40 Years of JEEM:
Research trends and influential publications
in environmental and resource economics

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Abstract

This paper analyzes the way the content of the *Journal of Environmental Economics and Management* (*JEEM*) has developed over the last 40 years. We have classified the articles in the journal into five dimensions: content, methods, environmental media (pollutants and resources), cross-cutting issues and the regional dimension of studies. Up to about 10 years ago, non-market valuation and cost-benefit analysis, natural resource economics and environmental policy instruments were the subjects regularly representing the lion's share of the articles published in the journal. Thereafter we register a significant shift towards a more diversified array of research areas, with climate change and energy issues finding their way into the journal. In addition, increasing methodological plurality becomes apparent, reflected in a significant shift away from economic theory and towards empirical approaches. We also analyze key distinctions between the major environmental economics journals. To this end, we compare the 100 most frequently cited articles in *JEEM*, *Ecological Economics*, *Land Economics*, *Environmental & Resource Economics*, and the *American Journal of Agricultural Economics*. Here we find that non-market valuation studies play an important role in all the journals considered. Econometric studies are also widely represented in all of them, with theoretical models particularly strong in *JEEM*. Finally, we use citations as a criterion for analyzing *JEEM*'s external influence on leading general economics (A+) journals. A regression analysis shows that a focus on market-based environmental policies and policy comparisons plus the use of econometric and statistical methods or experimental approaches correlates positively with an A+ citation. If we leave self-citations out of account, A+ citations are also positively correlated with a focus on air pollution and negatively correlated with a focus on water pollution and other pollutants.

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1. Introduction

The aim of this paper is to contribute to the *Journal of Environmental Economics and Management* (JEEM)'s 40th anniversary with a precise and up-to-date investigation of the research issues that have preoccupied the environmental economics profession so far and are most likely to do so in the upcoming years. In his citation analysis, Hamermesh (2013) warns against mere navel-gazing: "One hopes that the rationale for this activity is that it stimulates more than just a prurient interest, and that it can enhance our understanding of the process of scientific discovery, the nature of interpersonal interactions, and the role of rewards and incentives in stimulating activity." To our knowledge, the present paper is the first to examine *JEEM*'s progress in the 21st century. The research behind it is motivated by interest in a series of key environmental and socioeconomic issues that have altered the premises for modern-day environmental economics research.

Climate change has become the most prominent environmental problem around the globe. It has spawned far-reaching international agreements and a variety of mitigation policies. The diffusion of renewable energy technologies such as solar and wind power has made headlong progress, and the use of biofuels has become an important factor in many countries. The growth of the Chinese economy has taken place at the expense of hazardous air pollution levels in metropolises. Besides major catastrophes such as Hurricane Katrina in 2005 and the world's largest oil spill surrounding the Deepwater Horizon in 2010, the early 2000s are remarkable for a peak in resource prices, most notably for crude oil. But the demand for minerals and rare earth elements has also been on the rise, owing in part to the rapid growth of emerging economies. For economics researchers, digitization has brought about better data availability and more detailed insights from econometric data analyses.

For our purposes, we collected all 1672 *JEEM* articles published from 1974-2014 as well as the 100 most cited articles in *JEEM, Ecological Economics, Land Economics, Environmental & Resource Economics* and the *American Journal of Agricultural Economics*. A multi-dimensional classification scheme reveals major shifts and underlying patterns in study content, the methods applied, the particular environmental media (notably the pollutants and resources under investigation), cross-cutting issues, and finally also the regional dimension of articles. To the best of our knowledge, the repercussions of these recent developments on past and future environmental economics research have not yet been subjected to full-scale investigation.

Our paper is a contribution to a series of bibliometric research papers on the evolution and performance of environmental and resource economics as an economic subfield. Several of these have homed in on *JEEM* in particular, as it is one of the most prominent field journals in environmental and resource economics. However, compared to the analysis presented here, no other study has gone into the same degree of detail on the substance of the articles published in *JEEM* or placed as much emphasis on the particular pollutants and resources investigated. We further extend the existing literature by providing what we believe to be the first review to discuss *JEEM*'s progress in the 21st century. Shogren and Durden (1990) examine the first 15 years of *JEEM* (1974-88), the number of contributions from different institutes and countries, and the number of citations from leading general-interest economics journals. Brookshire and Scrogin (2000) not only update this study but also

categorize *JEEM* articles between 1974 and 1998 by content with a view to identifying major research trends. Deacon et al. (1998) identify the main topics up to 1998 and assess major future research issues and methodologies such as non-market valuation methods, renewable energy sources, global externalities (climate change, biodiversity), spatial issues, and land use. Fisher and Ward (2000) contribute to *JEEM*'s 25th anniversary celebrations with an analysis of thematic coverage and a breakpoint analysis of major topics (oil, climate, sustainability, forest, water) following policy-relevant events (e.g. the Oil Shock in 1980, the Brundtland Report in 1987, and the Rio Conference in 1992). Smith (2000) quantifies *JEEM*'s influence on the non-market valuation literature with a citation count and assesses performance relative to comparable field journals. He concludes that *JEEM* "has, over time, become recognized as a primary source for research in environmental economics." In their case study, Schymura and Löschel (2014) investigate the incidence of, and reasons for, increasing co-authorship in *JEEM*. One major finding is an increase in cooperation with regard to the methodological dimension of articles, an increase potentially caused by growing pressure to publish and by external funding. Another branch of literature assesses the importance of the environmental economics field in academic economics as a whole. Based on a Google Scholar search heuristic, Auffhammer (2009) analyzes the performance of the articles from different environmental and resource economics journals cited most frequently since 2000 in leading general economics (A+) journals. Hoepner et al. (2012) look at the impact factor of different environmental and ecological economics journals between 2000 and 2009. Kosnik (2015) and Wohlrabe and Rath (2015) report on JEL Category Q contributions in top-ranking general economics journals. Ma and Stern (2006) identify the most influential publications in *JEEM* and *Ecological Economics* between 1994 and 2003 and the overlap and interdependencies of research themes between these two field journals.

More recently, two other field journals have been assessed in a way that resembles our approach. Polyakov et al. (2017) analyze authorship patterns in the journal *Environmental and Resource Economics* by using automated text analysis to classify articles between 1991 and 2015 into a scheme similar to ours. Costanza et al. (2004, 2016) investigate the most influential publications of the journal *Ecological Economics* in terms of citation counts both within the journal itself and elsewhere. The research themes of articles are classified by an automated word-count and clustering method applied to article titles. By contrast, the classification presented in the present paper is guided by JEL codes and increases the level of detail compared to previous studies, for example by distinguishing between content and method and also by focusing on the particular pollution sources and resources investigated. We compare major research themes across the five major field journals, explicitly tracking sub-categories such as different methods for non-market valuation and experimental approaches and exploring the evolution of methodological approaches by distinguishing not only between theoretical and empirical/applied approaches. Manual screening of articles enables us to provide a detailed analysis of the pollutants and resources covered by *JEEM* articles in the past 40 years. In addition, we can explicitly identify policy-relevant cross-cutting issues such as climate change, even if the articles in question do not focus explicitly on this issue but deal with related topics like forest management and its relevance for carbon sequestration.

As indicated above, we classified articles with respect to five dimensions: content, methods, environmental media (pollutants and resources), cross-cutting issues, and the regional dimension of studies. While cost-benefit analysis and non-market valuation, natural resource economics and environmental policy instruments steadily comprise a large share of articles published until about 10 years ago, a significant shift towards a more diversified array of research areas becomes visible thereafter with climate change and energy issues entering the journal. Risk, uncertainty, and imperfect information are also crucial cross-cutting issues. In addition, an increasing methodological plurality becomes apparent, reflected in a significant shift away from economic theory and towards empirical approaches. Since the 1990s, there has been increasing interest in general methodological improvements of stated and revealed preference methods. Surprisingly, the journal focuses more on the assessment of environmental damages than on the cost of pollution controls. Air pollution and greenhouse gases are the most important environmental media investigated; fisheries, non-renewable resources, and forests are the major resources studied. While most of the publications do not refer to a particular country or region, there is an appreciable focus on North America in the remainder of the articles.

We also analyze key distinctions in the external perception of major environmental economics journals by comparing the 100 most frequently cited articles in *JEEM*, *Ecological Economics*, *Land Economics*, *Environmental & Resource Economics*, and the *American Journal of Agricultural Economics*. We find that non-market valuation studies play an important role in all the journals considered. Interdisciplinary approaches and ecological economics are encountered most frequently in *Ecological Economics*. While all journals boast a large number of econometric studies, theoretical models are particularly frequent in influential articles published in *JEEM*. Often-cited articles from other journals tend to focus on specific environmental media and concentrate more heavily on particular resources.

Finally, we use citations to analyze *JEEM*'s external influence on leading general-interest economics (A+) journals. Almost 10% of *JEEM* articles get cited at least once in an A+ journal article. *JEEM* articles are not cited in A+ journals before the year 1996. Thereafter, *JEEM* articles are continuously cited, indicating the incremental and sustained importance of environmental economics for the field of economics as a whole. A regression analysis shows that a focus on market-based policies and policy comparisons correlates positively with an A+ citation. This also applies to the use of econometric and statistical methods or experimental approaches. Furthermore, and leaving self-citations aside, A+ citations are positively correlated with a focus on air pollution and greenhouse gases and negatively correlated with a focus on water pollution and other pollutants.

The paper is organized as follows: Section 2 explains the classification scheme used for categorization. In section 3, this framework is applied to all *JEEM* articles. A comparison of the five major environmental economics journals' 100 most frequently cited articles follows in section 4. In section 5 we investigate *JEEM*'s external influence. Section 6 concludes.

2. Classification scheme

We drew on *Science Direct* to collect all *JEEM* articles published between the first issue in 1974 and 2014. Based on a comprehensive list of all the keywords appended to the articles, we devised the following classification scheme consisting of five main dimensions and a total of 114 items:

1) Content   (one out of 50 options)
2) Methods   (multiple out of 11 options)
3) Environmental media: pollutants and resources   (multiple out of 35 options)
4) Cross-cutting issues   (multiple out of 7 options)
5) Regional dimension   (one out of 11 options)

We sorted the articles according to the classification scheme. The articles were read manually and classified separately by two authors at different research institutes to ensure classification reliability. In a first iteration, each analyst categorized articles independently on their own. In this first stage already, 15% of the articles were classified in precisely the same way in all dimensions. Deviations were mostly to be found in only one of the five dimensions (e.g. a deviation in methods only). A classification manual with objective rules was created for the second iteration, improving the matching score to 92%. The remaining discrepancy was resolved via mutual agreement after discussion between the analysts. Accordingly, we can confidently assert that any substantial bias caused by measurement errors can be ruled out. Manual classification by experts seems to be more suitable for characterizing the substance of an article in this kind of detail than the classification algorithms based on keyword word counts used in similar papers (e.g. Polyakov et al., 2017, Costanza et al. 2016).

The exact options for each of the five dimensions are presented in the following sections.

2.1 Content

First, we formed nine major content groups, largely following the JEL Classification System. We took our bearings from the EconLit Subject Descriptors proposed by the American Economic Association (https://www.aeaweb.org/jel/guide/jel.php), as outlined below. However, the JEL Classification System cannot provide a comprehensive description of research trends in environmental and resource economics, so we extended and enhanced the classification system where necessary. As a result, each of the nine categories is further divided into sub-categories so that ultimately there are 50 content categories altogether. We allocated each article to exactly one content category out of the 50 options. If several categories were addressed in the paper, we opted for the most salient subject matter and study objective. This procedure allows for a detailed comparison of content development over time. The different content groups (indexed with letters A-I) are described in the following.

A   Natural resource economics

This content group is squarely based on JEL codes Q2 and Q3, referring to renewable and non-renewable resources respectively. In terms of non-renewable resources, our analysis addresses *ores*, *minerals,* and *biodiversity* individually, thus distinguishing more specific

resource types than those suggested by the JEL specification. One reason is that in the last few decades particular resources such as biodiversity have attracted more attention and have attained greater visibility than others. They also require special methods for valuation. Throughout the classification process, we identified the topics of *secondary materials*, *pesticide and anti-bacteria*, and *entropy laws and mass-stability* as recurrent major content in articles and therefore added these as categories under A.3*.

A.1   Natural resource economics: renewable resources

Category name	Typical articles in this category deal with:
General, methods, demand & supply	Optimal exploitation/management/preservation of unspecific renewable resources; general common-pool resource problems; general determinants for market prices, demand and supply of renewable resources; rent-seeking by suppliers; analysis of imperfect competition
Fishery, aquaculture	Optimal fishery management and policy design; management of (international) common-pool fishing grounds; fishery policy instruments such as individual transferable fishing quotas (ITQs) and others
Forestry	Optimal forestry management and policy design, e.g. optimal timber rotation periods; drivers and development of deforestation
Land	Optimal land utilization and conservation, e.g. regarding crop cycles; prevention of erosion; desertification issues; management of urban sprawl; deterioration of landscapes
Water	Optimal management of surface water, ground water, and waste water by private and public sector; methods for prevention of water pollution; analysis of water markets, estimation of water demand
Other	Other applications to renewable natural resources

A.2   Natural resource economics: non-renewable resources

Category name	Typical articles in this category deal with:
General, methods, demand & supply	Optimal exploitation/management/preservation of unspecific non-renewable resources; general determinants for market prices, demand and supply of non-renewable resources; rent-seeking of suppliers; analysis of imperfect competition; bidding for extraction rights; irreversible development of resources
Ores	Optimal exploitation/management of ores, especially metals such as iron, copper, zinc; empirical studies on prices and demand/supply
Non-renewable energy resources	Optimal exploitation/management of oil, coal, gas and other non-renewable energy sources; empirical studies on prices and demand/supply
Minerals	Applications to minerals, especially rare earth minerals; empirical studies on prices and demand/supply
Biodiversity	Theoretical models of mechanisms for the protection of endangered species; measurement and protection of biodiversity
Other	Other applications to non-renewable natural resources

A.3 Natural resource economics: other natural resources

Category name	Typical articles in this category deal with:
Secondary materials and recycling	Optimal management of secondary materials; specific recycling policies (e.g. taxes and regulations); (international) secondary material markets
Pesticide and anti-bacteria	Optimal pesticide deployment and pest management; issues of increasing antibiotic resistance of bacteria
Entropy laws and mass stability	Discussions about relevance of laws of entropy and mass-stability for natural resource economics; physical constraints in production and consumption
Other	Other applications to unspecified natural resources

B Climate change economics

To this content group we allocated papers addressing the broad issue of climate change (part of JEL code Q54). The use of three different categories enables us to distinguish between research areas in this field, e.g. between preventive and adaptive measures.

Category name	Typical articles in this category deal with:
General methods	Climate change models including central planning, decentralized, and game-theoretic models; discounting issues and net present values; CO_2 emission forecasts; ethical and distributive aspects (e.g. fair burden sharing)
Damages and adaptation	Estimation of global and local damages due to climate change; social cost of carbon; adaptation strategies
Mitigation of climate change	(Global) climate agreements for mitigation, e.g. Kyoto Protocol; analysis of climate policies, e.g. Clean Development Mechanism, carbon taxes/permits; carbon sequestration

C Energy economics

We based this content group on JEL code Q4 ('Energy'), but our categories distinguish explicitly between different energy-related sectors such as *electricity* or *traffic and transport* in order to identify the sectors that have received special attention from researchers at specific points in time.

