects on farmers, and aquatic and terrestrial ecosystems) as well as across geographical space, and given the non-negligible impact of research designs on the estimated WTP values, more primary research on pesticide risk valuation is called for. Some important implications for future primary research can, however, already be drawn from this meta-analysis. Apart from the abovementioned implications of research design characteristics, it is important that future valuation work carefully specifies both the baseline level of risk and the change in the risk level. More attention is also needed for the income and location specific nature of the valuation of reductions in pesticide risk exposure.

References

Baker, G. A. C., Crosbie, P. J. (1993). Measuring food safety preferences: identifying consumers segments. *Journal of Agricultural and Resource Economics* 18: 277–287.

Beach, D. E., Carlson, G. A. (1993). A hedonic analysis of herbicides: do user safety and water quality matter? *American Journal of Agricultural Economics* 75: 612–623.

Blend J. R., Ravenswaay van, E. O. (1999). Measuring consumer demand for ecolabeled apples. *American Journal of Agricultural Economics* 5: 1078–1083.

Brethour, C. A., Weersink, A. (2001). An economic evaluation of the environmental benefits from pesticide reduction. *Agricultural Economics* 25: 219–226.

Buzby, J. C., Ready, R. C., Skees, J. R. (1995). Contingent valuation in food policy analysis: a case study of pesticide residue risk reduction. *Journal of Agricultural and Applied Economics* 27: 613–625.

Cooper, H., Hedges, L. V. (eds.) (1994). *The Handbook of Research Synthesis*. New York: Russell Sage Foundation.

Crissman, C. C., Cole, D. C., Carpio, F. (1994). Pesticide use and farm worker health in Ecuadorian potato production. *American Journal of Agricultural Economics* 76: 593–597.

Cuyno, L. C. M., Norton, G. W., Rola, A. (2001). Economic analysis of environmental benefits of integrated pest management: a Philippine case study. *Agricultural Economics* 25: 227–233.

Dalhuisen, J. M., Florax, R. J. G. M., de Groot, H. L. F., Nijkamp, P. (2003), Price and income elasticities of residential water demand: a meta-analysis. *Land Economics* 79: 292–308.

de Blaeij, A. (2003). *The Value of a Statistical Life in Road Safety: Stated Preference Methodologies and Empirical Estimates for the Netherlands*. Amsterdam/Rotterdam: Tinbergen Institute.

de Blaeij, A., Florax, R. J. G. M., Rietveld P., Verhoef E. T. (2003). The value of statistical life in road safety: a meta-analysis. *Accident Analysis and Prevention* 35: 973–986.
Eom, Y. S. (1994). Pesticide residue risk and food safety valuation: a random utility approach. *American Journal of Agricultural Economics* 76: 760–771.
Florax, R. J. G. M. (2002a). Methodological pitfalls in meta-analysis: publication bias. In Florax, R. J. G. M., Nijkamp, P., Willis, K. G. (eds.), *Comparative Environmental Economic Assessment*. Cheltenham: Edward Elgar.
Florax, R. J. G. M. (2002b). Accounting for Dependence Among Study Results in Meta-Analysis: Methodology and Applications to the Valuation and Use of Natural Resources. Amsterdam: Faculty of Economics and Business Administration, Free University, Research Memorandum 5.
Florax, R. J. G. M., de Groot, H. L. F., de Mooij, R. A. (2002), Meta-analysis: a tool for upgrading inputs of macroeconomic policy models, *cpb Report 2002/1*, 21–25.
Foster V., Mourato, S. (2000). Valuing the multiple impacts of pesticides use in the UK: a contingent ranking approach. *Journal of Agricultural Economics* 51: 1–21.
Fu T-T, Liu J-T, Hammitt, J. K. (1999). Consumer willingness to pay for low-pesticide fresh produce in Taiwan. *Journal of Agricultural Economics* 50: 220–233.
Funari, E., Donati, L., Sandroni, D. and Vighi, M. (1995). Pesticide levels in groundwater: value and limitation of monitoring. In Vighi, M., Funari, E. (eds.), *Pesticide Risk in Groundwater*. Chelsea: Lewis Publishers.
Govindasamy, R., Italia, J., Rabin, J. (1998). Consumer Response and Perceptions of Integrated Pest Management Produce. New Brunswick, Department of Agricultural Economics. Rutgers: The State University of New Jersey.
Grossman, M. (1972). On the concept of health capital and the demand for health. *Journal of Political Economy* 80: 223–255.
Hammitt, J.K. (1993). Consumer willingness to pay to avoid pesticide residues. *Statistica Sinica* 3: 351–366.
Hammitt, J.K. (2000). Valuing mortality risk: theory and practice. *Environmental Science and Technology* 34: 1394–1400.
Higley, L.G., Wintersteen, W. K. (1992). A novel approach to environmental risk assessment of pesticides as a basis for incorporating environmental costs into economic injury level. *American Entomologist* 38: 34–39.
Higley, L.G., Wintersteen, W. K. (1997). Threshold and environmental quality. In L.G. Higley and L.P. Pedigo, (eds.), *Economic Thresholds for Integrated Pest Management*. University of Nebraska Press, Lincoln: NE in press.
Huang, C.L. (1993). Simultaneous-equation model for estimating consumer risk perception, attitudes and willingness-to-pay for residue-free produce. *Journal of Consumer Affairs* 27: 377-396.
Hunter, J., Schmidt, F. (1990). *Methods of Meta-Analysis: Correcting Error and Bias in Research Findings*. Newbury Park: Sage.
Johannesson, M., Johansson, P. O., O'Connor, R. M. (1996). The value of private safety versus the value of public safety. *Journal of Risk and Uncertainty* 13: 263–275.
Jones-Lee, M. W. (1976). *The Value of Life, An Economic Analysis*. London, UK: Martin Robertson.
List, J. A., Gallet C. A. (2001) What experimental protocol influence disparities between actual and hypothetical stated values? Evidence from a meta-analysis. *Environmental and Resource Economics* 20: 241–254.
Lohr L., Park T., Higley L. (1999). Farmer risk assessment for voluntary insecticide reduction. *Ecological Economics* 30: 121–130.
Luhdholm, E. (1987). Thinning of egg shells in birds by DDT: mode of action on the eggshell gland. *Comparative Biochemistry and Physiology* 88: 1–22.
Mason, C. F., Ford, T. C., Last, N. I. (1986). Organochlorine residues in British otters. *Bulletin of Environmental Contamination and Toxicology* 36: 29–436.
Miller, T. R. (2000). Variation between countries in values of statistical life. *Journal of Transport Economics and Policy* 34: 169–188.
Misra, S. K., Huang, C. L., Ott, S. L. (1991). Consumer willingness to pay for pesticide-free fresh produce. *Western Journal of Agricultural Economics* 16: 218–227.

Mourato, S., Ozdemiroglu, E., Foster, V. (2000). Evaluating health and environmental impacts of pesticide use: implications for the design of ecolabels and taxes. *Environmental Science & Technology* 34: 1456–1461.

Mrozek, J. R., Taylor, L. O. (2002). What determines the value of life? A meta-analysis. *Journal of Policy Analysis and Management* 21: 253–270.

Mullen J. D., Norton G. W., Reaves, D. W. (1997). Economic analysis of environmental benefits of integrated pest management. *Journal of Agricultural and Applied Economics* 29: 243–253.

Murray, A. (1985). Acute and residual toxicity of a new pyretroid insecticide, WL 85871, to honey bees. *Bulletin of Environmental Contamination and Toxicology* 34: 560–564.

Nijkamp, P., Pepping, G. (1998). Levies for sustainable agriculture? A meta-analytic exploration of different pesticide price elasticities in agriculture. *Journal of Environmental Systems* 26: 1–25.

Ott, S. T. (1990). Supermarket shoppers' pesticides concerns and willingness to purchase certified pesticide residue-free produce. *Agribusiness* 6: 593–602.

Owens, N. N., Swinton, S. M., Ravenswaay, E. O. (1997). Farmer Demand for Safer Corn Herbicides: Survey Methods and Descriptive Results. Michigan Agricultural Experiment Station. East Lansing, MI: Michigan State University.

Pearce, D. W., Seccombe-Hett, T. (2000). Economic Valuation and environmental decision-making in Europe. *Environmental Science & Technology* 34: 1419–1425.

Pimentel, D., Greiner, A. (1997). Environmental and socio-economic costs of pesticide use. In Pimentel, D. (ed.), *Techniques for Reducing Pesticide Use: Economics and Environmental Benefits*. Chichester: John Wiley and Sons.

Pimentel, D., Acquay, H., Biltonen, M., Rice, P., Silve, M., Nelson, J., Lipner, V., Giordano, S., Horowitz, A., D'amore, M. (1992). Environmental and human costs of pesticide use. *Bioscience* 42: 750–760.

Pingali, P. L., Marquez, C. B., Palis, F. G. (1994). Pesticides and Philippine rice farmer health: a medical and economic analysis. *American Journal of Agricultural Economics* 76: 587–592.

Roosen, J., Fox, J. A., Hennessy, A., Schreiber, A. (1998). Consumers' valuation of insecticide use restrictions: an application to apples. *Journal of Agricultural and Resource Economics* 23: 367–384.

Rosenberger, R. S., Loomis, J. B. (2000). Panel stratification in meta-analysis of economic studies: an investigation of its effects in the recreation valuation literature. *Journal of Agricultural and Applied Economics* 32:459–470.

Schou, J. S., Hasler, B., Kaltoft, P. (2002). Valuing Biodiversity Effects of Pesticide Use: What Does Perception of Uncertainty Mean for Survey Design? Conference Proceedings, Risk and Uncertainty in Environmental and Resource Economics. Wageningen: Wageningen University.

Sivayoganathan, C., Gnanachandran, S., Lewes, J., Fernando, M. (2000). Protective measure use and symptoms among agropesticide applicators in Sri Lanka. *Social Science & Medicine* 40: 431–436.

Sjoberg, L. (1998). Worry and risk perception. *Risk Analysis* 18: 85–93.

Sjoberg, L. (2000). Factors in risk perception. *Risk Analysis* 20: 1–11.

Slovic, P. (1987). Perception of risk. *Science* 30: 423–439.

Smith, V. K., Desvouges, V. K. (1987). An empirical analysis of the economic value of risk changes. *Journal of Political Economy* 95: 89–114.

Smith, V. K., Pattanayak, K. (2002). Is meta-analysis a Noah's ark for non-market valuation? *Environmental and Resource Economics* 22: 271–296.

Söderqvist, T. (1998). Valuing chemical characteristics: a hedonic approach. In Swanson, T., Vighi M. (eds), *Regulating Chemical Accumulation in the Environment*. Cambridge: Cambridge University Press.

Stanley, T. D. (2001). Wheat from chaff: meta-analysis as quantitative literature review. *Journal of Economic Perspectives* 15, 131–150.

Sutton, A. J., Abrams, K. R., Jones, D. R., Sheldon, T. A., Song, F. (2000). *Methods for Meta-Analysis in Medical Research*. New York: John Wiley and Sons.

Swanson, T. (1998). Optimal policies for regulating persistent chemicals. In Swanson, T., Vighi, M (eds.), *Regulating Chemical Accumulation in the Environment.* Cambridge: Cambridge University Press.
Thompson, G. D., Kidwell, J (1998). Explaining the choice of organic produce: cosmetic defects, prices, and consumer preferences. *American Journal of Agricultural Economics* 80: 277–287.
van den Bergh, J. C. J. M., Button, K. J., Nijkamp, P., Pepping, G. C. (1997). *Meta-analysis in Environmental Economics*. Dordrecht: Kluwer Academic Publishers.
Ravenswaay, E. O., Hoehn, J. P. (1991a). Contingent Valuation and Food Safety: The Case of Pesticides Residues. Department of Agricultural Economics, Staff Paper N. 91-13. East Lansing, MI: Michigan State University.
Ravenswaay, E. O., Hoehn, J. P (1991b). The impact of health risk information on food demand: a case study of alar and apples. In Caswell, J. A. (ed.), *Economics of Food Safety*. New York: Elsevier Science.
Viscusi, W. K., O'Connor, C. (1984). Adaptive response to chemical labelling: are workers Bayesian decision makers. *American Economic Review* 74: 942–956.
Wilson, C. (2002). Pesticide avoidance: a result from a Sri-Lankan study with health policy implications. In Hall, D. C., Moffitt L. J. (eds.), *Economics of Pesticides, Sustainable Food Production, and Organic Food Markets*. Amsterdam: Elsevier Science.
World Bank (2002). *World Development Indicators*. Washington DC: World Bank.

Appendix

Standardisation of effect sizes

The WTP estimates given in the underlying studies, $\widetilde{T}_i$, are transformed to standardised WTP estimates, *T*, defined as the WTP value per person, per year, in US dollars of the year 2000, using the transformation function $T = c \cdot t \cdot m_i \cdot \widetilde{T}_i$. The subscript *i* refers to three different measurement units: (1) per household, per time period, (2) per unit of produce weight, and (3) per pesticide application, per acre of cropland treated. Corresponding transformation factors are defined as:

(1) $m_1 = d/h$, where *h* is the average household size in a specific country and year, and *d* a conversion factor for a given time period to the per-year basis,
(2) $m_2 = c/w$, where *c* is the average annual per capita consumption of the produce concerned, and *w* a conversion factor from the weight unit concerned to the weight unit of *c*, and
(3) $m_3 = s/r$, where *s* is the average annual number of pesticide treatments for the crops concerned, and *r* the rural density of the country concerned, defined as the ratio of the rural population over the total acreage of land area.

The transformation factor *t* refers to the conversion of current prices to 2000, and is in fact a GDP deflator. The conversion of local currencies to US dollars of 2000 is implemented using the 2000 Purchasing Power Parity (PPP). Both the GDP deflators and the PPPs are taken from *World Development Indicators* (World Bank, 2002). The same procedure is applied to standardise GDPs used as proxy of the baseline income level. Further details are available upon request.

Baseline risk level

The baseline risk levels reported in the original studies can be classified into a three-level risk scale, discriminating among low, medium and high-risk. Some studies already use this classification. Studies concerning environmental and farmers risk by Higley and Wintersteen (1992), Lohr *et al.* (1999), Mullen *et al.* (1997), Brethour and Weersink (2001), and Cuyno *et al.* (2001) estimate the initial risk level (for each of the environmental targets analysed) by considering analogous toxicological endpoints and classify these endpoints according to the aforementioned three-level risk scale. For some other studies the baseline risk levels have to be transformed into the three-level risk scale. We used the following adjustments, based on expert advice of (eco)toxicologists. Further details are again available upon request.

Foster and Mourato (2000) measure negative pesticide impacts on consumers and farmland bird biodiversity using damage estimates. They set the baseline level of human health risk to 100 cases of pesticide intoxication per year, while the number of endangered bird species is set at 9. We classify the risk levels for human health and bird biodiversity as medium and high, respectively.

Wilson (2002) does not report the baseline risk level; nevertheless, useful information on the pesticide risk for human health in Sri Lanka is taken from Sivayoganathan *et al.* (2000). We classify the human health risks reported in Sivayoganathan *et al.* (2000) as high.

Bubzy *et al.* (1995), Eom (1994), Fu *et al.* (1999), and Ravenswaay and Hoehn (1991b) estimate WTPs for reducing cancer risk and measure the initial risk level as the number of cases per 10,000 or per 100,000 people. We classify these cancer risks as low, medium or high if the actual risk is lower than 5 cases, between 5 and 12 cases, and higher than 12 cases per 10,000 persons.

Finally, Ravenswaay and Hoehn (1991a), Misra *et al.* (1991), Roosen *et al.* (1998), Hammitt (1993), and Baker and Crosbie (1993) estimate consumers' preferences for a decrease in the health effects due to pesticide residues in fresh food. None of these studies provides the baseline risk level. As a proxy we use the percentage of products in violation of national pesticide residue regulation, as found during the national annual monitoring campaigns, and characterise residues risk as low, medium or high if the percentage of products found to be in violation of national limits is lower or equal to 0.5, between 0.5 and 2, and higher than 2, respectively.

Table 1. Alphabetical annotated overview of studies providing empirical WTP estimates for pesticide risk reductions[a]

					Environmental degradation							Human health						
Study	Data	Country	Measurement unit:	# Meta-	Aquatic			Terrestrial				Farmers			Consumers			
			value per	obs.	A1	A2	A3	A4	A5	A6	A7	B1	B2	B3	B4	B5	B6	B7
Baker and Crosbie (1993)	1992	US	person, produce unit	12	—	—	—	—	—	—	—	—	—	—	—	—	—	12
Buzby et al. (1995)	1995	US	person, produce unit	3	—	—	—	—	—	—	—	—	—	—	—	—	3	—
Cuyno et al. (2001)	1999	Philippines	household, crop season	10	2	—	—	2	2	—	2	—	—	2	—	—	—	—
Eom (1994)	1990	US	person, produce unit	12	—	—	—	—	—	—	—	—	—	—	—	—	12	—
Foster and Mourato (2000)	1996	UK	person, produce unit	26	—	—	—	—	—	13	—	—	—	13	—	—	—	—
Fu et al. (1999)	1995	Taiwan	person, produce unit	3	—	—	—	—	—	—	—	—	—	—	—	—	3	—
Hammitt (1993)	1985	US	person, produce unit	115	—	—	—	—	—	—	—	—	—	—	23	23	—	69
Higley and Wintersteen (1992)	1990	US	person, acre application	48[b]	6	6	6	6	6	—	6	6	6	—	—	—	—	—
Lohr et al. (1999)	1990	US	person, acre application	32[b]	4	4	4	4	4	—	4	4	4	—	—	—	—	—
Misra et al. (1991)	1989	US	person, produce unit	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Mullen et al. (1997)	1993	US	household, month	24	3	3	3	3	3	—	3	3	3	—	—	—	—	—
Ravenswaay and Hoehn (1991a)	1990	US	person, year	6	—	—	—	—	—	—	—	—	—	—	—	—	—	6
Ravenswaay and Hoehn (1991b)	1989	US	person, year	18	—	—	—	—	—	—	—	—	—	—	—	—	18	—
Roosen et al. (1998)	1998	US	person, produce unit	16	—	—	—	—	—	—	—	—	—	—	—	—	—	16
Wilson (2002)	1996	Sri Lanka	person, year	5	—	—	—	—	—	—	—	—	—	5	—	—	—	—
					15	13	13	15	15	13	15	13	13	20	23	23	36	104
			Total	331	41			58				46			186			

[a] See Figure 1 for the mnemonics referring to the different target types.
[b] Six observations in Higley and Wintersteen (1992), and four in Lohr *et al.* (1999) are excluded from the meta-sample because they refer to more than one target type simultaneously. The 32 observations from Lohr *et al.* (1999) are computed using additional information provided in Higley and Wintersteen (1992, 1997), starting from the four observations referring to environmental and human health risks simultaneously.