Category name	Typical articles in this category deal with:
Primary energy production	Generation of primary energy from oil, coal, gas, nuclear, hydropower, biofuels, wind etc.; analysis of primary energy supply
Electricity	Optimal management and development of power plants and networks; general treatment of electricity (without specific energy source)
Heat	Energy efficiency and insulation standards for houses
Traffic and transport	Development of gas prices; fuel economy standards and taxes; biofuel demand/supply and subsidies; technological adaptations in transport, e.g. hybrid cars

Energy and the macroeconomy, energy forecasting	Macroeconomic developments in energy consumption; forecasting of overall energy demand; energy intensity of an economy, e.g. in relation to GDP

D   Costs and benefits of pollution control, non-market valuation

We set up this content group to identify trends in cost-benefit analyses of pollution control and non-market valuation research. The category *general, methodological improvements* is equivalent to JEL code Q51 and covers articles with theoretical considerations as their main content. However, we also wanted to pinpoint the areas in which these methods are applied and therefore included individual categories for major types of pollution and non-market goods (based on JEL code Q53). This expands the JEL framework and enables us to track articles that focus on specific types of pollution.

Category name		**Typical articles in this category deal with:**
General, methodological improvements		Introduction/analysis/improvements of methods for non-market valuation (revealed & stated preferences) and cost-benefit analysis; developing appropriate discount rates for valuation
Methods applied to elicit benefits and damages in:	Air pollution	Local air pollutants, e.g. particulate matter, sulfur dioxide
	Water pollution	Oil spills, eutrophication, wastewater leaks, groundwater and surface contamination
	Noise	Aircraft noise control via charges and nighttime flight bans
	Hazardous waste	Pesticide residuals, oil spills on land, chemical waste
	Nuclear power	Nuclear waste, property devaluation due to proximity to nuclear power plant
	Solid waste	Household waste control, e.g. beverage containers
	Land degradation	Erosion and desertification; welfare effects of urban sprawl; landscape degradation
	Biodiversity loss	Species extinction and protection; biodiversity issues, e.g. due to invasive species
	Recreational activities	Estimation of recreation demand, e.g. recreational hunting and fishing or recreational beach and national park visits
	Other	Benefits of mosquito abatement; other applied valuation studies
Measuring the costs of pollution control, estimating abatement costs		Estimation of aggregate marginal abatement cost curves of an industry/country; estimation of aggregate costs of applying a particular policy (e.g. taxes, standards) without consideration of benefits
Other		Other applications to benefits/cost of pollution control

E   International economics, innovation, and growth

Based on JEL codes O, Q55, and Q56, this content group is designed to capture research trends in macroeconomics, international economics, and innovation that are connected to environmental economics. Under a separate category, we also investigated whether environmental issues in developing countries (due to rapid industrialization and population growth, etc.) are addressed by research articles.

Category name	Typical articles in this category deal with:
Macroeconomic impacts, growth, and GDP	Models of GDP growth and aggregate consumption; sustainable growth models; Environmental Kuznets Curve
Innovation and technological change	(International) technological change and innovation dispersion; models of aggregate production/consumption with explicit focus on the role of technological change
International economic issues	International trade and relocation of pollution; transboundary pollution problems (except for CO_2 emission problems listed in content category *climate change economics*); pollution havens and tax competition; environmental impacts of tariffs; international agreements (if not related to climate change)
Development issues	Environmental impacts of population growth; specific environmental issues in developing countries; economic booms, e.g. due to resource exploitation

F   Analysis of environmental policy instruments

We expanded the rather general JEL code Q58 ('Government Policy') by distinguishing between articles that focus on *environmental standards* or *market-based approaches* (and policy comparisons) in order to identify trends in the standards vs. taxes/permits debate. Similarly, we included additional categories to gather detailed information on the frequency with which researchers address other environmental policy instruments.

Category name	Typical articles in this category deal with:
Command and control policies, environmental standards	Optimal regulation by different types of standard; compliance and control mechanisms; non-transferable quotas
Market-based approaches, policy comparisons	Optimal regulation via market mechanisms, e.g. taxes/subsidies, tradable permits; comparisons of market-based instruments and environmental standards
Liability rules	Liability rules for environmental damages; Coase theorem
Environmental behavior, public goods, voluntary approaches	Environmental attitudes of households; willingness to pay price premiums for eco-friendly products; voluntary provision of public goods; effects of (voluntary) eco-labelling on consumer and producer decisions; voluntary transparency initiatives by firms; behavior by firms in connection with consumer pressure and public information

Political economy aspects	Optimal regulatory authority, e.g. federal vs. state government; lobbying and rent-seeking in politics; bureaucratic decision processes; voting
Other	Other applications to environmental policy instruments

G   Environmental management at firm level

To take account of the management dimension in *JEEM*, which is also addressed in the journal's title, we included a category that refers to environmental management decisions and firms' behavior. The papers in question sometimes use JEL classification code L (Industrial Organization).

Category name	Typical articles in this category deal with:
Environmental management at firm level	Pollution control decisions at the firm/sector level, e.g. substitution of inputs or changes in production processes; behavior of firms in response to regulatory measures; Porter hypothesis

H   Equity and justice

There is no JEL code Q category that adequately reflects ethics and justice issues. Papers addressing environmental justice would resemble the D3 and D63 codes.

Category name	Typical articles in this category deal with:
Equity and justice	(Intergenerational) distributional justice and equity, e.g. with regard to irreversible resources

I   Other content

In the final category we assembled all articles that were relatively singular and could not be listed under a common heading.

Category name	Typical articles in this category deal with:
Other content	Other topics not covered by any of the above categories

2.2 Methods

In the second dimension, we allotted each article to at least one of 11 methods in order to analyze how researchers approach the different kinds of content referred to above. Again we started out from the JEL Classification System, which also classifies articles on the basis of their methodologies, for example in category C1 (Econometric and Statistical Methods and Methodology: General), C6 (Mathematical Methods, Programming Models, Mathematical and Simulation Modeling) or Q51 (Valuation of Environmental Effects). We extended and enhanced the classification system to facilitate the identification of research methods applied in environmental economics. Our categories range from theoretical modeling to econometric, simulative, and experimental approaches. To complement the corresponding content group, we also included categories for environmental valuation methods. Since articles often feature combinations of several methods (e.g. theoretical and empirical;

theoretical and experimental), we permitted the selection of more than one research method per article in the methods category.

Category name		Articles in this category use the following methods:
Theory	Static theory	Theoretical static models, including models with two or three time periods
	Dynamic theory	Theoretical models with infinite time horizons
	Theory of non-market valuation & cost/benefit analysis	Theoretical development/improvement of approaches for non-market valuation or cost/benefit analysis
	Other theory	Verbal descriptions (incl. literature surveys); comments; qualitative analysis
Econometric and statistical methods		Design of new econometric and statistical techniques related to environmental economics problems; application of econometric techniques to real-world datasets; improvement of estimators
Non-market valuation	Hedonic pricing	Hedonic regressions applied to housing or wages
	Other revealed preferences	Household production functions, notably travel-cost method and defensive expenditures method; prices, premiums, donations, and voluntary contributions paid by agents to reveal preferences
	Stated preferences	Evaluation of willingness to pay/accept via surveys, e.g. contingent valuation method, choice experiments
Mathematical and simulation modeling		Computable general equilibrium (CGE) models; input-output models; programming models; Monte-Carlo simulations; evaluation of theoretical models with numerical simulations
Experi-mental	Lab experiments	(Laboratory) experiments within a controlled environment
	Field experiments	(Field) experiments conducted in a natural environment

2.3 Environmental media: pollutants and resources

This dimension indicates whether an article deals with a particular form of externalities or resources, and if so, which one. While some content categories automatically imply particular environmental media (e.g. *forestry* as content implies *forests* as resource), we have also marked the specific pollutant and/or resource for articles with different primary content (e.g. studies with *market-based approaches and policy comparisons* as content discussing taxes on CO_2). The category *none* comprises articles that either do not address particular pollutants or resources or refer to one arbitrary form only (often referring generally to "pollution" or "resource(s)"). Where a particular pollutant or resource was mentioned, we delved deeper into the sub-categories referred to below. For instance, in the case of *air pollution and greenhouse gases,* we selected the category of a particular pollutant (e.g. NO_X) if it was explicitly mentioned. If no explicit air pollutant was mentioned, we used the tag *general air pollution*. Specific pollutants that do not match the items listed (volatile organic compounds (VOCs), etc.) are categorized under *other air pollution*.

As articles often feature several pollutants or resources, multiple categories can be selected for each article. The environmental media categories are listed below.

Category name			**Articles are placed in this category if they include**
Air pollution and greenhouse gases (GHG)	Sulfur	NO$_X$	CO	Explicit reference to air pollutants (each of the listed air pollutants on the left has its own category)
	PM	CFCs	Ozone	
	CO$_2$ and general referrals to greenhouse gases (GHG)			
	General air pollution			General references to air pollution
	Other air pollution			Specific air pollutants not listed above
Water pollution	C-H compounds			Carbon-hydrogen compounds, incl. oil spills
	Cl compounds			Chemical compounds with chlorine
	Fertilizers			Fertilizer residuals from agriculture; eutrophication
	Solid waste			Measurements of total suspended solids; microplastics
	Heavy metals			Toxic heavy metals, e.g. arsenic, mercury, lead
	General water pollution			General references to water pollution; biological oxygen demand (BOD)
	Other water pollution			Specific water pollutants not listed above
Land pollution	Solid waste			Household waste; wastepaper; plastics; waste sites, solid waste collection
	Landscape degradation			Erosion; desertification; urban sprawl
	Other land pollution			Hazardous waste sites; land pollution according to Toxic Release Inventory; pesticide residuals on land; specific land pollution not mentioned above
Other pollution				Pests, invasive species; diseases; human overpopulation, congestion at recreational sites; heatwaves; noise
Resources	Fisheries			Fisheries and aquaculture; coral reefs
	Forests			Forests of any kind, incl. mangrove forests
	Non-renewables			Oil, coal, gas, minerals, ores
	Recreation, landscape			National parks; natural sites and landscapes; recreational sites, e.g. beaches
	Wildlife, biodiversity			Wildlife (other than fish); biodiversity
	Water as a resource			Ground and surface water; potable water
	Secondary materials, waste recycling			Recyclable materials, e.g. wastepaper, beverage containers, (scrap) metals
	Other			Renewable energy sources, e.g. wind, solar, biofuels; nuclear materials
None				No further specification of a resource or pollutant

2.4 Cross-cutting issues

Our definition of the cross-cutting issues dimension encompasses content displaying a connection to certain policy-relevant issues (even when this is not the main content) and methods that have shaped scientific work in environmental economics. This dimension is a flexible way of "tagging" articles, e.g., in cases where although the content is not classified as *climate change economics,* the article is still related to that issue. Examples are forest management content with respect to carbon sequestration, the performance of particular mitigation policies, or measurement of a respective firm's behavior.

Category name	Articles are placed in this category if they include:
Climate change	Topics/pollutants/resources related to climate change, e.g. the mitigation of greenhouse gases or adaptation to damages
Energy efficiency	Topics/resources related to energy efficiency, e.g. efficiency of power generation from different sources or standards for car fuel efficiency
Renewable energy sources	Particular renewable energy sources and/or policies regarding their use, e.g. analysis of (renewable) energy subsidies
Nuclear	Impacts of nuclear power plants, nuclear energy use, or nuclear waste
Risk, uncertainty, imperfect information	Models or narrative descriptions referring to risk, uncertainty, or imperfect information, e.g. uncertainty and imperfect information in pollution regulation, risks due to climate change, health risks etc.
Discounting methods	Explicit analysis of different discounting methods/approaches; models where the simple use of a constant discount rate is not sufficient
Interdisciplinary approaches and ecological economics	Frameworks introducing ecological perspectives into economic analysis, e.g. predator-prey models, ecological footprints, etc.; interdisciplinary approaches from other fields, e.g. psychology, physics, engineering, and philosophy

2.5 Regional dimension

The last of the five dimensions is the regional context. For each article we selected only one regional dimension. Studies that do not apply to a specific region are classified as *general, no regional context*. We selected a specific regional dimension whenever an article dealt with a certain dataset or a region-specific issue. The regional dimensions are:

- General, no regional context
- U.S., Canada
- Europe
- China
- Middle East
- Rest of Asia
- Latin America, Caribbean
- Africa
- Oceania
- Other region, e.g. at sea
- Multi-region analysis and comparative studies of countries

3. Analysis of *JEEM*

This section contains the descriptive results and the graphs/diagrams obtained by applying the classification scheme presented above to *JEEM*. For each individual dimension we indicate the general development over the whole observation period 1974-2014 and discuss major findings and research trends. An additional pie chart shows the total number of articles per sub-category over the whole time range. In a second step we explore sub-categories of each dimension in more detail. Although information is available for each year, we have elected to look at the overall period in terms of decades (1974-1984, 1985-1994, 1995-2004, and 2005-2014). There are two reasons for this. First, it makes the diagrams more descriptive. Second, our aim is to investigate whether the magnitude of the individual dimensions is independent of the decades. Decade-clustering is necessary for non-parametric chi-squared tests designed to obtain a minimum number of observations per sub-category.[1] The null hypothesis is that the volume of sub-categories is evenly distributed over time, i.e. across decades. The corresponding p-values are reported in the captions of each figure. For example, the p-value (0.000) in Figure 1 means that the volume of sub-categories varies significantly over the four decades. In the category *natural resource economics – renewable resources,* by contrast, the amplitudes of the sub-categories shown in Figure 3 do not vary significantly over the decades.[2]

3.1 Content

Figure 1 shows the breakdown of articles into nine major content groups throughout the existence of *JEEM*. In line with the findings by Brookshire and Scrogin (2000) for the period 1974-1998, the main topics are *costs and benefits of pollution control,* n*on-market valuation* (483 articles in all), *natural resource economics* (450 articles in all), and *analysis of environmental policy instruments* (412 articles in all). Together they consistently constitute more than 70% of the articles published per volume up to 2008.

Thereafter, however, a significant (p-value 0.000) shift towards a more diversified array of research areas becomes apparent.[3] From the 1990s onwards, *JEEM* has become a platform for novel issues such as international pollution problems, technological change, and growth. After the 1992 Rio Conference, *climate change economics* found its way into the journal, consistently gaining in prominence and achieving a share of 10% of all articles by 2010. Other expanding subjects are *energy economics* issues and *environmental management at firm level*, the latter facilitated by the increasing availability of microeconomic datasets.

Only nine articles focus on the ethical issues involved in environmental economics, while eleven articles resisted group classification in terms of content. The chi-squared test shows that the presence of sub-categories varies significantly (p-value: 0.000) over time.

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[1] Throughout this section 3 we use the term "significant" to refer to an overall significant chi-squared test statistic (see Appendix B). We also indicate where a certain article dimension contributes substantially to the chi-squared value. The chi-squared test yields chi-values for each sub-category/decade cell from which we can infer the cell's contribution to the test result.

[2] The p-value of the chi-squared test is 0.190.

[3] At the one-percent significance level, the chi-squared test rejects the null hypothesis that the evolution of content groups is independent of time.