Table 2. Unrestricted and restricted weighted least squares estimates for different target types[a,b]

Variable	WLS	WLS restricted
Constant	–5.76	–5.76**
	(6.31)	(2.57)
Farmer health		
Acute effects †	4.58***	4.70***
	(0.41)	(0.25)
Chronic effects †	4.58***	4.70***
	(0.41)	(0.25)
General effects ‡	–0.14	–0.14
	(0.60)	(0.46)
Consumer health		
Acute effects ‡	–0.22	–0.14
	(10.86)	(0.46)
Chronic effects ‡	–0.02	–0.14
	(10.36)	(0.46)
Cancer risk	1.84***	1.84***
	(0.44)	(0.30)
Aquatic ecosystem		
Surface water †	4.65***	4.70***
	(0.41)	(0.25)
Ground water †	4.84***	4.70***
	(0.40)	(0.25)
Aquatic organisms †	4.87***	4.70***
	(0.38)	(0.25)
Terrestrial ecosystem		
Mammals †	4.69***	4.70***
	(0.40)	(0.25)
Birds †	4.70***	4.70***
	(0.40)	(0.25)
Biodiversity	1.41***	1.41***
	(0.47)	(0.46)
Beneficial insects †	4.72***	4.70***
	(0.40)	(0.25)
Risk assessment and income		
Medium risk	0.34***	0.34***
	(0.12)	(0.12)
High risk	0.82***	0.82***
	(0.11)	(0.12)
Log(GDP)	0.63	0.63**
	(0.60)	(0.25)
n	316	316
R^2-adjusted	0.72	0.73[c]
Log-likelihood	–760.90	–390.25
F-test	52.24***	121.02***
Breusch-Pagan (df = 16)	229.89***	
F(9,322)-test on restrictions		0.40

[a] The weights are determined as the number of observations in the underlying studies used to determine the risk value. White-adjusted standard errors are given in parentheses, and significance is indicated by ***, ** and * for the 1, 5, and 10 percent level, respectively.
[b] The omitted target type is general health risk for consumers. The restrictions refer to the different target types. The first group has an additional label †, the second group ‡, and cancer risk and biodiversity are unrestricted.
[c] Because of the restrictions, the adjusted R^2 is not bound to the usual interval.

Table 3. Random effects specifications, with random effects for studies, target types, and method types[a,b]

Variable / Random effects	Studies[b]	Targets	Methods
Constant	5.97	1.49	–5.48**
	(4.74)	(2.31)	(2.63)
Risk assessment and income			
Medium risk	0.12*	0.79***	0.21*
	(0.07)	(0.22)	(0.13)
High risk	0.82***	0.90***	0.76***
	(0.07)	(0.21)	(0.13)
Log(GDP)	–0.31	0.26	0.77***
	(0.48)	(0.23)	(0.25)
n	315	316	316
LM(FE/RE vs no effects)	1599.68***	1185.89***	785.18***
LM(Hausman)	3.42	53.39***	0.63

[a] The variables are weighted using the number of observations in the underlying studies as weights. Significance is indicated by ***, ** and * for the 1, 5, and 10 percent level, respectively. The omitted category is low risk.
[b] For reasons of identification the single result of Misra *et al.* (1991) is omitted in this specification.

Table 4. Extended specifications with fixed effects for differences between studies, using the weighted least squares estimator[a]

Variable / Specification	I		II
Constant	–27.40*		–26.57*
	(16.50)		(16.04)
Target types[b]		**Target types**[c]	
Aquatic ecosystem	–2.68	Acute effect consumer	–1.30
	(2.50)		(10.89)
Terrestrial ecosystem	–2.73	Chronic effect consumer	–1.07
	(2.50)		(10.40)
Farmer health	–2.94	Biodiversity	–2.00
	(2.50)		(2.52)
		Other targets	–3.66
			(2.54)
Risk assessment and income			
Medium risk	0.13**		0.17***
	(0.06)		(0.06)
High risk	0.81***		0.78***
	(0.04)		(0.03)
Log(GDP)	2.83**		2.75**
	(1.32)		(1.27)
Geographical location			
Non-US	6.16***		5.99***
	(2.32)		(2.20)
Method			
Revealed preferences	0.16		0.22
	(2.54)		(2.58)
Type survey and sampling			
Face-to-face survey	0.20		0.22
	(2.55)		(2.59)
Stratified sample	–2.62***		–2.55***
	(0.73)		(0.72)
Bias control	–0.19***		–0.19***
	(0.04)		(0.05)
Risk perception			
General risk	0.09		0.02
	(0.72)		(0.72)
Potential scenario	1.31		1.26
	(3.18)		(3.17)
Payment vehicle			
Yield	0.24		0.32
	(0.77)		(0.75)
Type safety device			
Integrated pest management	6.76***		7.51***
	(2.16)		(2.07)
Pesticide ban	–0.29		–0.37
	(0.75)		(0.63)
n	316		316
R^2-adjusted	0.93		0.93
Log-likelihood	–552.78		–541.13
F-test	246.09***		249.84***
Breusch-Pagan (df = 16 and 17)	564.76***		854.47***

[a] See footnote a to Table 2.
[b] The omitted category in specification I is consumer health.
[c] Other targets refers to all targets except acute and chronic health effects on consumers, biodiversity, and the omitted category, general health effects for consumers.

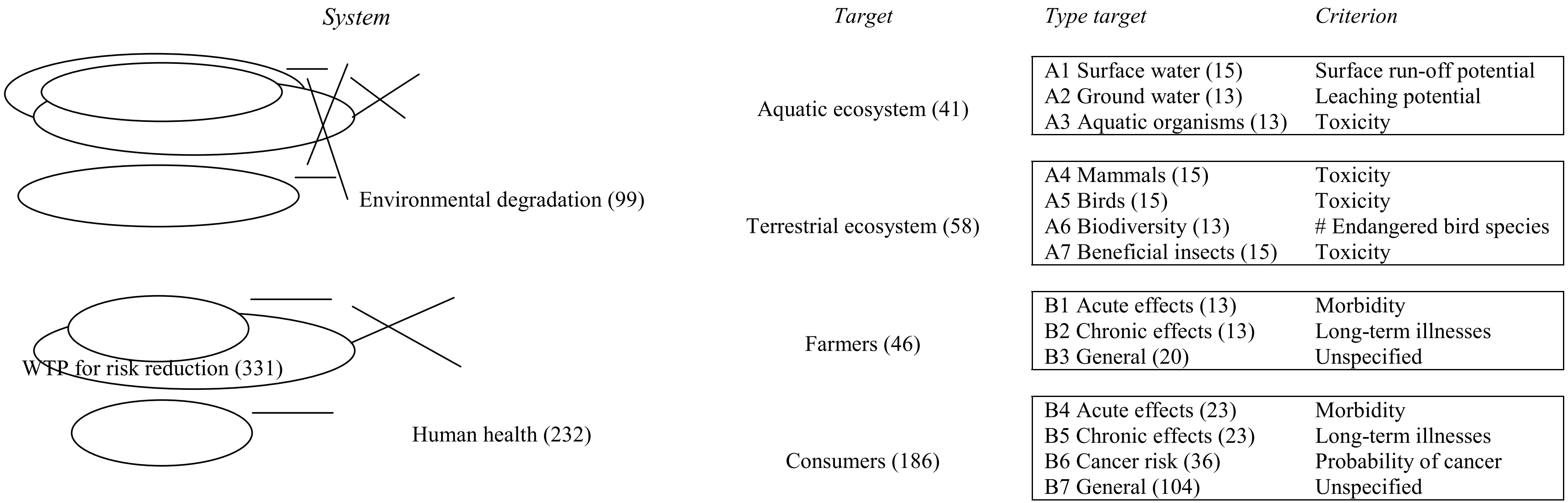
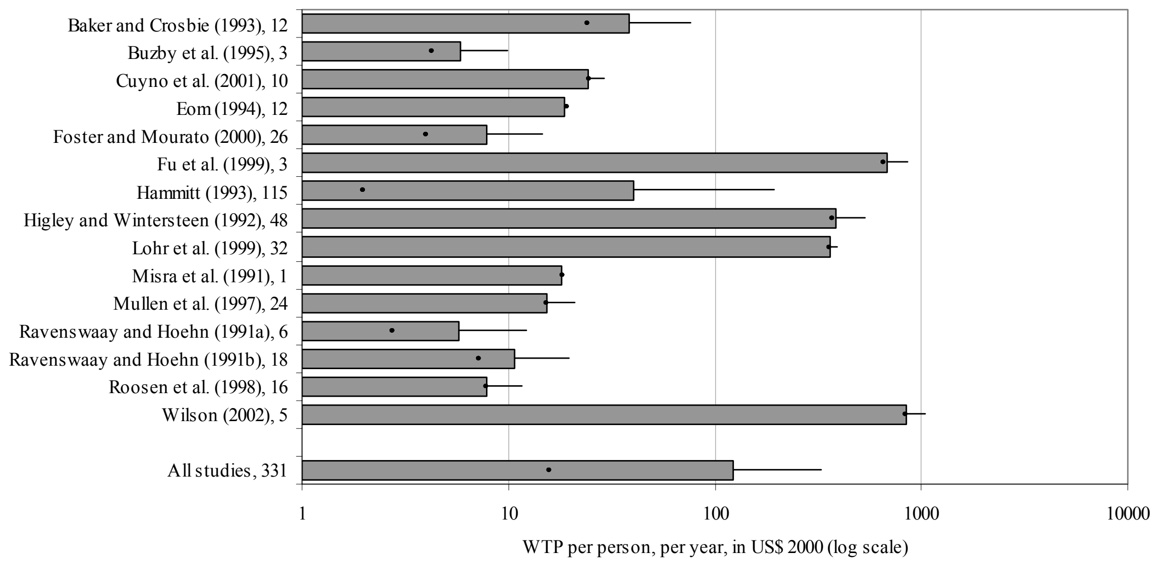


Figure 1. Taxonomy of WTP estimates for pesticide risk reduction according to system, target, type, and criterion, with the number of observations in the meta-analysis sample in parentheses.



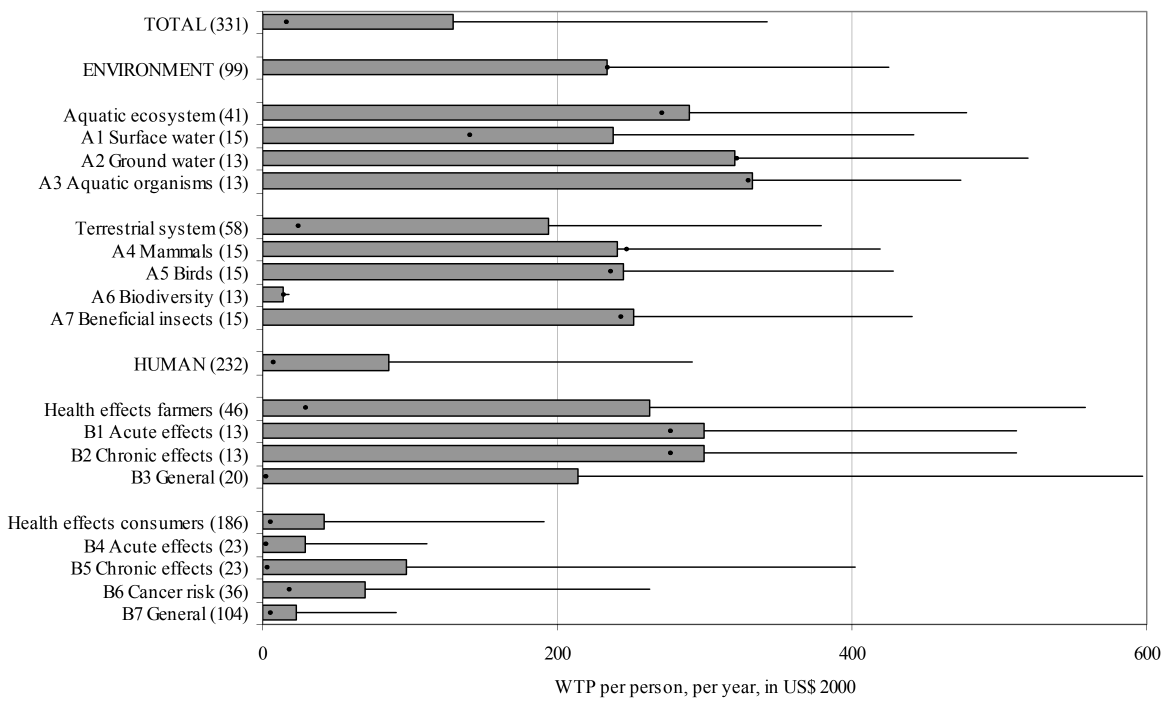


Figure 2. Willingness to pay per person, per year, in US$ referring to 2000, organised by study (top; note the log scale) or by target type (bottom), where bars represent the average value, the median value is indicated by solid squares, and the error bars represent the standard deviation of the WTP values within each study or target type.

NOTE DI LAVORO DELLA FONDAZIONE ENI ENRICO MATTEI

Fondazione Eni Enrico Mattei Working Paper Series

Our Note di Lavoro are available on the Internet at the following addresses:

http://www.feem.it/Feem/Pub/Publications/WPapers/default.html

http://www.ssrn.com/link/feem.html

NOTE DI LAVORO PUBLISHED IN 2003

PRIV	1.2003	*Gabriella CHIESA and Giovanna NICODANO*: Privatization and Financial Market Development: Theoretical Issues
PRIV	2.2003	*Ibolya SCHINDELE*: Theory of Privatization in Eastern Europe: Literature Review
PRIV	3.2003	*Wietze LISE, Claudia KEMFERT and Richard S.J. TOL*: Strategic Action in the Liberalised German Electricity Market
CLIM	4.2003	*Laura MARSILIANI and Thomas I. RENSTRÖM*: Environmental Policy and Capital Movements: The Role of Government Commitment
KNOW	5.2003	*Reyer GERLAGH*: Induced Technological Change under Technological Competition
ETA	6.2003	*Efrem CASTELNUOVO*: Squeezing the Interest Rate Smoothing Weight with a Hybrid Expectations Model
SIEV	7.2003	*Anna ALBERINI, Alberto LONGO, Stefania TONIN, Francesco TROMBETTA and Margherita TURVANI:* The Role of Liability, Regulation and Economic Incentives in Brownfield Remediation and Redevelopment: Evidence from Surveys of Developers
NRM	8.2003	*Elissaios PAPYRAKIS and Reyer GERLAGH*: Natural Resources: A Blessing or a Curse?
CLIM	9.2003	*A. CAPARRÓS, J.-C. PEREAU and T. TAZDAÏT*: North-South Climate Change Negotiations: a Sequential Game with Asymmetric Information
KNOW	10.2003	*Giorgio BRUNELLO and Daniele CHECCHI*: School Quality and Family Background in Italy
CLIM	11.2003	*Efrem CASTELNUOVO and Marzio GALEOTTI*: Learning By Doing vs Learning By Researching in a Model of Climate Change Policy Analysis
KNOW	12.2003	*Carole MAIGNAN, Gianmarco OTTAVIANO and Dino PINELLI (eds.)*: Economic Growth, Innovation, Cultural Diversity: What are we all talking about? A critical survey of the state-of-the-art
KNOW	13.2003	*Carole MAIGNAN, Gianmarco OTTAVIANO, Dino PINELLI and Francesco RULLANI* (lix): Bio-Ecological Diversity vs. Socio-Economic Diversity. A Comparison of Existing Measures
KNOW	14.2003	*Maddy JANSSENS and Chris STEYAERT* (lix): Theories of Diversity within Organisation Studies: Debates and Future Trajectories
KNOW	15.2003	*Tuzin BAYCAN LEVENT, Enno MASUREL and Peter NIJKAMP* (lix): Diversity in Entrepreneurship: Ethnic and Female Roles in Urban Economic Life
KNOW	16.2003	*Alexandra BITUSIKOVA* (lix): Post-Communist City on its Way from Grey to Colourful: The Case Study from Slovakia
KNOW	17.2003	*Billy E. VAUGHN and Katarina MLEKOV* (lix): A Stage Model of Developing an Inclusive Community
KNOW	18.2003	*Selma van LONDEN and Arie de RUIJTER* (lix): Managing Diversity in a Glocalizing World
Coalition Theory Network	19.2003	*Sergio CURRARINI:* On the Stability of Hierarchies in Games with Externalities
PRIV	20.2003	*Giacomo CALZOLARI and Alessandro PAVAN* (lx): Monopoly with Resale
PRIV	21.2003	*Claudio MEZZETTI* (lx): Auction Design with Interdependent Valuations: The Generalized Revelation Principle, Efficiency, Full Surplus Extraction and Information Acquisition
PRIV	22.2003	*Marco LiCalzi and Alessandro PAVAN* (lx): Tilting the Supply Schedule to Enhance Competition in Uniform-Price Auctions
PRIV	23.2003	*David ETTINGER* (lx): Bidding among Friends and Enemies
PRIV	24.2003	*Hannu VARTIAINEN* (lx): Auction Design without Commitment
PRIV	25.2003	*Matti KELOHARJU, Kjell G. NYBORG and Kristian RYDQVIST* (lx): Strategic Behavior and Underpricing in Uniform Price Auctions: Evidence from Finnish Treasury Auctions
PRIV	26.2003	*Christine A. PARLOUR and Uday RAJAN* (lx): Rationing in IPOs
PRIV	27.2003	*Kjell G. NYBORG and Ilya A. STREBULAEV* (lx): Multiple Unit Auctions and Short Squeezes
PRIV	28.2003	*Anders LUNANDER and Jan-Eric NILSSON* (lx): Taking the Lab to the Field: Experimental Tests of Alternative Mechanisms to Procure Multiple Contracts
PRIV	29.2003	*TangaMcDANIEL and Karsten NEUHOFF* (lx): Use of Long-term Auctions for Network Investment
PRIV	30.2003	*Emiel MAASLAND and Sander ONDERSTAL* (lx): Auctions with Financial Externalities
ETA	31.2003	*Michael FINUS and Bianca RUNDSHAGEN:* A Non-cooperative Foundation of Core-Stability in Positive Externality NTU-Coalition Games
KNOW	32.2003	*Michele MORETTO*: Competition and Irreversible Investments under Uncertainty
PRIV	33.2003	*Philippe QUIRION:* Relative Quotas: Correct Answer to Uncertainty or Case of Regulatory Capture?
KNOW	34.2003	*Giuseppe MEDA, Claudio PIGA and Donald SIEGEL*: On the Relationship between R&D and Productivity: A Treatment Effect Analysis
ETA	35.2003	*Alessandra DEL BOCA, Marzio GALEOTTI and Paola ROTA:* Non-convexities in the Adjustment of Different Capital Inputs: A Firm-level Investigation