Accordingly, we can reject the null hypothesis that sub-categories are evenly distributed across the four decades.
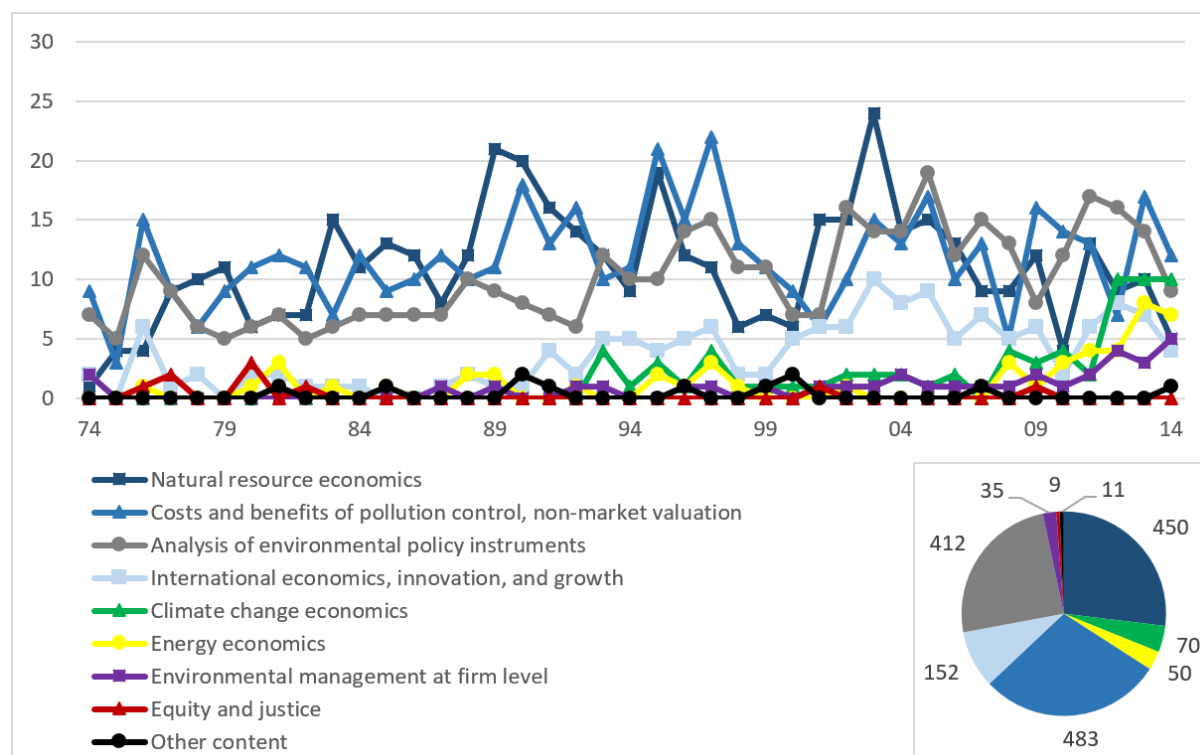

Figure 1: Classification of JEEM *articles by content (one per article, N=1672, p-value: 0.000)*

Next we take a closer look at each major sub-category, beginning with *natural resource economics*.

A   Natural resource economics

We divide the overall content of *natural resource economics* into the sub-categories *renewable resources*, *non-renewable resources,* and *other natural resources* (Figure 2). During the 1970s and 1980s, an era marked by oil crises and resource scarcity, studies on *renewable* and *non-renewable resources* make up a large percentage of the articles. Over the course of time, we find greater interest in *renewable* (275 articles in all) than *non-renewable resources* (127 articles in all) asserting itself. Changes in sub-category volume over time are significant (p-value: 0.000 in Figure 2). After the 1970s, studies on *other natural resources* (48 articles in all), mostly devoted to secondary materials, recycling, and antibiotics and pesticide issues, declined substantially.
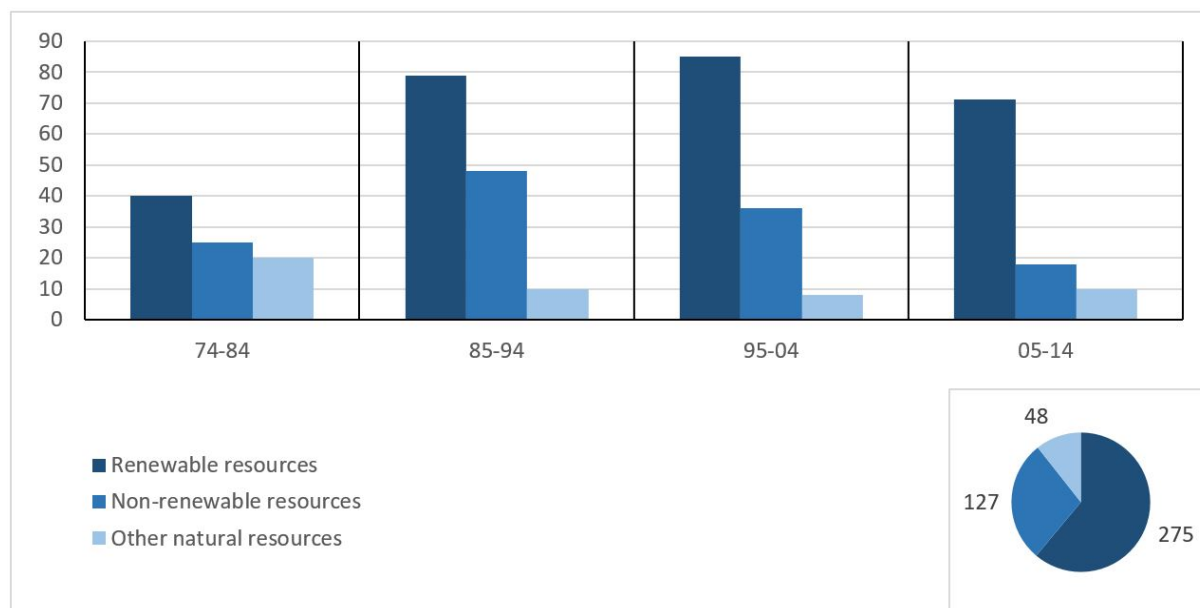
Figure 2: Natural resource economics (one per article, N=450, p-value: 0.000)

A.1 Natural resource economics: renewable resources

Fisheries are the renewable resource that the journal focuses on most assiduously (Figure 3). The subject has been of unremitting importance since the seminal paper by Clark and Munro (1975). *Forestry* comes second. It was especially relevant in the 1980s and 1990s but declined afterwards. Polyakov et al. (2017) observe a similar decline of interest in *forestry* in *Environmental and Resource Economics* between 1991 and 2015. Other important fields are the management of *water* and *land* resources, the latter looming large in this century. Only 20% of articles analyze renewable resources *in general* without homing in on a particular resource (such as *fishery*). The constitution of the categories does not vary significantly over the four decades (p-value: 0.132).
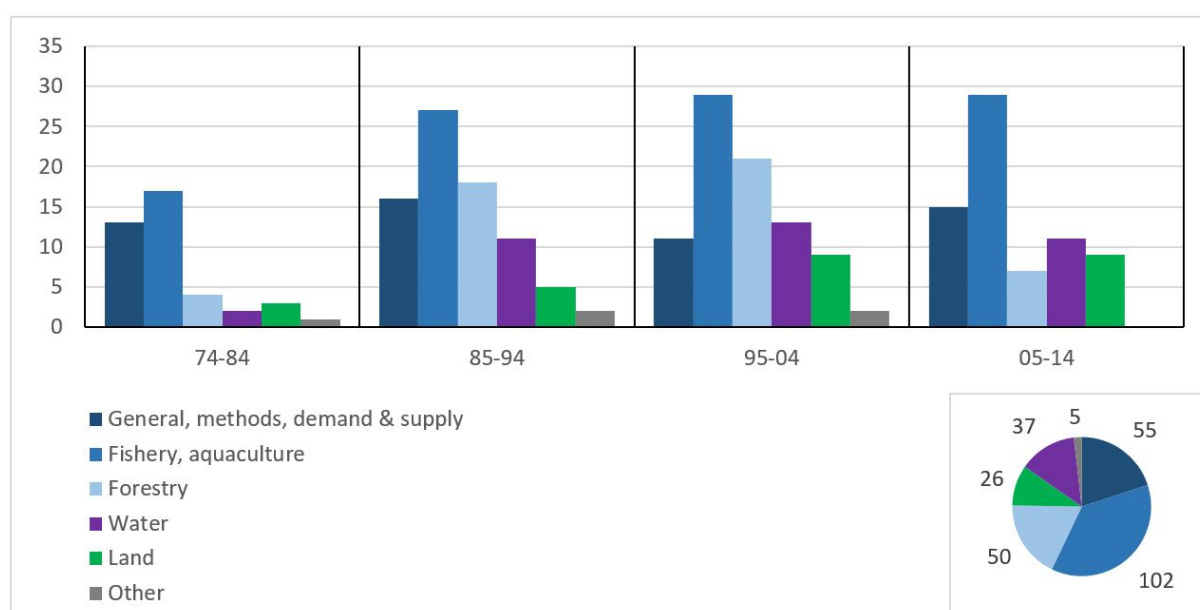

Figure 3: Natural resource economics – renewable resources (one per article, N=275, p-value: 0.190)

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A.2 Natural resource economics: non-renewable resources

In contrast to *renewable resources*, the majority of articles on *non-renewable resources* address *general* aspects of non-renewable resource management without referring to a specific resource (Figure 4). *Non-renewable energy resources, minerals,* and *ores* are more conspicuous in the first three decades, when resource scarcity was a prominent issue in the literature. As the 21st century approaches, the number of articles on *biodiversity* (e.g. the extinction of species) increases, and the overall compositional changes are statistically significant at a 5-percent level (p-value: 0.015).
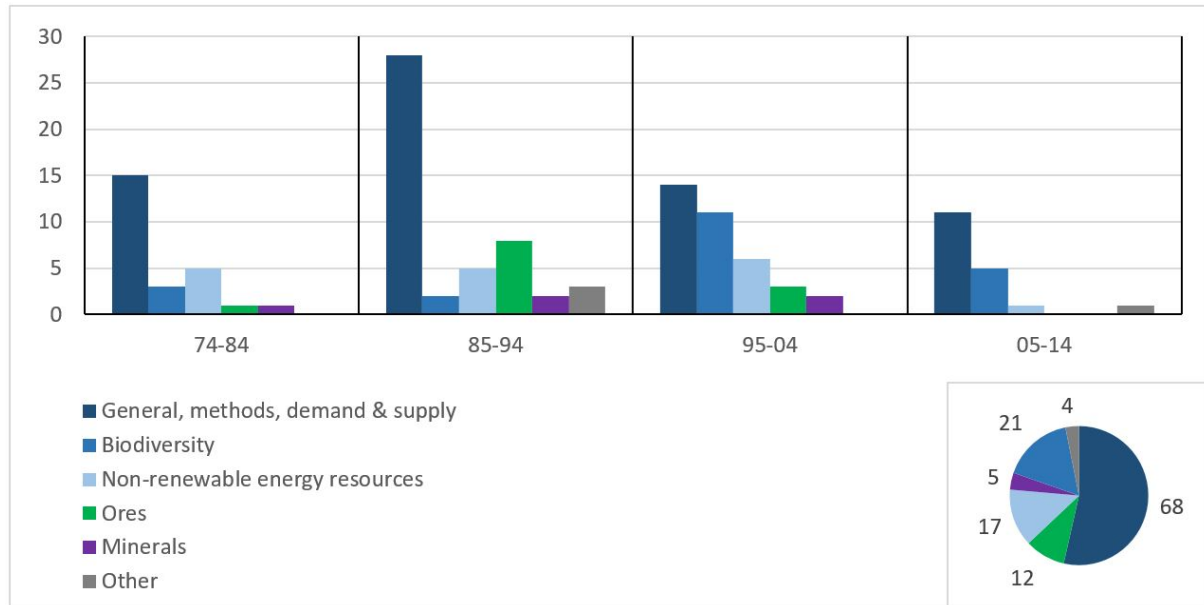
Figure 4: Natural resource economics – non-renewable resources (one per article, N=127, p-value: 0.015)

A.3 Natural resource economics: other natural resources

Other natural resources (48 articles in all) mostly covers articles on *secondary materials and recycling*, especially during the journal's first decade (15 out of 25 articles in all). The remaining subjects are the use of *pesticide and antibiotics* (12 articles in all), *mass stability and entropy laws* (7 articles in all), and *other resources* (4 articles in all).

B Climate change economics

The potential threat of climate change due to anthropogenic greenhouse gas emissions is addressed in *JEEM* at an early stage, the first article on the subject being published in 1981 (by co-founder V. Kerry Smith). Nonetheless, the issue only became an integral part of the journal after 1992, when the Rio Conference took place. Publications on the subject peak remarkably after 2012, 30 of all the 70 articles published from 2012 to 2014 being devoted to the subject. In Figure 5 we omit the time dimension due to the novelty of the content and insignificant variation (p-value: 0.178) in sub-category shares over the last two decades,

when the majority of articles were published.[4] One half of these studies address particular strategies for *mitigating* climate change and aspects of policy instruments designed to abate greenhouse gas emissions. The other half is divided up between *general methods* of investigation, such as game-theoretic analyses for dealing with global public bads or discounting issues and assessments of *damages through climate change and adaptation strategies*.
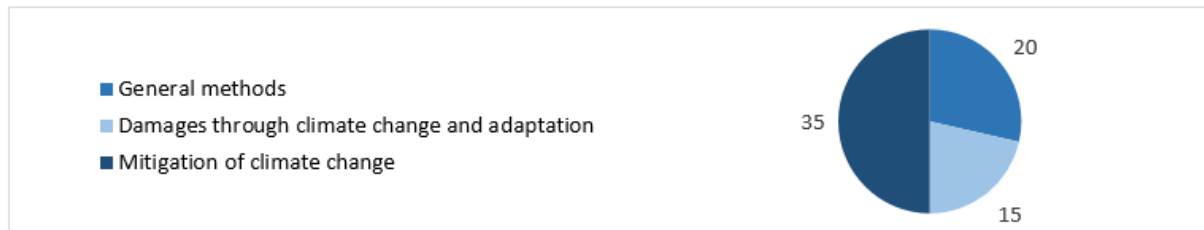
Figure 5: Climate change economics (one per article, N=70, p-value: 0.178)

C   Energy economics

Despite the obvious links with resource scarcity, studies on *energy economics* play a minor role in the journal (50 articles in all). Of the three energy usage sectors addressed (electricity, heat, transport), issues related to *traffic and transport* outnumber the others.[5] Examples are studies on the effects of fuel efficiency standards or biofuel policies proposed since 1995 (Figure 6).
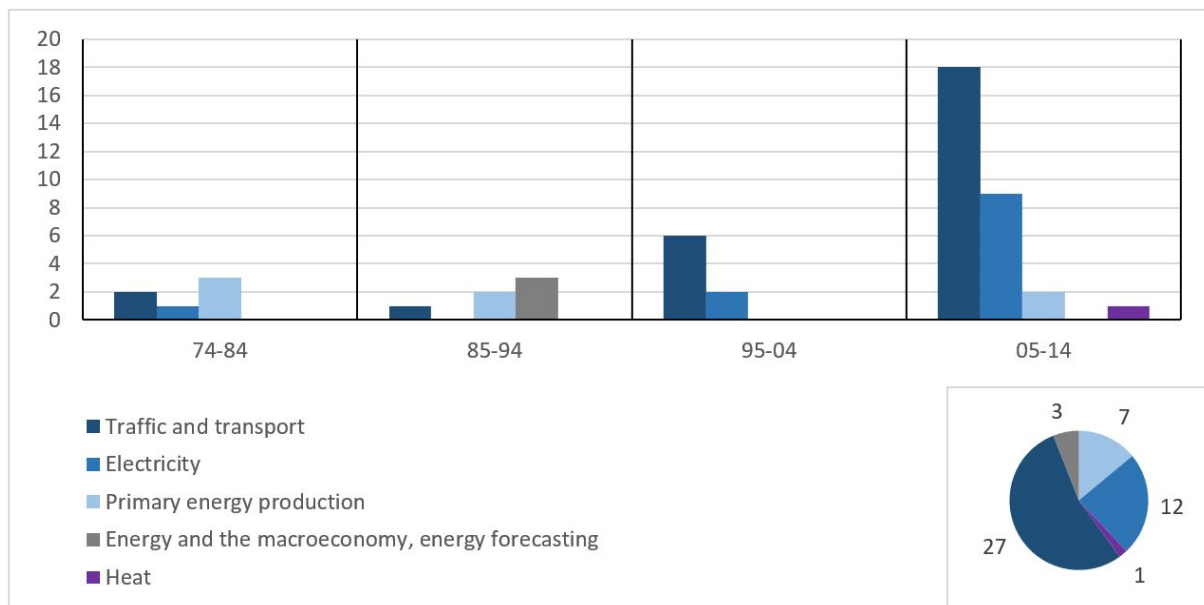
Figure 6: Energy economics (one per article, N=50, p-value: 0.000)

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[4] We omit the first two decades in the chi-squared test as only 6 of the 70 articles were published in that period.

[5] One reason may be that other influential energy economics journals exist, notably *The Energy Journal*, *Energy Economics*, *Energy Policy*, and several journals specializing in utility management and policy. By contrast, transport journals focus more on the increasing efficiency of transport and on congestion problems than on environmental issues.

In the last decade, *electricity* generation issues have also gained importance. In all, there are fewer than ten studies on *primary energy production* and *macroeconomic* analyses. Despite its major importance for fossil fuel use, there is only one study on the *heating* sector. The quantitative variation of sub-categories over time is statistically significant (p-value: 0.000).[6]

D Costs and benefits of pollution control, non-market valuation

In this content group, we further distinguish the categories *general, methodological improvements,* and *applied methods* (case studies) as well as studies on the *costs of pollution control* (Figure 7). These categories display a statistically significant shift over time (p-value: 0.000). In *JEEM*'s first decade, most articles focus on *applied methods,* with special emphasis on *air pollution* (e.g. health risks from particulate matter) and the value of *recreational activities* (Figure 8).[7] Since then, there has been significantly greater interest in *general and methodological improvements*, e.g. improvements to the stated or revealed preference method. To our surprise, studies assessing *the costs of pollution control*, including estimates of particular abatement cost functions, do not figure at all prominently in the journal, which focuses more on the assessment of environmental damages rather than on costs.
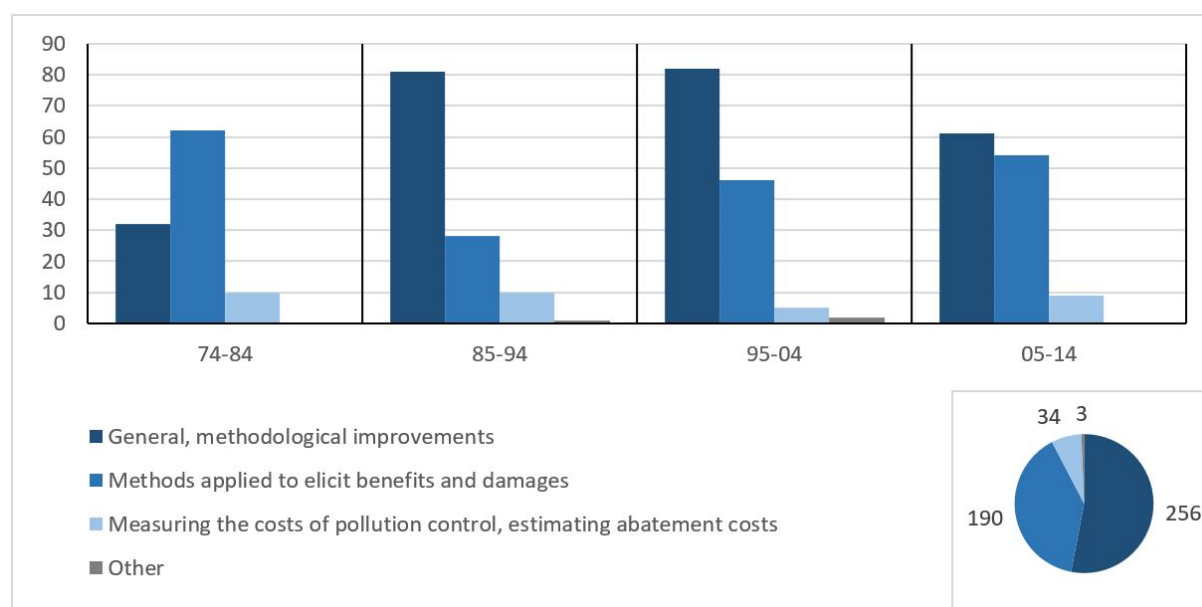
Figure 7: Costs and benefits of pollution control, non-market valuation (one per article, N=483, p-value: 0.000)

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[6] Given the small number of cases, we use 2-decade periods instead of 1-decade periods for the chi-squared test, and we also group the sub-categories *primary energy production*, *heat* and *energy and the macroeconomy* into a single category.
[7] For the sake of clarity, Figure 8 is shown without a time dimension. However, the respective chi-squared test still refers to the decade structure and shows highly significant variation over time.
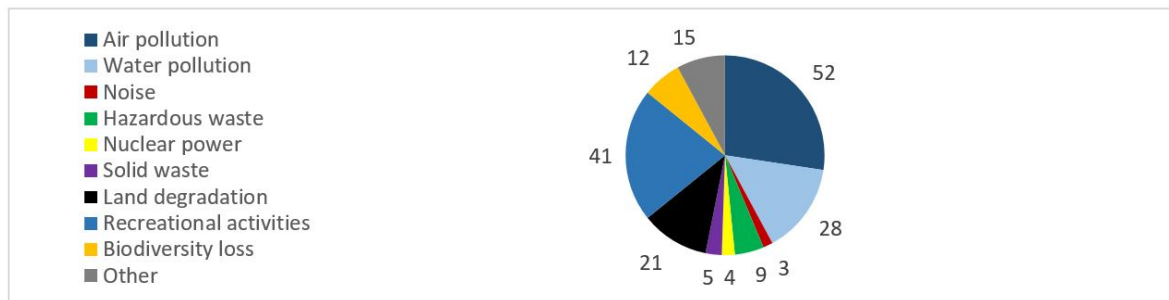
Figure 8: Costs and benefits of pollution control, non-market valuation - methods applied to elicit benefits and damages (one per article, N=190, p-value: 0.000)

E   International economics, innovation, and growth

The presence of research on *international economics, innovation, and growth* in connection with environmental economics has increased since the 1990s, with a specific focus on *international economic issues* such as international environmental agreements and trade-related pollution (Figure 9). This agrees with the increase of `trade and investment` content in *Environmental and Resource Economics* established by Polyakov et al. (2017). *Macroeconomic impacts*, such as growth model applications to resources and environmental pollution, and especially *innovation and technological change* studies increased in prominence after *JEEM*'s 30th anniversary. However, particular *development issues* such as the energy consumption patterns in developing countries play only a minor role. Given that cases of environmental pollution tend to be severer in these countries and environmental regulation less commonplace, this is another surprising finding. One reason may be the scant availability of relevant data for developing countries.
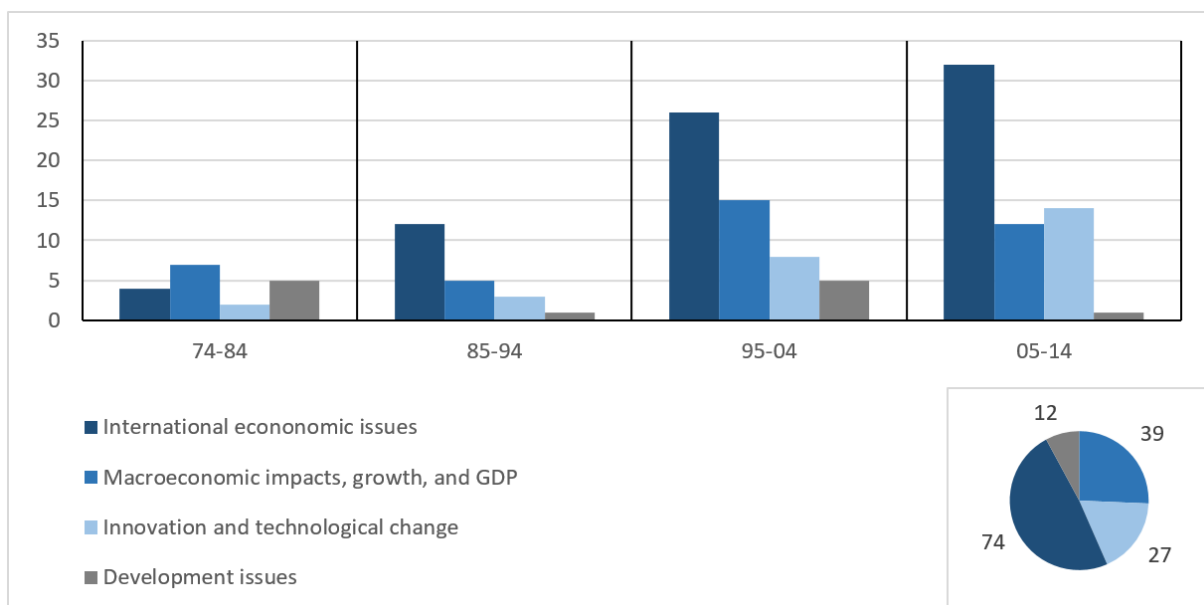
Figure 9: International economics, innovation, and growth (one per article, N=152, p-value: 0.021)

F   Analysis of environmental policy instruments

The third major content group, the *analysis of environmental policy instruments*, displays a strong bias towards *market-based approaches and policy comparisons* (Figure 10). The minor role of c*ommand and control policies, environmental standards* goes hand in hand with a paradigm shift in environmental policymaking. Alongside classical environmental economics instruments, two new aspects have come in for an upsurge of interest during the journal's last two decades: first, voluntary pollution control by producers and pro-environmental behavior and attitudes *on the part of* consumers (cf. our category *environmental behavior, public goods, voluntary approaches*) - again, we find overlap with Polyakov et al. (2017) and their reference to the rising popularity of articles on 'Voluntary environmentalism' in *ERE* between 1991 and 2015 - and second, *political economy aspects* of environmental regulation. Driven by these developments, the changes in category structure over a period of decades are statistically significant at a five-percent level (p-value: 0.042).
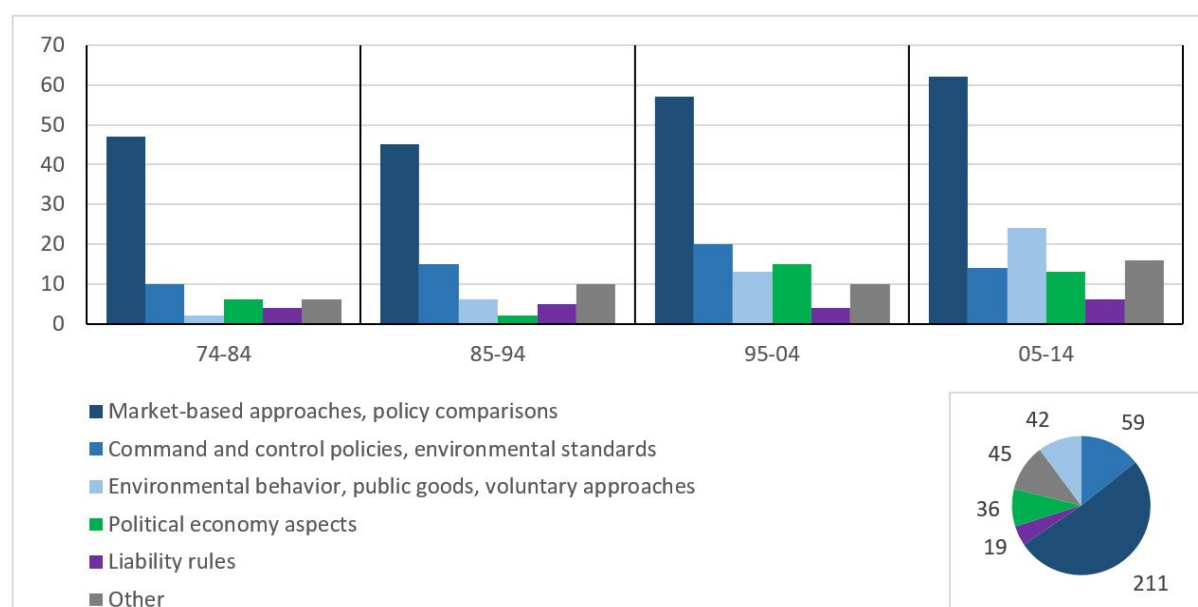
Figure 10: Analysis of environmental policy instruments (one per article, N=412, p-value: 0.042)

3.2 Methods

Theoretical models are the most common methodology discussed in *JEEM* articles (Figure 11); other methods have played only a minor role for most of the time. As the turn of the century approaches, increasing methodological plurality becomes apparent, driven by a significant shift towards *econometric and statistical methods* over the four decades in question. This is in line with Hamermesh's (2013) observations on an increasing proportion of empirical work among the top three A+ economics journals over time.[8] During the 1990s, non-market valuation methods increased in popularity. In the last decade, *mathematical and simulation modeling* has proved to be another important methodology. In the *JEEM*'s first years, simulation methods were mainly input-output analyses. Later the category still figured

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[8] His sample comprises *American Economic Review (AER), Journal of Political Economy (JPE),* and *Quarterly Journal of Economics (QJE)* between 1963 and 2011.