GG	36.2003	*Matthieu GLACHANT*: Voluntary Agreements under Endogenous Legislative Threats
PRIV	37.2003	*Narjess BOUBAKRI, Jean-Claude COSSET and Omrane GUEDHAMI*: Postprivatization Corporate Governance: the Role of Ownership Structure and Investor Protection
CLIM	38.2003	*Rolf GOLOMBEK and Michael HOEL*: Climate Policy under Technology Spillovers
KNOW	39.2003	*Slim BEN YOUSSEF*: Transboundary Pollution, R&D Spillovers and International Trade
CTN	40.2003	*Carlo CARRARO and Carmen MARCHIORI*: Endogenous Strategic Issue Linkage in International Negotiations
KNOW	41.2003	*Sonia OREFFICE*: Abortion and Female Power in the Household: Evidence from Labor Supply
KNOW	42.2003	*Timo GOESCHL and Timothy SWANSON*: On Biology and Technology: The Economics of Managing Biotechnologies
ETA	43.2003	*Giorgio BUSETTI and Matteo MANERA*: STAR-GARCH Models for Stock Market Interactions in the Pacific Basin Region, Japan and US
CLIM	44.2003	*Katrin MILLOCK and Céline NAUGES*: The French Tax on Air Pollution: Some Preliminary Results on its Effectiveness
PRIV	45.2003	*Bernardo BORTOLOTTI and Paolo PINOTTI*: The Political Economy of Privatization
SIEV	46.2003	*Elbert DIJKGRAAF and Herman R.J. VOLLEBERGH*: Burn or Bury? A Social Cost Comparison of Final Waste Disposal Methods
ETA	47.2003	*Jens HORBACH*: Employment and Innovations in the Environmental Sector: Determinants and Econometrical Results for Germany
CLIM	48.2003	*Lori SNYDER, Nolan MILLER and Robert STAVINS:* The Effects of Environmental Regulation on Technology Diffusion: The Case of Chlorine Manufacturing
CLIM	49.2003	*Lori SNYDER, Robert STAVINS and Alexander F. WAGNER*: Private Options to Use Public Goods. Exploiting Revealed Preferences to Estimate Environmental Benefits
CTN	50.2003	*László Á. KÓCZY and Luc LAUWERS* (lxi): The Minimal Dominant Set is a Non-Empty Core-Extension
CTN	51.2003	*Matthew O. JACKSON* (lxi)*:*Allocation Rules for Network Games
CTN	52.2003	*Ana MAULEON and Vincent VANNETELBOSCH* (lxi): Farsightedness and Cautiousness in Coalition Formation
CTN	53.2003	*Fernando VEGA-REDONDO* (lxi): Building Up Social Capital in a Changing World: a network approach
CTN	54.2003	*Matthew HAAG and Roger LAGUNOFF* (lxi): On the Size and Structure of Group Cooperation
CTN	55.2003	*Taiji FURUSAWA and Hideo KONISHI* (lxi): Free Trade Networks
CTN	56.2003	*Halis Murat YILDIZ* (lxi): National Versus International Mergers and Trade Liberalization
CTN	57.2003	*Santiago RUBIO and Alistair ULPH* (lxi): An Infinite-Horizon Model of Dynamic Membership of International Environmental Agreements
KNOW	58.2003	*Carole MAIGNAN, Dino PINELLI and Gianmarco I.P. OTTAVIANO*: ICT, Clusters and Regional Cohesion: A Summary of Theoretical and Empirical Research
KNOW	59.2003	*Giorgio BELLETTINI and Gianmarco I.P. OTTAVIANO:* Special Interests and Technological Change
ETA	60.2003	*Ronnie SCHÖB:* The Double Dividend Hypothesis of Environmental Taxes: A Survey
CLIM	61.2003	*Michael FINUS, Ekko van IERLAND and Robert DELLINK*: Stability of Climate Coalitions in a Cartel Formation Game
GG	62.2003	*Michael FINUS and Bianca RUNDSHAGEN*: How the Rules of Coalition Formation Affect Stability of International Environmental Agreements
SIEV	63.2003	*Alberto PETRUCCI:* Taxing Land Rent in an Open Economy
CLIM	64.2003	*Joseph E. ALDY, Scott BARRETT and Robert N. STAVINS*: Thirteen Plus One: A Comparison of Global Climate Policy Architectures
SIEV	65.2003	*Edi DEFRANCESCO*: The Beginning of Organic Fish Farming in Italy
SIEV	66.2003	*Klaus CONRAD*: Price Competition and Product Differentiation when Consumers Care for the Environment
SIEV	67.2003	*Paulo A.L.D. NUNES, Luca ROSSETTO, Arianne DE BLAEIJ*: Monetary Value Assessment of Clam Fishing Management Practices in the Venice Lagoon: Results from a Stated Choice Exercise
CLIM	68.2003	*ZhongXiang ZHANG:* Open Trade with the U.S. Without Compromising Canada's Ability to Comply with its Kyoto Target
KNOW	69.2003	*David FRANTZ* (lix): Lorenzo Market between Diversity and Mutation
KNOW	70.2003	*Ercole SORI* (lix): Mapping Diversity in Social History
KNOW	71.2003	*Ljiljana DERU SIMIC* (lxii): What is Specific about Art/Cultural Projects?
KNOW	72.2003	*Natalya V. TARANOVA* (lxii):The Role of the City in Fostering Intergroup Communication in a Multicultural Environment: Saint-Petersburg's Case
KNOW	73.2003	*Kristine CRANE* (lxii)*:* The City as an Arena for the Expression of Multiple Identities in the Age of Globalisation and Migration
KNOW	74.2003	*Kazuma MATOBA* (lxii): Glocal Dialogue- Transformation through Transcultural Communication
KNOW	75.2003	*Catarina REIS OLIVEIRA* (lxii): Immigrants' Entrepreneurial Opportunities: The Case of the Chinese in Portugal
KNOW	76.2003	*Sandra WALLMAN* (lxii): The Diversity of Diversity - towards a typology of urban systems
KNOW	77.2003	*Richard PEARCE* (lxii): A Biologist's View of Individual Cultural Identity for the Study of Cities
KNOW	78.2003	*Vincent MERK* (lxii): Communication Across Cultures: from Cultural Awareness to Reconciliation of the Dilemmas
KNOW	79.2003	*Giorgio BELLETTINI, Carlotta BERTI CERONI and Gianmarco I.P.OTTAVIANO*: Child Labor and Resistance to Change
ETA	80.2003	*Michele MORETTO, Paolo M. PANTEGHINI and Carlo SCARPA*: Investment Size and Firm's Value under Profit Sharing Regulation

IEM	81.2003	*Alessandro LANZA, Matteo MANERA and Massimo GIOVANNINI:* Oil and Product Dynamics in International Petroleum Markets
CLIM	82.2003	*Y. Hossein FARZIN and Jinhua ZHAO*: Pollution Abatement Investment When Firms Lobby Against Environmental Regulation
CLIM	83.2003	*Giuseppe DI VITA*: Is the Discount Rate Relevant in Explaining the Environmental Kuznets Curve?
CLIM	84.2003	*Reyer GERLAGH and Wietze LISE*: Induced Technological Change Under Carbon Taxes
NRM	85.2003	*Rinaldo BRAU, Alessandro LANZA and Francesco PIGLIARU*: How Fast are the Tourism Countries Growing? The cross-country evidence
KNOW	86.2003	*Elena BELLINI, Gianmarco I.P. OTTAVIANO and Dino PINELLI:* The ICT Revolution: opportunities and risks for the Mezzogiorno
SIEV	87.2003	*Lucas BRETSCGHER and Sjak SMULDERS:* Sustainability and Substitution of Exhaustible Natural Resources. How resource prices affect long-term R&D investments
CLIM	88.2003	*Johan EYCKMANS and Michael FINUS:* New Roads to International Environmental Agreements: The Case of Global Warming
CLIM	89.2003	*Marzio GALEOTTI:* Economic Development and Environmental Protection
CLIM	90.2003	*Marzio GALEOTTI*: Environment and Economic Growth: Is Technical Change the Key to Decoupling?
CLIM	91.2003	*Marzio GALEOTTI and Barbara BUCHNER*: Climate Policy and Economic Growth in Developing Countries
IEM	92.2003	*A. MARKANDYA, A. GOLUB and E. STRUKOVA*: The Influence of Climate Change Considerations on Energy Policy: The Case of Russia
ETA	93.2003	*Andrea BELTRATTI*: Socially Responsible Investment in General Equilibrium
CTN	94.2003	*Parkash CHANDER*: The γ-Core and Coalition Formation
IEM	95.2003	*Matteo MANERA and Angelo MARZULLO*: Modelling the Load Curve of Aggregate Electricity Consumption Using Principal Components
IEM	96.2003	*Alessandro LANZA, Matteo MANERA, Margherita GRASSO and Massimo GIOVANNINI:* Long-run Models of Oil Stock Prices
CTN	97.2003	*Steven J. BRAMS, Michael A. JONES, and D. Marc KILGOUR:* Forming Stable Coalitions: The Process Matters
KNOW	98.2003	*John CROWLEY, Marie-Cecile NAVES* (lxiii): Anti-Racist Policies in France. From Ideological and Historical Schemes to Socio-Political Realities
KNOW	99.2003	*Richard THOMPSON FORD* (lxiii*)*: Cultural Rights and Civic Virtue
KNOW	100.2003	*Alaknanda PATEL* (lxiii): Cultural Diversity and Conflict in Multicultural Cities
KNOW	101.2003	*David MAY* (lxiii): The Struggle of Becoming Established in a Deprived Inner-City Neighbourhood
KNOW	102.2003	*Sébastien ARCAND, Danielle JUTEAU, Sirma BILGE, and Francine LEMIRE* (lxiii) : Municipal Reform on the Island of Montreal: Tensions Between Two Majority Groups in a Multicultural City
CLIM	103.2003	*Barbara BUCHNER and Carlo CARRARO:* China and the Evolution of the Present Climate Regime
CLIM	104.2003	*Barbara BUCHNER and Carlo CARRARO*: Emissions Trading Regimes and Incentives to Participate in International Climate Agreements
CLIM	105.2003	*Anil MARKANDYA and Dirk T.G. RÜBBELKE:* Ancillary Benefits of Climate Policy
NRM	106.2003	*Anne Sophie CRÉPIN (*lxiv)*:* Management Challenges for Multiple-Species Boreal Forests
NRM	107.2003	*Anne Sophie CRÉPIN* (lxiv)*:* Threshold Effects in Coral Reef Fisheries
SIEV	108.2003	*Sara ANIYAR (* lxiv): Estimating the Value of Oil Capital in a Small Open Economy: The Venezuela's Example
SIEV	109.2003	*Kenneth ARROW, Partha DASGUPTA and Karl-Göran MÄLER(*lxiv)*:* Evaluating Projects and Assessing Sustainable Development in Imperfect Economies
NRM	110.2003	*Anastasios XEPAPADEAS and Catarina ROSETA-PALMA(*lxiv)*:* Instabilities and Robust Control in Fisheries
NRM	111.2003	*Charles PERRINGS and Brian WALKER* (lxiv): Conservation and Optimal Use of Rangelands
ETA	112.2003	*Jack GOODY* (lxiv): Globalisation, Population and Ecology
CTN	113.2003	*Carlo CARRARO, Carmen MARCHIORI and Sonia OREFFICE*: Endogenous Minimum Participation in International Environmental Treaties
CTN	114.2003	*Guillaume HAERINGER and Myrna WOODERS*: Decentralized Job Matching
CTN	115.2003	*Hideo KONISHI and M. Utku UNVER*: Credible Group Stability in Multi-Partner Matching Problems
CTN	116.2003	*Somdeb LAHIRI*: Stable Matchings for the Room-Mates Problem
CTN	117.2003	*Somdeb LAHIRI*: Stable Matchings for a Generalized Marriage Problem
CTN	118.2003	*Marita LAUKKANEN*: Transboundary Fisheries Management under Implementation Uncertainty
CTN	119.2003	*Edward CARTWRIGHT and Myrna WOODERS*: Social Conformity and Bounded Rationality in Arbitrary Games with Incomplete Information: Some First Results
CTN	120.2003	*Gianluigi VERNASCA*: Dynamic Price Competition with Price Adjustment Costs and Product Differentiation
CTN	121.2003	*Myrna WOODERS, Edward CARTWRIGHT and Reinhard SELTEN*: Social Conformity in Games with Many Players
CTN	122.2003	*Edward CARTWRIGHT and Myrna WOODERS*: On Equilibrium in Pure Strategies in Games with Many Players
CTN	123.2003	*Edward CARTWRIGHT and Myrna WOODERS*: Conformity and Bounded Rationality in Games with Many Players
	1000	**Carlo CARRARO, Alessandro LANZA and Valeria PAPPONETTI: One Thousand Working Papers**