prominently in the journal, extending to more elaborate approaches such as computable general equilibrium (CGE) modeling. In 1982 the first *laboratory experiment* was published, and the experimental approach has grown in prominence ever since (43 articles in all), especially in the context of *non-market valuation* and the *analysis of environmental policy instruments*. Since their introduction in 1988, *field experiments* have gradually stepped up their showing in the journal. In the following, we discuss the sub-categories *theoretical methods* and *non-market valuation methods* in more detail.
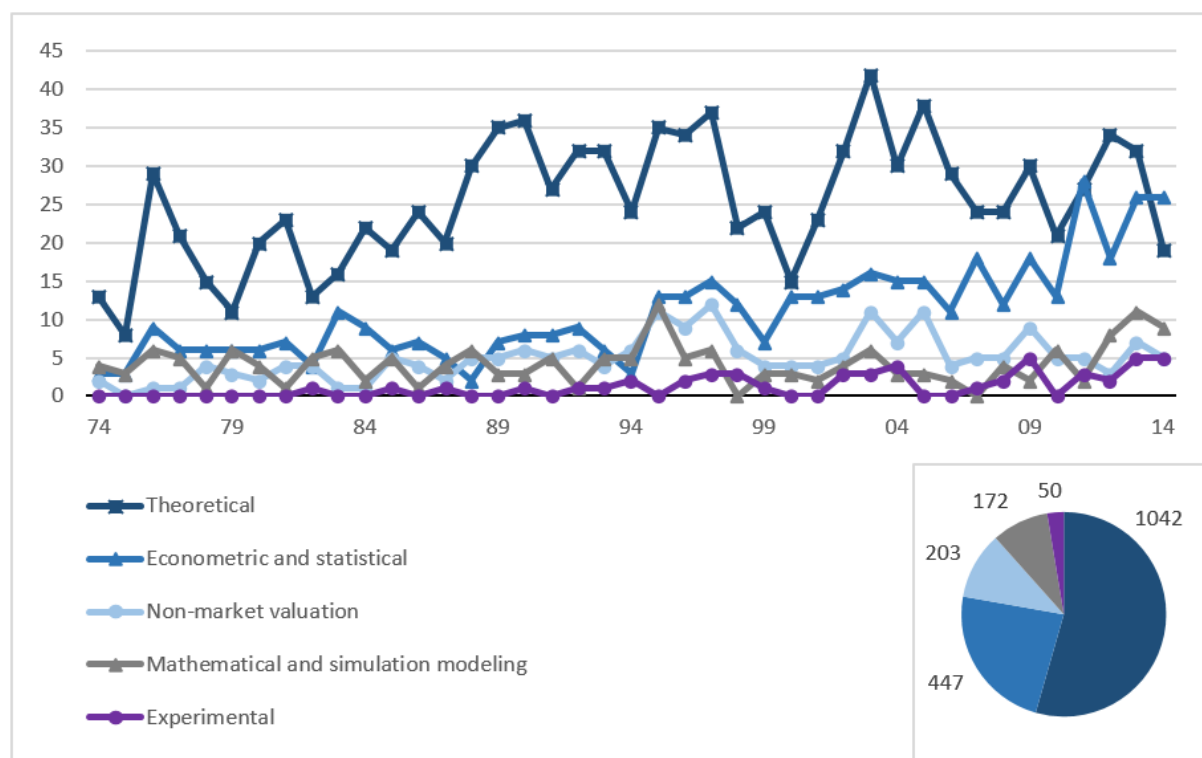
Figure 11: Methods utilized for analysis (multiple per article possible, N=1914, p-value: 0.000)

Theoretical methods

For the analysis of problems such as resource scarcity, the journal's first two decades feature *dynamic theory models* (up to infinite time periods) rather than *static theory models* (with up to three time periods) (Figure 12). *Static theory models* are typically used to analyze regulatory instruments. Overall, both methods are equally represented. *Theoretical foundations of non-market valuation and cost-benefit analysis* rank third with a peak during the 1990s. Since then, articles classified as *other theories*, including purely verbal descriptions, have disappeared from the journal.
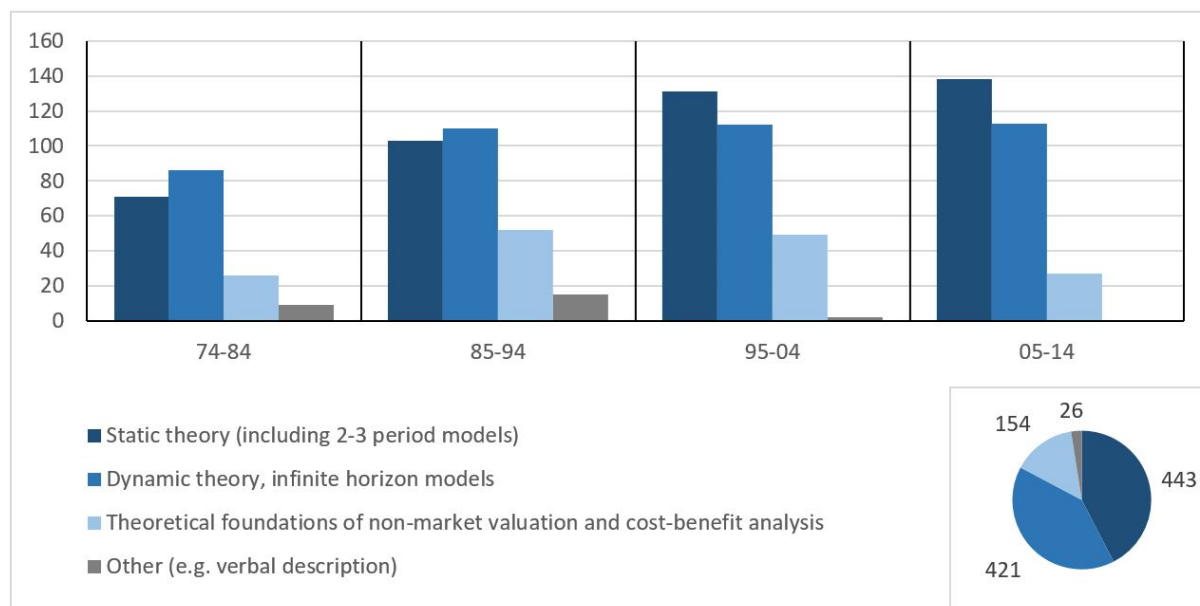
Figure 12: Theoretical methods (multiple per article possible, N=1044, p-value: 0.000)

Non-market valuation methods

Non-market valuation has become an increasingly prominent method in *JEEM* with a peak in the third decade stimulated by the Exxon Valdez oilspill of 1989 and contingent valuation studies for damage assessments [Carson et al. 2003]. The most common method is the *stated preferences approach* using surveys for contingent valuations or choice experiments (Figure 13).
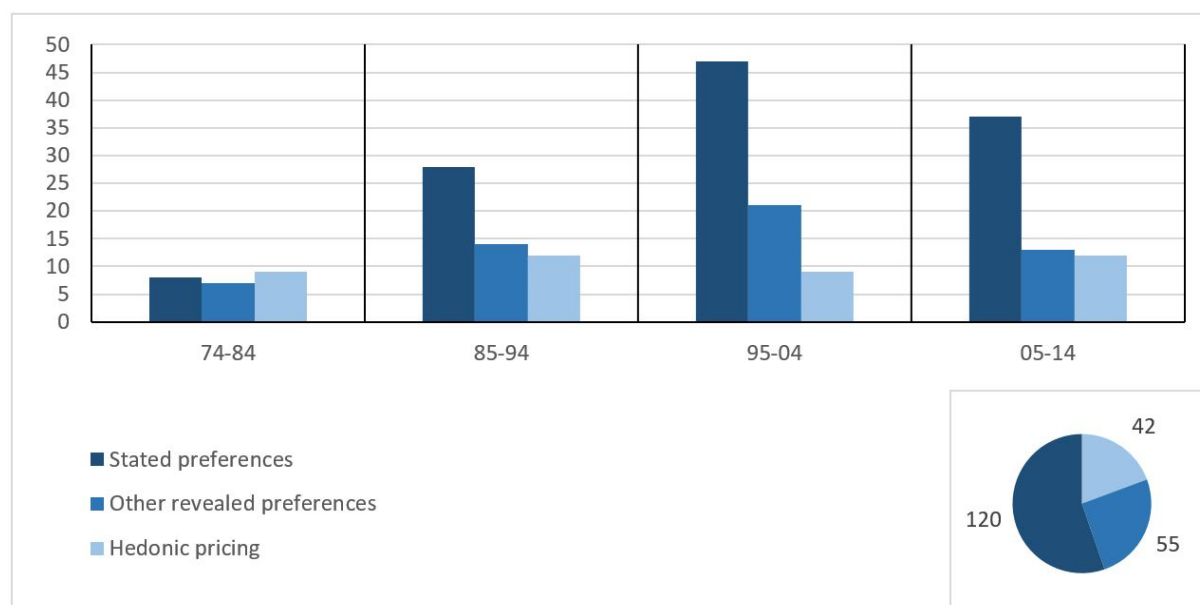
Figure 13: Non-market valuation methods (multiple per article possible, N=217, p-value = 0.114)

Runner-up is the *revealed preferences approach.* Here the travel-cost method is the one most frequently applied. Contrary to the findings of Polyakov et al. (2017) for *Environmental and Resource Economics*, we find no increase of *recreational activities* studies in *JEEM* since the 1990s. Although present since the journal's first issue in 1974, *hedonic pricing* is the least frequently applied method for non-market valuation. Typical research interests are the amenity values of air pollution or health risks.

3.3 Environmental media: pollutants and resources

Next we investigate whether articles deal with particular forms of environmental media. In all, more than half of the articles do indeed address particular pollutants or resources (Figure 14). The ratio between pollutants and resources evens out and becomes more or less equal in the second and third decades. Since the late 2000s, the number of studies on *air pollution and greenhouse gases* has grown significantly. *Land pollution*, including solid and toxic wastes, and *water pollution* play a minor role. *Other pollutants* such as pesticides or invasive species are not consistently relevant over all the four decades. Changes throughout this period are statistically significant (p-value: 0.000).
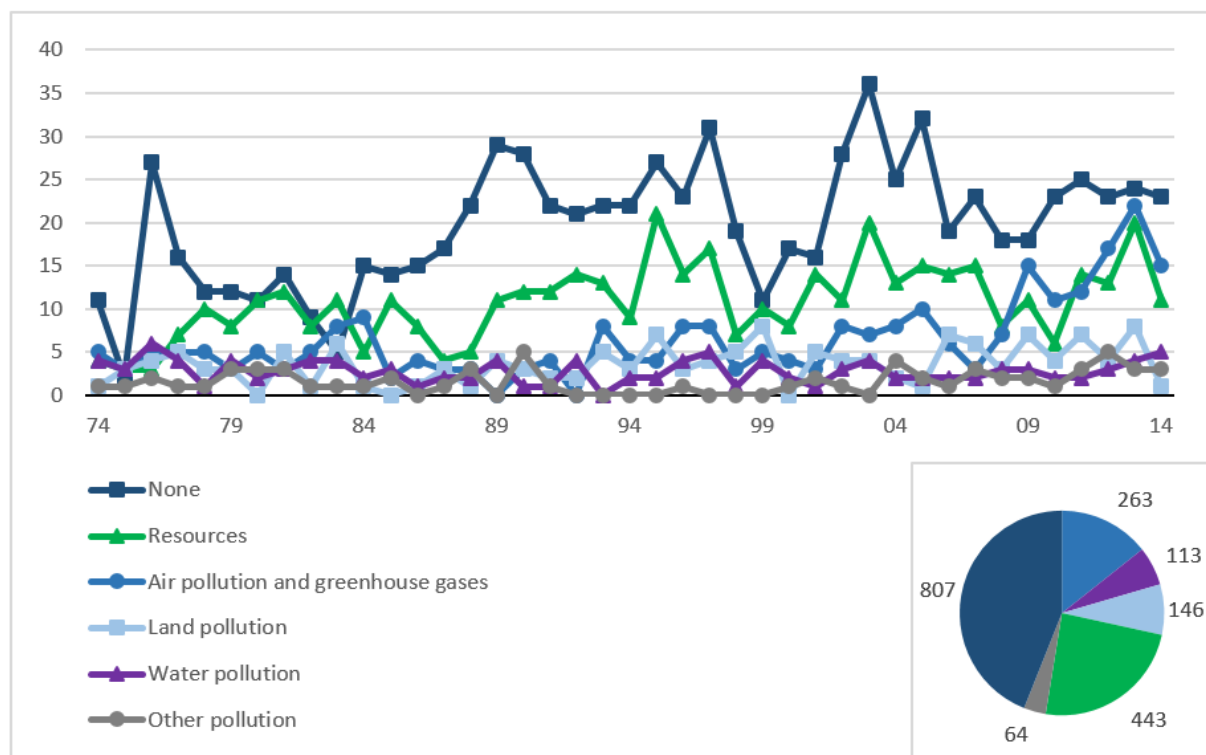
Figure 14: Environmental media: pollutants and resources (multiple per article possible, N=1836, p-value: 0.000)

Air pollution and greenhouse gases

In the journal's first two decades, studies on *air pollution and greenhouse gases* emphasize local air pollutants only, notably *sulfur*, *particulate matter, nitrogen oxides (NOX),* and *ozone* (Figure 15). With the publication of the First Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) in 1990 and the creation of the United Nations Framework

Convention on Climate Change (UNFCCC) in 1992, the last two decades show a significant shift towards *CO₂ and general references to greenhouse gases*.[9] Nonetheless, there is no fall in the number of studies on local air pollutants as air pollution problems are still persistent in the current century despite various environmental policy efforts. Only 14 articles explicitly discuss *other air pollution*, such as volatile organic compounds.
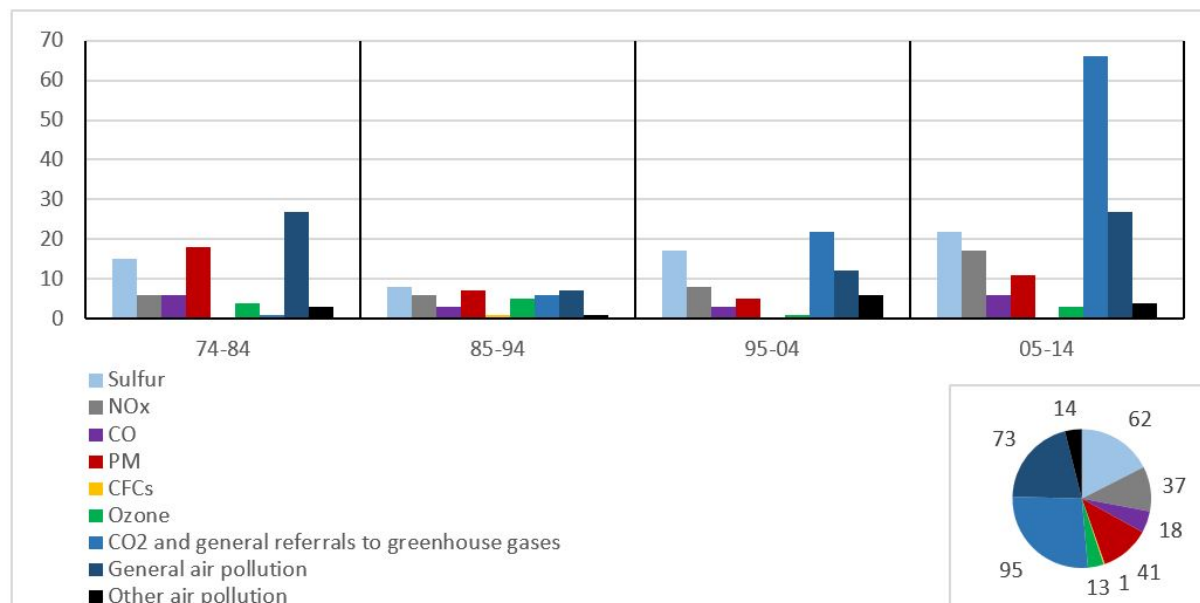
Figure 15: Environmental media - air pollution (multiple per article possible, N=354, p-value: 0.016)

Water pollution

The category structure for *water pollution* studies is fairly constant over time (p-value: 0.370) so that a static pie-chart is sufficient for its representation (Figure 16). Most applied studies investigate *general water pollution* problems without specifying pollutants or metering general indicators for water quality (such as the biological oxygen demand). A minor proportion explores particular kinds of pollution such as damages from *fertilizers* or oil spills (*C-H compounds*).
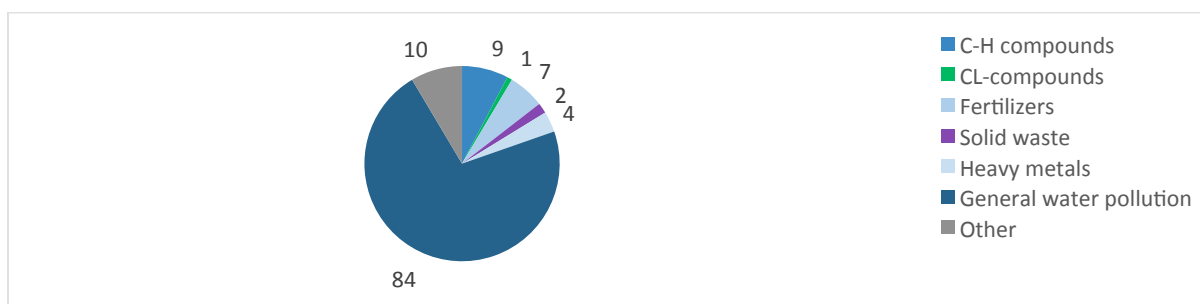
Figure 16: Environmental media - water pollution (Multiple per article possible, N=117, p-value: 0.370)

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[9] Given the small number of cases, we apply the chi-squared test for differences across *general air pollution*, *CO₂ and general references to greenhouse gases* and an aggregate of all local air pollutants. We further restrict the test to the last two decades, since *CO₂ and general references to greenhouse gases* only found their way into the journal in its third decade.