NOTE DI LAVORO PUBLISHED IN 2004

IEM	1.2004	*Anil MARKANDYA, Suzette PEDROSO and Alexander GOLUB*: Empirical Analysis of National Income and So2 Emissions in Selected European Countries
ETA	2.2004	*Masahisa FUJITA and Shlomo WEBER:* Strategic Immigration Policies and Welfare in Heterogeneous Countries
PRA	3.2004	*Adolfo DI CARLUCCIO, Giovanni FERRI, Cecilia FRALE and Ottavio RICCHI:* Do Privatizations Boost Household Shareholding? Evidence from Italy
ETA	4.2004	*Victor GINSBURGH and Shlomo WEBER:* Languages Disenfranchisement in the European Union
ETA	5.2004	*Romano PIRAS:* Growth, Congestion of Public Goods, and Second-Best Optimal Policy
CCMP	6.2004	*Herman R.J. VOLLEBERGH:* Lessons from the Polder: Is Dutch CO2-Taxation Optimal
PRA	7.2004	*Sandro BRUSCO, Giuseppe LOPOMO and S. VISWANATHAN* (lxv): Merger Mechanisms
PRA	8.2004	*Wolfgang AUSSENEGG, Pegaret PICHLER and Alex STOMPER* (lxv): IPO Pricing with Bookbuilding, and a When-Issued Market
PRA	9.2004	*Pegaret PICHLER and Alex STOMPER* (lxv): Primary Market Design: Direct Mechanisms and Markets
PRA	10.2004	*Florian ENGLMAIER, Pablo GUILLEN, Loreto LLORENTE, Sander ONDERSTAL and Rupert SAUSGRUBER* (lxv): The Chopstick Auction: A Study of the Exposure Problem in Multi-Unit Auctions
PRA	11.2004	*Bjarne BRENDSTRUP and Harry J. PAARSCH* (lxv): Nonparametric Identification and Estimation of Multi-Unit, Sequential, Oral, Ascending-Price Auctions With Asymmetric Bidders
PRA	12.2004	*Ohad KADAN* (lxv): Equilibrium in the Two Player, k-Double Auction with Affiliated Private Values
PRA	13.2004	*Maarten C.W. JANSSEN* (lxv): Auctions as Coordination Devices
PRA	14.2004	*Gadi FIBICH, Arieh GAVIOUS and Aner SELA* (lxv): All-Pay Auctions with Weakly Risk-Averse Buyers
PRA	15.2004	*Orly SADE, Charles SCHNITZLEIN and Jaime F. ZENDER* (lxv): Competition and Cooperation in Divisible Good Auctions: An Experimental Examination
PRA	16.2004	*Marta STRYSZOWSKA* (lxv): Late and Multiple Bidding in Competing Second Price Internet Auctions
CCMP	17.2004	*Slim Ben YOUSSEF:* R&D in Cleaner Technology and International Trade
NRM	18.2004	*Angelo ANTOCI, Simone BORGHESI and Paolo RUSSU* (lxvi): Biodiversity and Economic Growth: Stabilization Versus Preservation of the Ecological Dynamics
SIEV	19.2004	*Anna ALBERINI, Paolo ROSATO, Alberto LONGO and Valentina ZANATTA:* Information and Willingness to Pay in a Contingent Valuation Study: The Value of S. Erasmo in the Lagoon of Venice
NRM	20.2004	*Guido CANDELA and Roberto CELLINI* (lxvii): Investment in Tourism Market: A Dynamic Model of Differentiated Oligopoly
NRM	21.2004	*Jacqueline M. HAMILTON* (lxvii): Climate and the Destination Choice of German Tourists
NRM	22.2004	*Javier Rey-MAQUIEIRA PALMER, Javier LOZANO IBÁÑEZ and Carlos Mario GÓMEZ GÓMEZ* (lxvii): Land, Environmental Externalities and Tourism Development
NRM	23.2004	*Pius ODUNGA and Henk FOLMER* (lxvii): Profiling Tourists for Balanced Utilization of Tourism-Based Resources in Kenya
NRM	24.2004	*Jean-Jacques NOWAK, Mondher SAHLI and Pasquale M. SGRO* (lxvii):Tourism, Trade and Domestic Welfare
NRM	25.2004	*Riaz SHAREEF* (lxvii): Country Risk Ratings of Small Island Tourism Economies
NRM	26.2004	*Juan Luis EUGENIO-MARTÍN, Noelia MARTÍN MORALES and Riccardo SCARPA* (lxvii): Tourism and Economic Growth in Latin American Countries: A Panel Data Approach
NRM	27.2004	*Raúl Hernández MARTÍN* (lxvii): Impact of Tourism Consumption on GDP. The Role of Imports
CSRM	28.2004	*Nicoletta FERRO:* Cross-Country Ethical Dilemmas in Business: A Descriptive Framework
NRM	29.2004	*Marian WEBER* (lxvi): Assessing the Effectiveness of Tradable Landuse Rights for Biodiversity Conservation: an Application to Canada's Boreal Mixedwood Forest
NRM	30.2004	*Trond BJORNDAL, Phoebe KOUNDOURI and Sean PASCOE* (lxvi): Output Substitution in Multi-Species Trawl Fisheries: Implications for Quota Setting
CCMP	31.2004	*Marzio GALEOTTI, Alessandra GORIA, Paolo MOMBRINI and Evi SPANTIDAKI:* Weather Impacts on Natural, Social and Economic Systems (WISE) Part I: Sectoral Analysis of Climate Impacts in Italy
CCMP	32.2004	*Marzio GALEOTTI, Alessandra GORIA ,Paolo MOMBRINI and Evi SPANTIDAKI:* Weather Impacts on Natural, Social and Economic Systems (WISE) Part II: Individual Perception of Climate Extremes in Italy
CTN	33.2004	*Wilson PEREZ:* Divide and Conquer: Noisy Communication in Networks, Power, and Wealth Distribution
KTHC	34.2004	*Gianmarco I.P. OTTAVIANO and Giovanni PERI* (lxviii): The Economic Value of Cultural Diversity: Evidence from US Cities
KTHC	35.2004	*Linda CHAIB* (lxviii): Immigration and Local Urban Participatory Democracy: A Boston-Paris Comparison
KTHC	36.2004	*Franca ECKERT COEN and Claudio ROSSI* (lxviii): Foreigners, Immigrants, Host Cities: The Policies of Multi-Ethnicity in Rome. Reading Governance in a Local Context
KTHC	37.2004	*Kristine CRANE* (lxviii): Governing Migration: Immigrant Groups' Strategies in Three Italian Cities – Rome, Naples and Bari
KTHC	38.2004	*Kiflemariam HAMDE* (lxviii): Mind in Africa, Body in Europe: The Struggle for Maintaining and Transforming Cultural Identity - A Note from the Experience of Eritrean Immigrants in Stockholm
ETA	39.2004	*Alberto CAVALIERE:* Price Competition with Information Disparities in a Vertically Differentiated Duopoly
PRA	40.2004	*Andrea BIGANO and Stef PROOST:* The Opening of the European Electricity Market and Environmental Policy: Does the Degree of Competition Matter?
CCMP	41.2004	*Micheal FINUS* (lxix): International Cooperation to Resolve International Pollution Problems

KTHC	42.2004	*Francesco CRESPI:* Notes on the Determinants of Innovation: A Multi-Perspective Analysis
CTN	43.2004	*Sergio CURRARINI and Marco MARINI:* Coalition Formation in Games without Synergies
CTN	44.2004	*Marc ESCRIHUELA-VILLAR:* Cartel Sustainability and Cartel Stability
NRM	45.2004	*Sebastian BERVOETS and Nicolas GRAVEL* (lxvi): Appraising Diversity with an Ordinal Notion of Similarity: An Axiomatic Approach
NRM	46.2004	*Signe ANTHON and Bo JELLESMARK THORSEN* (lxvi): Optimal Afforestation Contracts with Asymmetric Information on Private Environmental Benefits
NRM	47.2004	*John MBURU* (lxvi)*:* Wildlife Conservation and Management in Kenya: Towards a Co-management Approach
NRM	48.2004	*Ekin BIROL, Ágnes GYOVAI and Melinda SMALE* (lxvi)*:* Using a Choice Experiment to Value Agricultural Biodiversity on Hungarian Small Farms: Agri-Environmental Policies in a Transition al Economy
CCMP	49.2004	*Gernot KLEPPER and Sonja PETERSON:* The EU Emissions Trading Scheme. Allowance Prices, Trade Flows, Competitiveness Effects
GG	50.2004	*Scott BARRETT and Michael HOEL:* Optimal Disease Eradication
CTN	51.2004	*Dinko DIMITROV, Peter BORM, Ruud HENDRICKX and Shao CHIN SUNG:* Simple Priorities and Core Stability in Hedonic Games
SIEV	52.2004	*Francesco RICCI*: Channels of Transmission of Environmental Policy to Economic Growth: A Survey of the Theory
SIEV	53.2004	*Anna ALBERINI, Maureen CROPPER, Alan KRUPNICK and Nathalie B. SIMON:* Willingness to Pay for Mortality Risk Reductions: Does Latency Matter?
NRM	54.2004	*Ingo BRÄUER and Rainer MARGGRAF* (lxvi): Valuation of Ecosystem Services Provided by Biodiversity Conservation: An Integrated Hydrological and Economic Model to Value the Enhanced Nitrogen Retention in Renaturated Streams
NRM	55.2004	*Timo GOESCHL and Tun LIN* (lxvi): Biodiversity Conservation on Private Lands: Information Problems and Regulatory Choices
NRM	56.2004	*Tom DEDEURWAERDERE* (lxvi): Bioprospection: From the Economics of Contracts to Reflexive Governance
CCMP	57.2004	*Katrin REHDANZ and David MADDISON:* The Amenity Value of Climate to German Households
CCMP	58.2004	*Koen SMEKENS and Bob VAN DER ZWAAN:* Environmental Externalities of Geological Carbon Sequestration Effects on Energy Scenarios
NRM	59.2004	*Valentina BOSETTI, Mariaester CASSINELLI and Alessandro LANZA* (lxvii): Using Data Envelopment Analysis to Evaluate Environmentally Conscious Tourism Management
NRM	60.2004	*Timo GOESCHL and Danilo CAMARGO IGLIORI* (lxvi):Property Rights Conservation and Development: An Analysis of Extractive Reserves in the Brazilian Amazon
CCMP	61.2004	*Barbara BUCHNER and Carlo CARRARO*: Economic and Environmental Effectiveness of a Technology-based Climate Protocol
NRM	62.2004	*Elissaios PAPYRAKIS and Reyer GERLAGH*: Resource-Abundance and Economic Growth in the U.S.
NRM	63.2004	*Györgyi BELA, György PATAKI, Melinda SMALE and Mariann HAJDÚ* (lxvi): Conserving Crop Genetic Resources on Smallholder Farms in Hungary: Institutional Analysis
NRM	64.2004	*E.C.M. RUIJGROK and E.E.M. NILLESEN* (lxvi): The Socio-Economic Value of Natural Riverbanks in the Netherlands
NRM	65.2004	*E.C.M. RUIJGROK* (lxvi): Reducing Acidification: The Benefits of Increased Nature Quality. Investigating the Possibilities of the Contingent Valuation Method
ETA	66.2004	*Giannis VARDAS and Anastasios XEPAPADEAS*: Uncertainty Aversion, Robust Control and Asset Holdings
GG	67.2004	*Anastasios XEPAPADEAS and Constadina PASSA*: Participation in and Compliance with Public Voluntary Environmental Programs: An Evolutionary Approach
GG	68.2004	*Michael FINUS*: Modesty Pays: Sometimes!
NRM	69.2004	*Trond BJØRNDAL and Ana BRASÃO*: The Northern Atlantic Bluefin Tuna Fisheries: Management and Policy Implications
CTN	70.2004	*Alejandro CAPARRÓS, Abdelhakim HAMMOUDI and Tarik TAZDAÏT*: On Coalition Formation with Heterogeneous Agents
IEM	71.2004	*Massimo GIOVANNINI, Margherita GRASSO, Alessandro LANZA and Matteo MANERA*: Conditional Correlations in the Returns on Oil Companies Stock Prices and Their Determinants
IEM	72.2004	*Alessandro LANZA, Matteo MANERA and Michael MCALEER*: Modelling Dynamic Conditional Correlations in WTI Oil Forward and Futures Returns
SIEV	73.2004	*Margarita GENIUS and Elisabetta STRAZZERA*: The Copula Approach to Sample Selection Modelling: An Application to the Recreational Value of Forests
CCMP	74.2004	*Rob DELLINK and Ekko van IERLAND*: Pollution Abatement in the Netherlands: A Dynamic Applied General Equilibrium Assessment
ETA	75.2004	*Rosella LEVAGGI and Michele MORETTO*: Investment in Hospital Care Technology under Different Purchasing Rules: A Real Option Approach
CTN	76.2004	*Salvador BARBERÀ and Matthew O. JACKSON* (lxx): On the Weights of Nations: Assigning Voting Weights in a Heterogeneous Union
CTN	77.2004	*Àlex ARENAS, Antonio CABRALES, Albert DÍAZ-GUILERA, Roger GUIMERÀ and Fernando VEGA-REDONDO* (lxx): Optimal Information Transmission in Organizations: Search and Congestion
CTN	78.2004	*Francis BLOCH and Armando GOMES* (lxx): Contracting with Externalities and Outside Options