This relative paucity is surprising given that oil spills (Exxon Valdez, Deepwater Horizon, etc.) are usually among the environmental catastrophes that receive top-level media attention and hence major public awareness.

Land pollution

Interest in the different forms of *land pollution* varies significantly over time (p-value: 0.004; Figure 17)[10]. *Degradation of landscapes* is a major category, its prominence in the 2000s coinciding with an increasing number of studies on wildlife habitats. Studies on *solid waste* peaked in the 1970s, while since the 1990s interest in *other land pollutants* such as hazardous wastes has been greater. This coincides with the introduction of the Toxic Release Inventory (TRI) in the United States in 1987, part of a policy requiring firms to disclose their pollution data to the public.
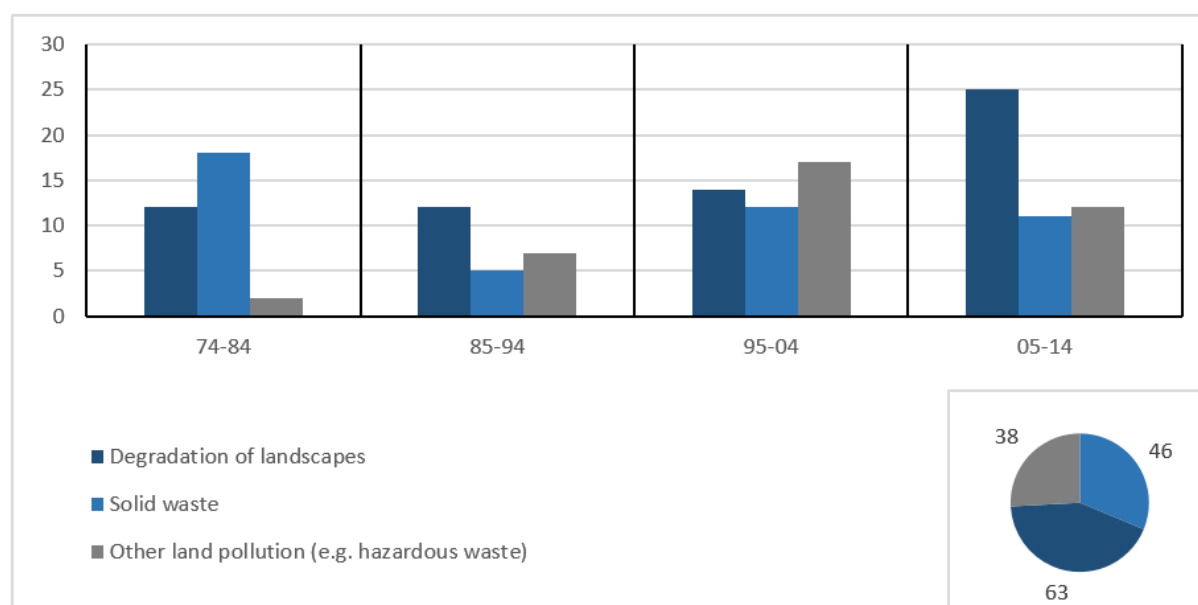
Figure 17: Environmental media - land pollution (multiple per article possible, N=147, p-value: 0.004)

Resources

To a large extent, Figure 18 resembles the findings in Figures 3 and 4, since articles with a focus on a particular natural resource are typically classified for the same resource in the environmental media dimension. *Fisheries* and *forests* are the renewable resources receiving the greatest emphasis, followed by *recreation and landscape*. Most studies on w*ildlife and biodiversity* and on *water as a resource* were published in the third decade. Studies on *non-renewables*, e.g. fossil fuels and minerals*,* are more conspicuous in the 20th century, whereas the 21st century shows an increase in *other resources* such as biofuels and renewables (11

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[10] We report the p-value for a chi-squared test over decades. The same test for a comparison between the first and second two-decade period is also significant at the five-percent level.

out of 14 articles in all). There is also a revival of interest in *secondary materials and waste recycling* in this period. Changes over the four decades are significant (p-value: 0.000)
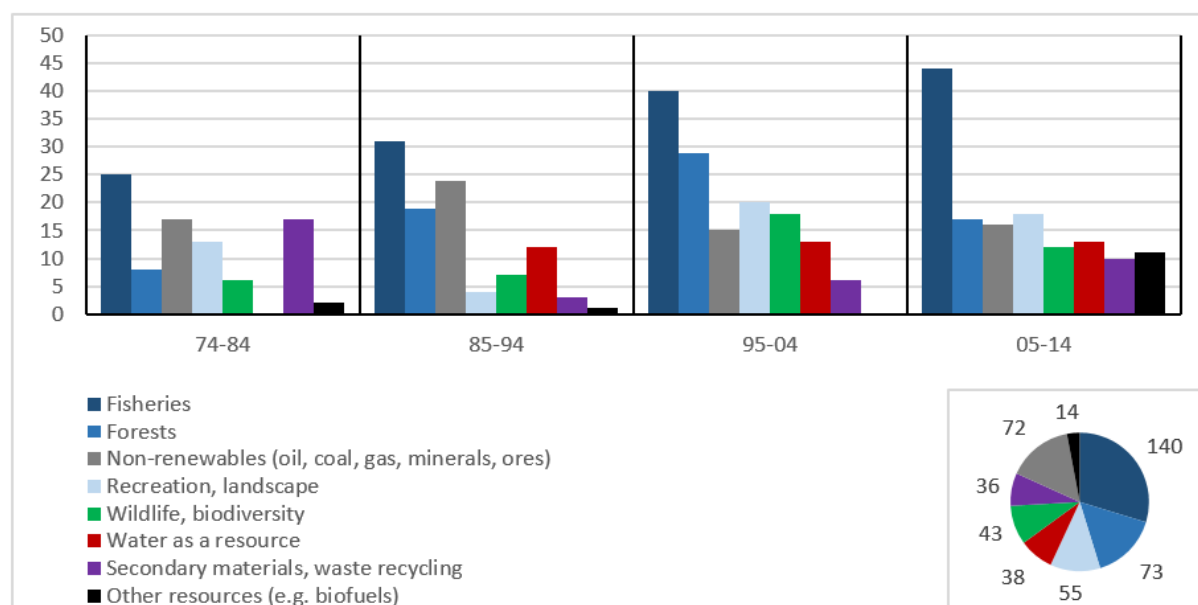
Figure 18: Environmental media - resources (multiple per article possible, N=471, p-value: 0.000)

3.4 Cross-cutting issues

Figure 19 shows that the implementation of *risk, uncertainty, imperfect information* – mostly in theoretical models - is the cross-cutting category most frequently applied in the journal.
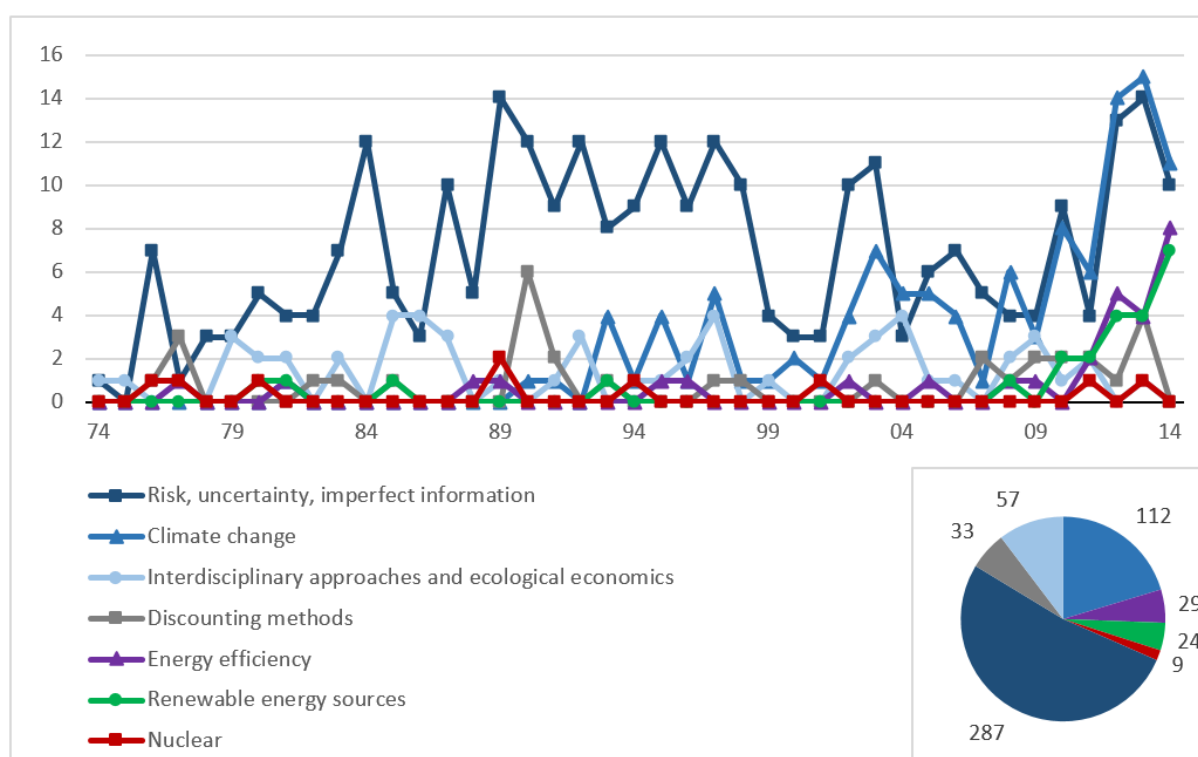
Figure 19: Cross-cutting issues (multiple per article possible, N=551, p-value: 0.000)

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Interdisciplinary approaches and ecological economics figure regularly but to less of an extent. Articles on *discounting methods,* e.g. in cost-benefit analysis, only appear sporadically. Articles pertaining to *renewable energy sources* and *energy efficiency* have become significantly more prominent in the latter decades. The same applies to *climate change* issues, suggesting a recent research orientation switch towards these interrelated fields. *Nuclear* energy issues turn up rarely and sporadically, as discussion on this topic is mainly driven by the sciences and by engineering disciplines.

3.5 Regional dimension

Most *JEEM* publications (56%) do not restrict themselves to any particular country or region (Figure 20). Of the others, 73% focus on the *U.S. and Canada*, with specific references to *other countries* remaining rare until the 1990s (19 out of 194 articles in all). Since then, *Europe* has slowly established itself as another major research region (Figure 21), while *Asia*, *Oceania*, *Latin America* and *Africa* also figure more prominently in the studies.[11] The rise of the *Chinese* economy is reflected by the greater attention accorded to it in *JEEM* articles after 2005.
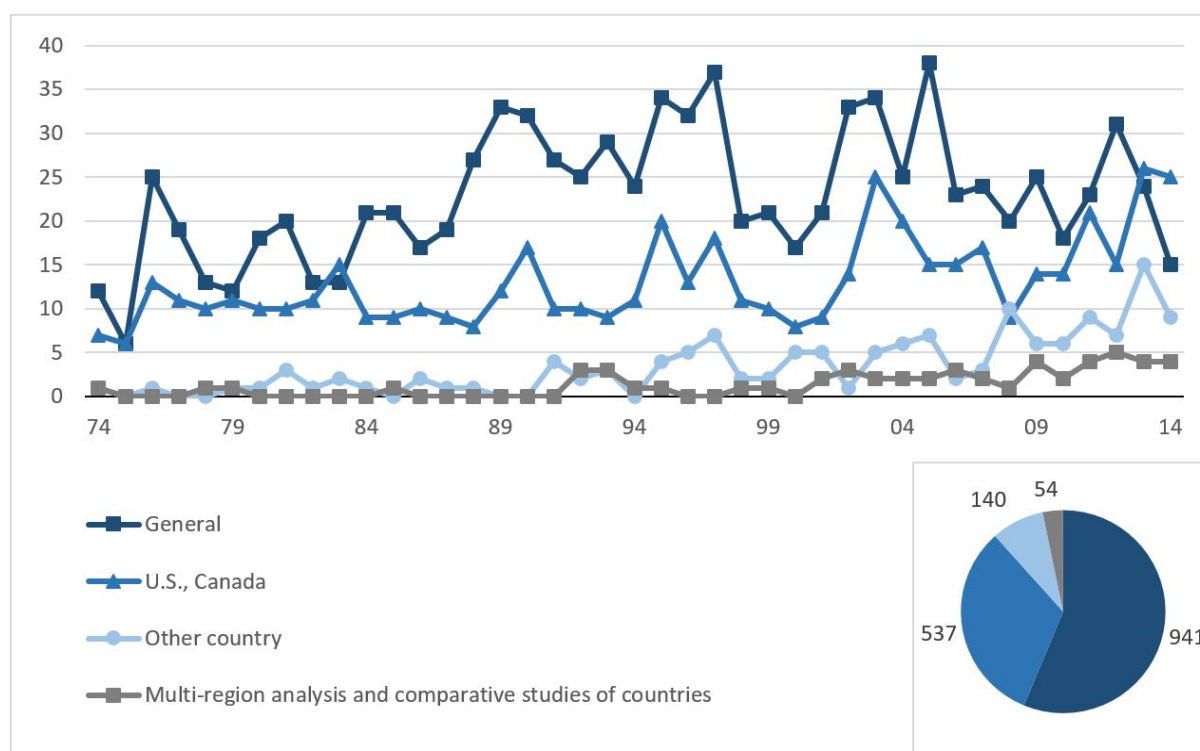
Figure 20: Regional dimension (one per article, N=1672, p-value: 0.000)

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[11] Due to scarcity of observations, the chi-squared Test is for two-decade time periods (1974-1994; 1995-2014), while *Middle East* and *Other Regions* are aggregated.
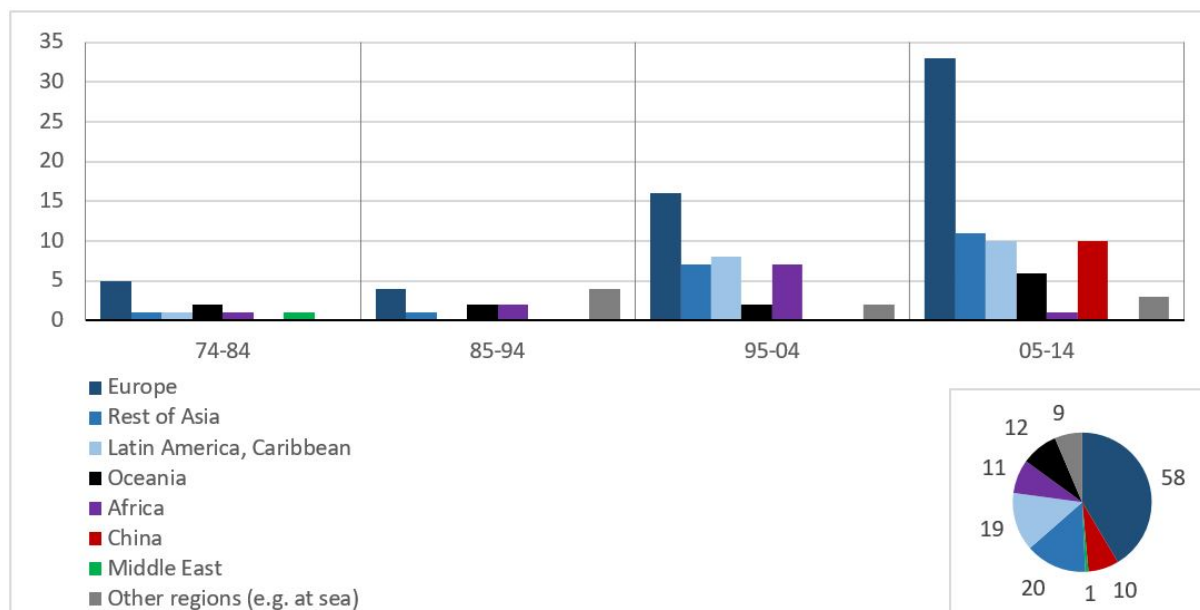
Figure 21: Regional dimension – other country (one per article, N=140, p-value: 0.008)

This concludes our descriptive statistical survey of developments in *JEEM* articles with respect to our five dimensions content, methods, environmental media, cross-cutting issues, and regions.

4. Comparison with other major field journals

After the in-depth analysis of *JEEM* content in the previous section, we now transfer the classification scheme to other publications pertaining to environmental and resource economics. We were investigating the dimensions that shape the perception of a journal within the research community and whether a journal is particularly associated with certain research areas. For that purpose, we selected the five major field journals dealing with environmental and resource economics. We implemented the same procedure as for *JEEM* and undertook our classification with respect to the five categories presented in section 2. However, due to resource constraints we restricted our comparison to the 100 most frequently cited articles per journal from the Reuters Web of Science citation count. This creates a certain bias, as some topics may attract more attention than others, and it does not precisely reflect journal policy. However, it may still be a reasonable proxy for characterizing different environmental and resource economics journals. The journals selected are:

- *Journal of Environmental Economics and Management* (*JEEM*)
- *Ecological Economics* (*EE*)
- *Environmental & Resource Economics* (*ERE*)
- *Land Economics* (*LE*)
- *American Journal of Agricultural Economics* (*AJAE*)

Since it was only founded in 2013, we did not include the *Journal of the Association of Environmental and Resource Economists (JEARE)*.

Again we made use of the non-parametric chi-squared test. A significant p-value states that the appearance of sub-categories varies significantly across the 100 most cited articles of the five journals. Before we show the results obtained by applying the classification scheme, we briefly compare the citation time frame for each journal's most successful publications.

4.1 Time dimension

For a better understanding of the time dimension, we analyzed the publication and citation years of the respective articles. Figure 22 illustrates the distribution of the publication years among each journal's 100 most cited articles. The year of a journal's foundation is given in parentheses in the caption. The graph for the journal subsamples suggests that there are two categories, the more firmly established economics field journals *AJAE*, *LE*, and *JEEM* over and against the younger journals *EE* and *ERE*.
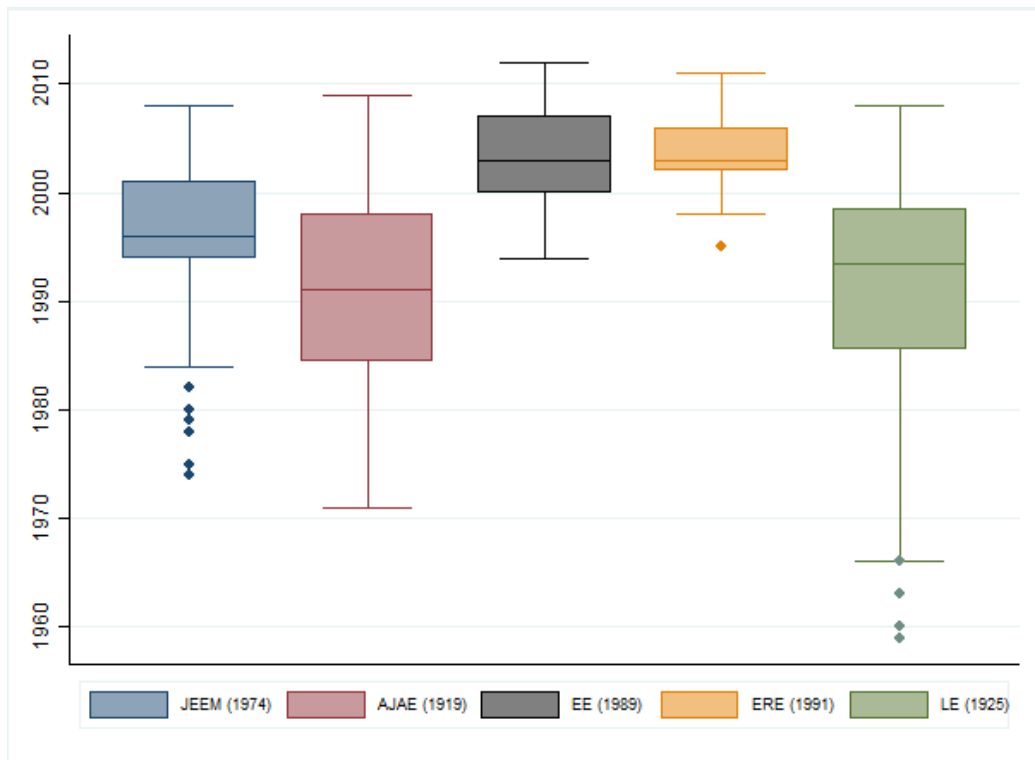
Figure 22: Distribution of the publication years of the 100 most cited articles per journal. The journals' foundation years are given in parentheses.

The next step was to count the number of citations for each journal and publication. Accordingly, Figure 23 provides some insight into the most influential eras of each journal by means of the citation count per journal publication year. To take account of the shorter periods of existence for *EE* and *ERE* - and hence more cited publications per year in the last two decades - we divide the yearly citation sum by the amount of articles per year for each journal. The most cited articles from *AJAE*, *JEEM*, and *LE* show almost equal distribution over time, with important *LE* articles figuring from as early as 1959 onwards. *JEEM* has a peak in the mid-1990s, *AJAE* in the 1980s. The 2000s show large citation counts especially for *EE* and to a lesser extent for *ERE*. We now move on to the results obtained from applying the classification scheme.
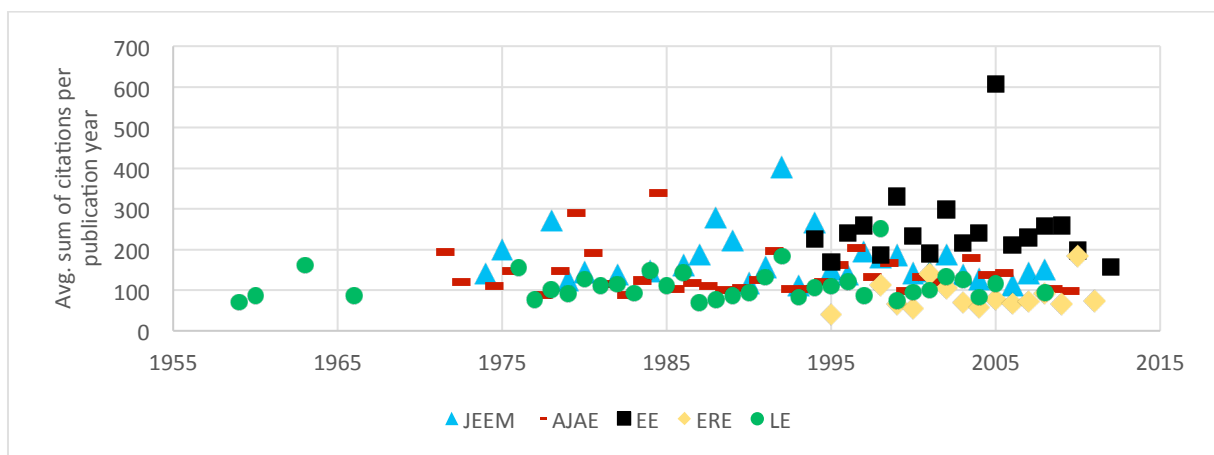
Figure 23: Average sum of citations per publication year among journals 100 most cited articles.

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4.2 Content

The content groups of the 100 most cited articles for the five journals are shown in Figure 24. Except for *AJAE* with its focus on *natural resource economics*, the research areas *costs and benefits of pollution control, non-market valuation* receive a large number of citations in the leading field journals. This is in line with the finding by Polyakov et al. (2017) that 'Nonmarket valuation', 'Recreation and amenity', and 'Conservation' are *ERE*'s most frequently cited topic groups. It also confirms the finding by Costanza et al. (2016) that 'Valuation' is the second most frequently published article subject in *EE* between 2004-2014. Besides *costs and benefits of pollution control, non-market valuation*, the most frequently cited articles in *EE* focus on *international economics, innovation, and growth* issues such as international pollution problems and aspects of technological adaptation. The most cited articles on the *analysis of environmental policy instruments* are to be found in *JEEM* and to a lesser extent in *ERE*. While our count for *analysis of environmental policy instruments* in *EE*'s 100 most cited articles is middling, Costanza et al. (2016) report 'Social aspects' and 'Environmental policy and governance' as the most frequently and third-most-frequently counted themes respectively in *EE* between 2004 and 2014. A chi-squared test indicates that *Climate change economics* figures much more prominently in *ERE* than in other journals.
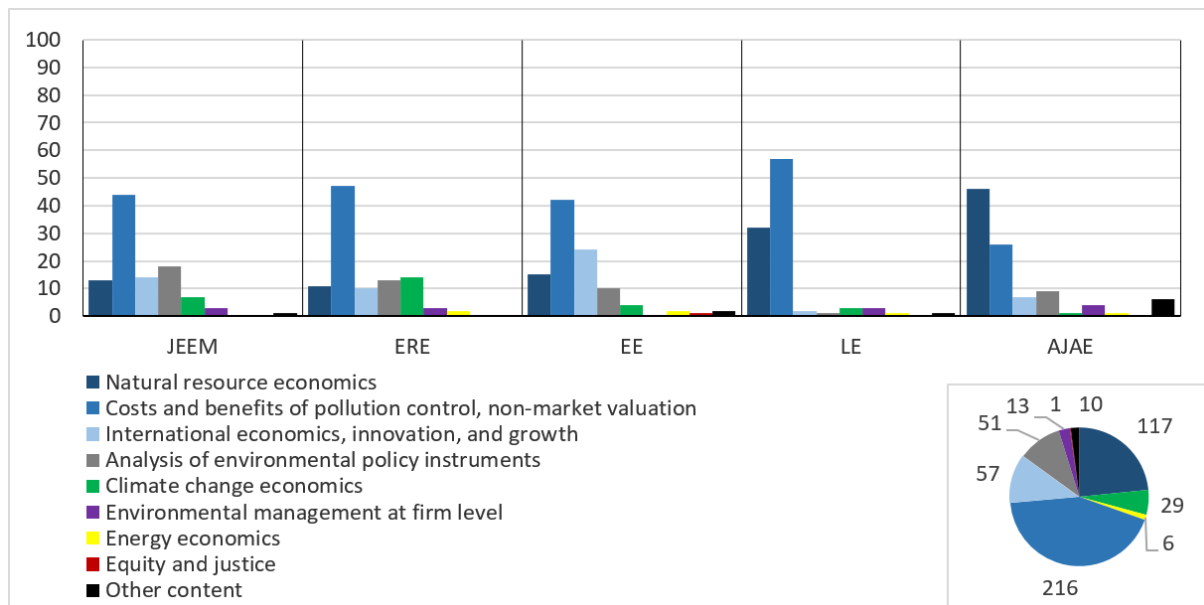
Figure 24: Articles grouped by content (one per article, N=500, p-value: 0.000)

Given the importance of *costs and benefits of pollution control, non-market valuation* studies, Figure 25 provides an additional analysis of the sub-categories grouped under this heading. Among the most frequently cited assessments in *JEEM* and *ERE* are *general, methodological improvements,* whereas *applied cases* dominate in the other journals. Another factor in the significant difference (p-value: 0.000) across journals is the number of applications to *land degradation,* which are more common in *LE* and *EE*, plus the relatively high number of studies on *biodiversity loss* in *EE.* Analyses on *air pollution* are mostly found in the 100 most cited articles from *JEEM*.
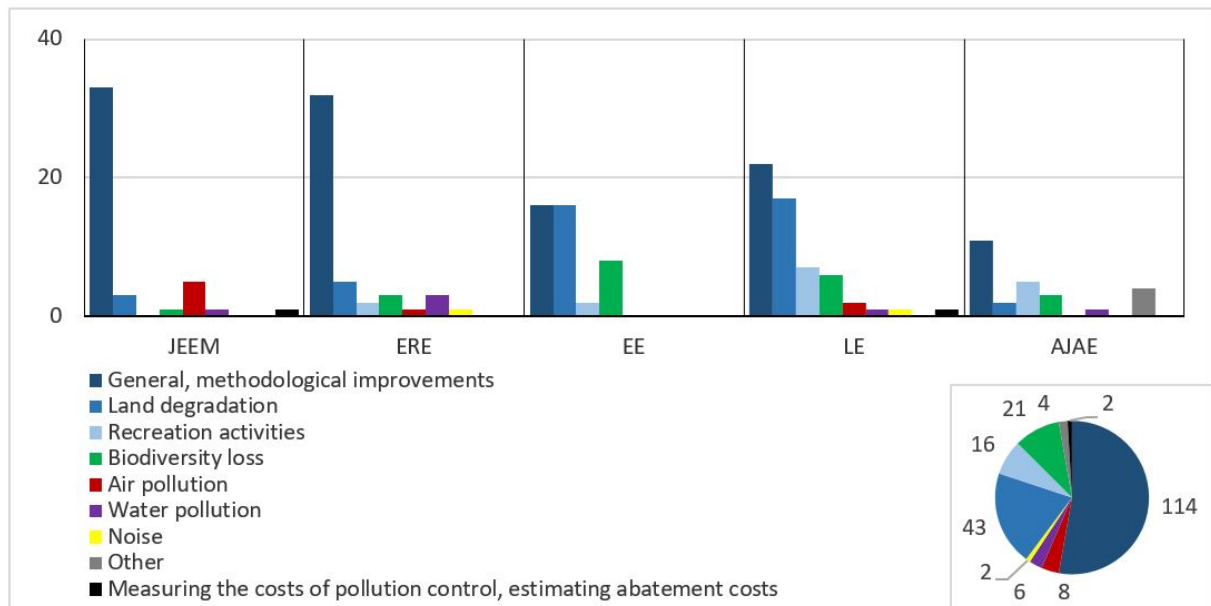
Figure 25: Costs and benefits of pollution control, non-market valuation (one per article, N=216, p-value: 0.000)