CTN	79.2004	*Rabah AMIR, Effrosyni DIAMANTOUDI and Licun XUE* (lxx): Merger Performance under Uncertain Efficiency Gains
CTN	80.2004	*Francis BLOCH and Matthew O. JACKSON* (lxx): The Formation of Networks with Transfers among Players
CTN	81.2004	*Daniel DIERMEIER, Hülya ERASLAN and Antonio MERLO* (lxx): Bicameralism and Government Formation
CTN	82.2004	*Rod GARRATT, James E. PARCO, Cheng-ZHONG QIN and Amnon RAPOPORT* (lxx): Potential Maximization and Coalition Government Formation
CTN	83.2004	*Kfir ELIAZ, Debraj RAY and Ronny RAZIN* (lxx): Group Decision-Making in the Shadow of Disagreement
CTN	84.2004	*Sanjeev GOYAL, Marco van der LEIJ and José Luis MORAGA-GONZÁLEZ* (lxx): Economics: An Emerging Small World?
CTN	85.2004	*Edward CARTWRIGHT* (lxx): Learning to Play Approximate Nash Equilibria in Games with Many Players
IEM	86.2004	*Finn R. FØRSUND and Michael HOEL*: Properties of a Non-Competitive Electricity Market Dominated by Hydroelectric Power
KTHC	87.2004	*Elissaios PAPYRAKIS and Reyer GERLAGH*: Natural Resources, Investment and Long-Term Income
CCMP	88.2004	*Marzio GALEOTTI and Claudia KEMFERT*: Interactions between Climate and Trade Policies: A Survey
IEM	89.2004	*A. MARKANDYA, S. PEDROSO and D. STREIMIKIENE*: Energy Efficiency in Transition Economies: Is There Convergence Towards the EU Average?
GG	90.2004	*Rolf GOLOMBEK and Michael HOEL* : Climate Agreements and Technology Policy
PRA	91.2004	*Sergei IZMALKOV* (lxv): Multi-Unit Open Ascending Price Efficient Auction
KTHC	92.2004	*Gianmarco I.P. OTTAVIANO and Giovanni PERI*: Cities and Cultures
KTHC	93.2004	*Massimo DEL GATTO*: Agglomeration, Integration, and Territorial Authority Scale in a System of Trading Cities. Centralisation versus devolution
CCMP	94.2004	*Pierre-André JOUVET, Philippe MICHEL and Gilles ROTILLON*: Equilibrium with a Market of Permits
CCMP	95.2004	*Bob van der ZWAAN and Reyer GERLAGH*: Climate Uncertainty and the Necessity to Transform Global Energy Supply
CCMP	96.2004	*Francesco BOSELLO, Marco LAZZARIN, Roberto ROSON and Richard S.J. TOL*: Economy-Wide Estimates of the Implications of Climate Change: Sea Level Rise
CTN	97.2004	*Gustavo BERGANTIÑOS and Juan J. VIDAL-PUGA*: Defining Rules in Cost Spanning Tree Problems Through the Canonical Form
CTN	98.2004	*Siddhartha BANDYOPADHYAY and Mandar OAK*: Party Formation and Coalitional Bargaining in a Model of Proportional Representation
GG	99.2004	*Hans-Peter WEIKARD, Michael FINUS and Juan-Carlos ALTAMIRANO-CABRERA*: The Impact of Surplus Sharing on the Stability of International Climate Agreements
SIEV	100.2004	*Chiara M. TRAVISI and Peter NIJKAMP*: Willingness to Pay for Agricultural Environmental Safety: Evidence from a Survey of Milan, Italy, Residents
SIEV	101.2004	*Chiara M. TRAVISI, Raymond J. G. M. FLORAX and Peter NIJKAMP*: A Meta-Analysis of the Willingness to Pay for Reductions in Pesticide Risk Exposure

(lix) This paper was presented at the ENGIME Workshop on “Mapping Diversity”, Leuven, May 16-17, 2002
(lx) This paper was presented at the EuroConference on “Auctions and Market Design: Theory, Evidence and Applications”, organised by the Fondazione Eni Enrico Mattei, Milan, September 26-28, 2002
(lxi) This paper was presented at the Eighth Meeting of the Coalition Theory Network organised by the GREQAM, Aix-en-Provence, France, January 24-25, 2003
(lxii) This paper was presented at the ENGIME Workshop on “Communication across Cultures in Multicultural Cities”, The Hague, November 7-8, 2002
(lxiii) This paper was presented at the ENGIME Workshop on “Social dynamics and conflicts in multicultural cities”, Milan, March 20-21, 2003
(lxiv) This paper was presented at the International Conference on “Theoretical Topics in Ecological Economics”, organised by the Abdus Salam International Centre for Theoretical Physics - ICTP, the Beijer International Institute of Ecological Economics, and Fondazione Eni Enrico Mattei – FEEM Trieste, February 10-21, 2003
(lxv) This paper was presented at the EuroConference on “Auctions and Market Design: Theory, Evidence and Applications” organised by Fondazione Eni Enrico Mattei and sponsored by the EU, Milan, September 25-27, 2003
(lxvi) This paper has been presented at the 4th BioEcon Workshop on “Economic Analysis of Policies for Biodiversity Conservation” organised on behalf of the BIOECON Network by Fondazione Eni Enrico Mattei, Venice International University (VIU) and University College London (UCL) , Venice, August 28-29, 2003
(lxvii) This paper has been presented at the international conference on “Tourism and Sustainable Economic Development – Macro and Micro Economic Issues” jointly organised by CRENoS (Università di Cagliari e Sassari, Italy) and Fondazione Eni Enrico Mattei, and supported by the World Bank, Sardinia, September 19-20, 2003
(lxviii) This paper was presented at the ENGIME Workshop on “Governance and Policies in Multicultural Cities”, Rome, June 5-6, 2003
(lxix) This paper was presented at the Fourth EEP Plenary Workshop and EEP Conference “The Future of Climate Policy”, Cagliari, Italy, 27-28 March 2003
(lxx) This paper was presented at the 9th Coalition Theory Workshop on "Collective Decisions and Institutional Design" organised by the Universitat Autònoma de Barcelona and held in Barcelona, Spain, January 30-31, 2004

2003 SERIES	
CLIM	*Climate Change Modelling and Policy* (Editor: Marzio Galeotti)
GG	*Global Governance* (Editor: Carlo Carraro)
SIEV	*Sustainability Indicators and Environmental Valuation* (Editor: Anna Alberini)
NRM	*Natural Resources Management* (Editor: Carlo Giupponi)
KNOW	*Knowledge, Technology, Human Capital* (Editor: Gianmarco Ottaviano)
IEM	*International Energy Markets* (Editor: Anil Markandya)
CSRM	*Corporate Social Responsibility and Management* (Editor: Sabina Ratti)
PRIV	*Privatisation, Regulation, Antitrust* (Editor: Bernardo Bortolotti)
ETA	*Economic Theory and Applications* (Editor: Carlo Carraro)
CTN	*Coalition Theory Network*

2004 SERIES	
CCMP	*Climate Change Modelling and Policy* (Editor: Marzio Galeotti)
GG	*Global Governance* (Editor: Carlo Carraro)
SIEV	*Sustainability Indicators and Environmental Valuation* (Editor: Anna Alberini)
NRM	*Natural Resources Management* (Editor: Carlo Giupponi)
KTHC	*Knowledge, Technology, Human Capital* (Editor: Gianmarco Ottaviano)
IEM	*International Energy Markets* (Editor: Anil Markandya)
CSRM	*Corporate Social Responsibility and Management* (Editor: Sabina Ratti)
PRA	*Privatisation, Regulation, Antitrust* (Editor: Bernardo Bortolotti)
ETA	*Economic Theory and Applications* (Editor: Carlo Carraro)
CTN	*Coalition Theory Network*