4.3 Methods

Figure 26 shows us the methodological range and mix across the journals' most cited articles. A high proportion of *econometric and statistical methods* is common to all journals, especially *AJAE*. *Theoretical* models rank second overall, figuring especially prominently in *JEEM*.
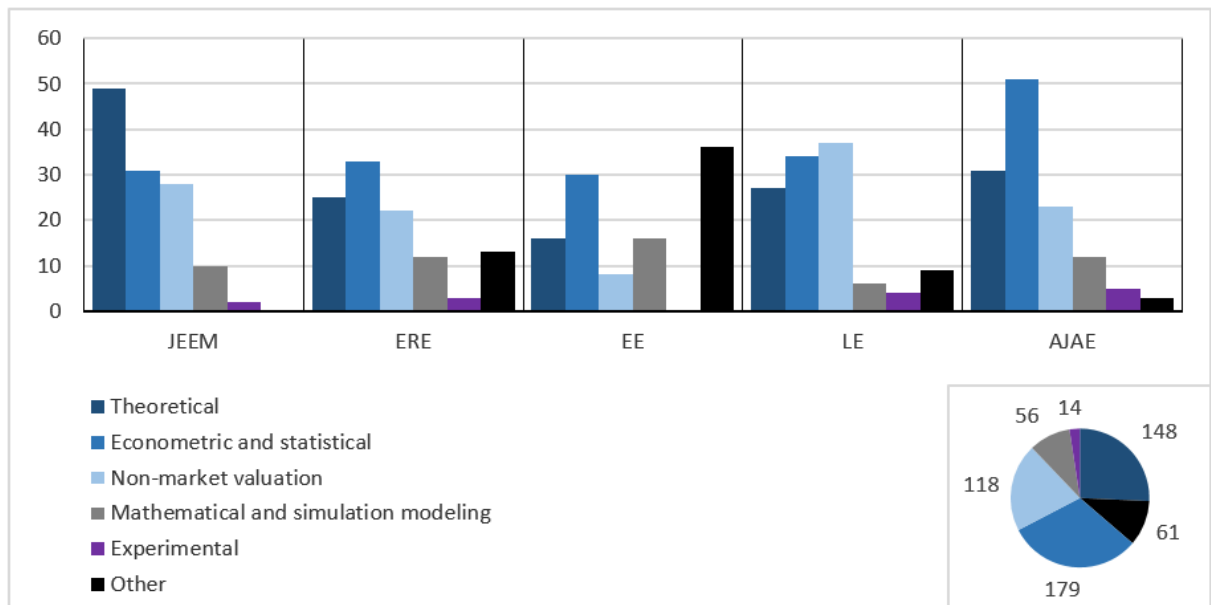
Figure 26: Methods utilized for analysis (multiple per article possible, N=576, p-value: 0.000)

All in all, *non-market valuation* achieves an almost equal rank. It is the commonest methodology in *LE*, but also plays an important role in *JEEM*. As Costanza et al. (2016) also point out, 'Statistical/econometric' methods make an insignificant showing in *EE*. We display the *other theory* category separately, given the large number of descriptive treatments and literature reviews among the articles cited from *EE*. *Mathematical and simulation modeling*

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(including input-output and CGE models) are used in 11% of the articles, for instance in *EE,* where most applications consider the ecological footprint concept. *Experiments* are an emerging method and hence the least widely represented among the 100 most cited articles, with a degree of prominence in *AJAE* and *LE.* Along with *JEEM*, these latter journals display the largest overall number of methodological combinations.

4.4 Environmental media: pollutants and resources

The majority of frequently cited articles in the five journals deals with specific resources or - to a lesser extent - to externalities (*air, water* or *land pollution*) rather than falling under the *none* option (Figure 27). Among externalities, *air pollution and greenhouse gases* are the most common. Unsurprisingly, articles cited from *LE* are fairly often concerned with *land pollution* issues. *Water* and *other pollution* are of minor importance. The most frequently cited articles in *EE*, *LE*, and *ERE* also focus on specific *resources*.
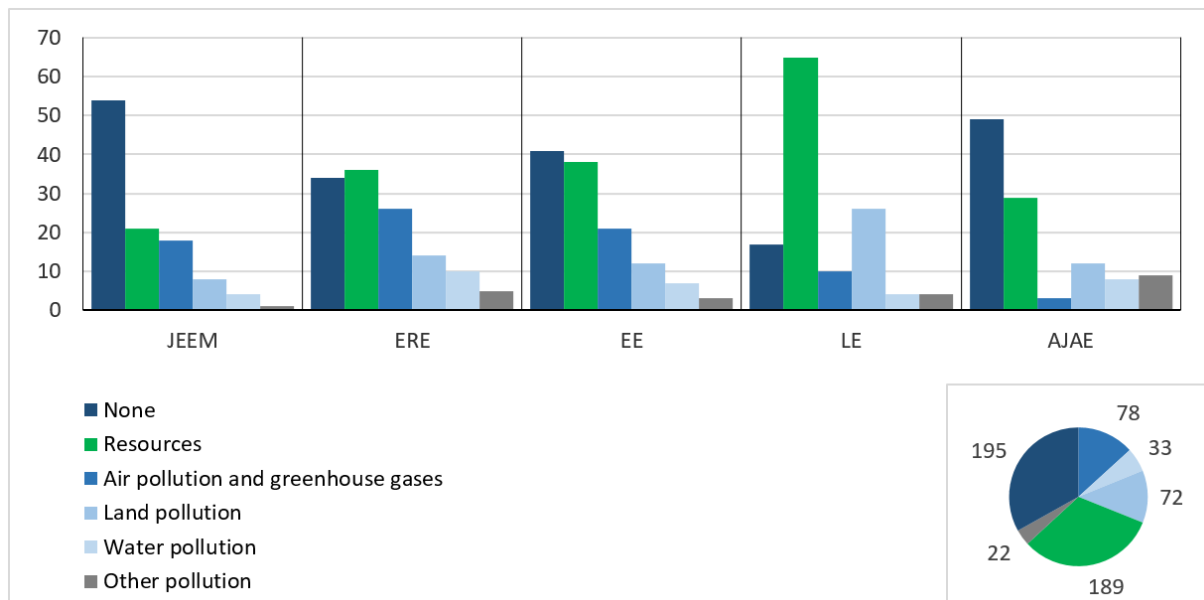
Figure 27: Environmental media: pollutants and resources (multiple per article possible, N=589, p-value: 0.000)

4.5 Cross-cutting issues

Results for cross-cutting issues vary significantly across journals. Unsurprisingly, we find a large number of *interdisciplinary and ecological economics approache*s in *EE* (Figure 28). Since this category comprises ecosystem services, we are in line with Costanza et al. (2016) in finding that in terms of the citation count this category is the most significant subject matter in *EE*. A high count for *ERE* is also in line with Polyakov et al. (2017), who register an increasing number of citations for *ERE* articles on 'Conservation', including ecosystem services. A further significant contribution to the diversity thus observed stems from the focus of many *AJAE* articles on *risk, uncertainty and imperfect information*, for instance in the context of crop cycle planning or pesticide use by farmers. *JEEM* and *ERE* also score significantly in this category. Furthermore, *ERE* is not only a major platform for all energy-related issues (energy *efficiency*, *renewable energy sources* and *nuclear*) but also the leader

in references to *climate change*. Among the most frequently cited *LE* articles cross-cutting issues do not figure prominently.
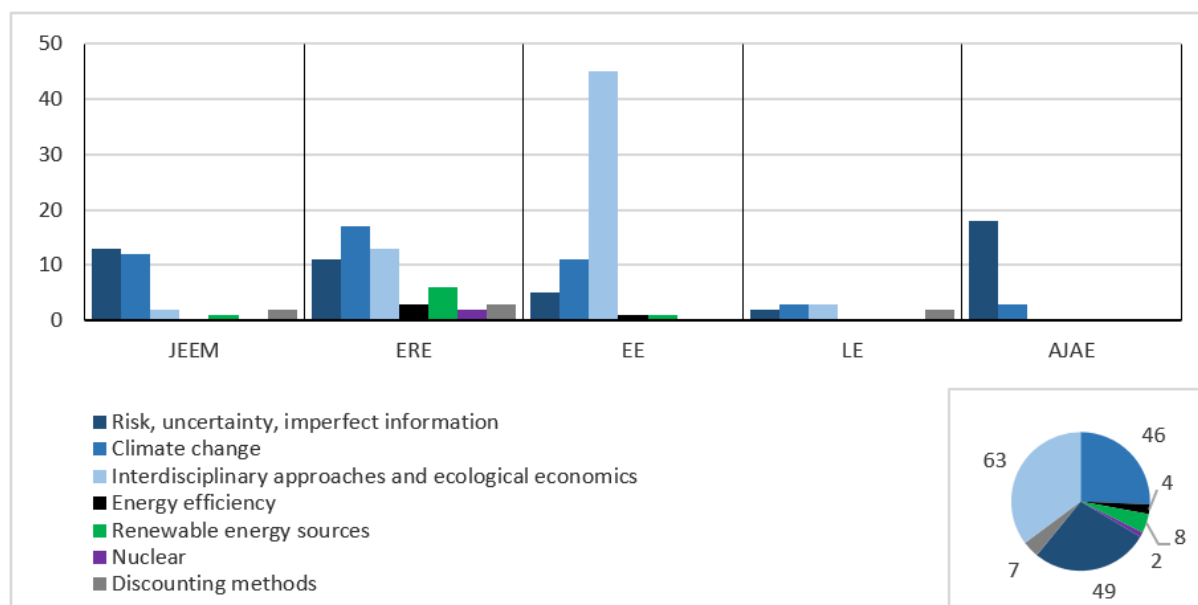
Figure 28: Cross-cutting issues (multiple per article possible, N=179, p-value: 0.000)

4.6 The regional dimension

More than 70% of the frequently cited articles in *AJAE* and *LE* are related to specific regions (Figure 29), which applies to only about half of the corresponding articles in *JEEM*, *ERE*, and *EE*. Whereas *AJAE*, *LE,* and *JEEM* are largely geared to the *U.S. and Canada*, *ERE* has also a strong focus on *Europe*. The *EE* articles most frequently cited tend either to be *general* in regional terms or to draw *multi-country comparisons*. The proportion of other regions apart from *Northern America* and *Europe* is equally low and equally mixed in all five journals. Only very few articles on *China* or *other Asian countries* are to be found among the most frequently cited articles.
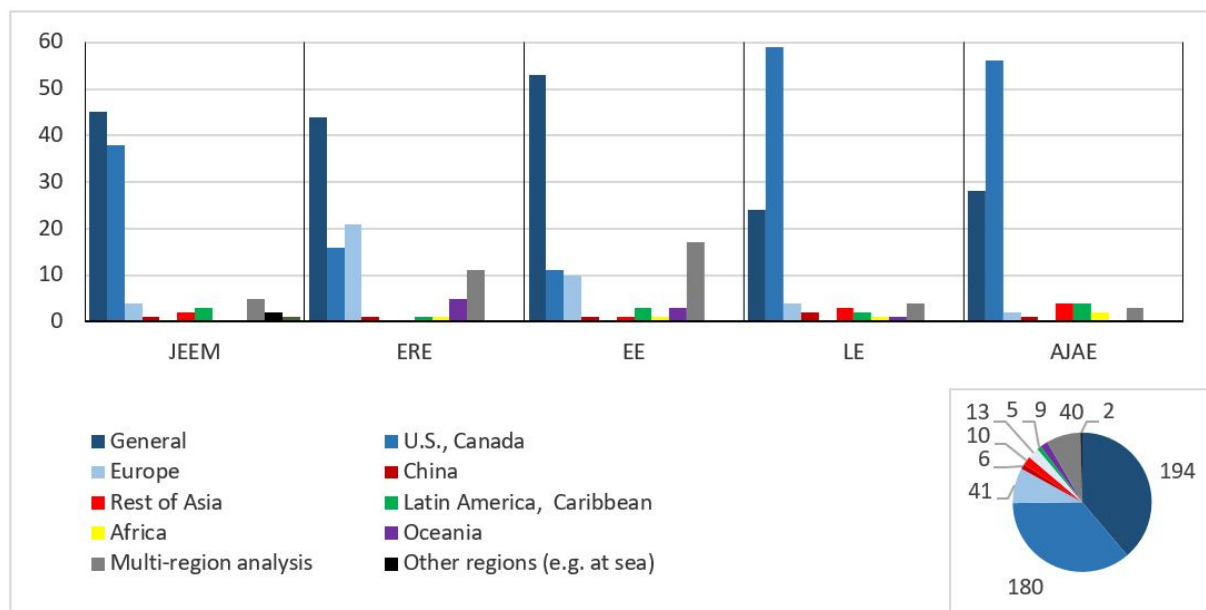
Figure 29: Regional dimension (one per article, N=500, p-value: 0.000)

5. Influence on leading general-interest economics journals

Now that we have compared the subject matter in *JEEM* with that of other major environmental economics journals, we look at the presence of *JEEM* articles in the five most renowned general-interest economics journals. In line with the rankings customarily accorded to them in the literature, [Combes and Linnemer (2010), Kalaitzakidis et al. (2001, 2010), Engemann and Wall (2009)], these are commonly referred to as *A+ journals.* Using OLS and ML estimation, we identify article categories that significantly correlate with citation by A+ journal articles. The A+ journals we consider are:

- *American Economic Review*
- *Econometrica*
- *The Journal of Political Economy*
- *The Quarterly Journal of Economics*
- *The Review of Economic Studies*

To measure the impact on these journals, we handsearched the citation list for each *JEEM* article on *Science Direct* to identify citations in articles from A+ journals and the publication year of those A+ articles.

This approach is comparable to the definition of "outward influence" by Costanza et al. (2016) in their study of the most influential publications of the journal *Ecological Economics* in terms of total citations. However, our study differs in that we only count citation in A+ journal articles as the quality measure for article diffusion in the overall field of economics.[12]

5.1 Citation count

Of all 1672 articles published in *JEEM* between 1974 and 2014, a total of 162 articles (10 %) are referred to at least once in the articles assembled in an A+ journal. The sum of citations is 218. While studies from the first decade show the lowest degree of diffusion into A+ journals (one to three articles per year), an increasing number of references to articles published since the late 1980s suggests that there is now a broader interest in environmental and resource issues in economics as a whole (Figure 30). The majority of A+ cited *JEEM* articles were published during the 1990s, and citations remain at a more or less comparable level during the first decade of the 21st century. More recently published articles may suggest a lower citation rate as the diffusion process exhibits some delay. Despite increasing diffusion, only 37 of the 162 A+ cited *JEEM* articles (23%) are cited more than once by A+ articles, most of them dating from the 1990s and 2000s. The average number of

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[12] One problem in measuring A+ citations arises when instead of referring to articles in a journal, the A+ citations refer to work papers published previously rather than to the article version later published in *JEEM*. To obviate this measurement error, we selected a random sample of at least 10 *JEEM* articles per given year and searched for a corresponding work-paper version via Ideas/RePEc, Google Scholar, ISI Web Of Science as well as the CVs published by authors on their institution websites. We were able to detect work papers on the internet from the year 1995 onwards, but not for previous years. In all we checked 190 *JEEM* articles. For 103 of them we were unable to track down online-published work papers. Of these, 14 were cited in A+ articles, and we consider these cases to be A+ citations of the respective *JEEM* article in our dataset. However, only in 4 of the 103 cases was the work paper cited in the A+ articles without reference to the respective *JEEM* article version. Accordingly, we neglect the eventuality of this posing a potential threat to the accuracy of the analysis.

A+ citations among the A+ cited articles is 1.35, which is why we prefer a binary dependent variable to count data for the regressions in section 5.2.
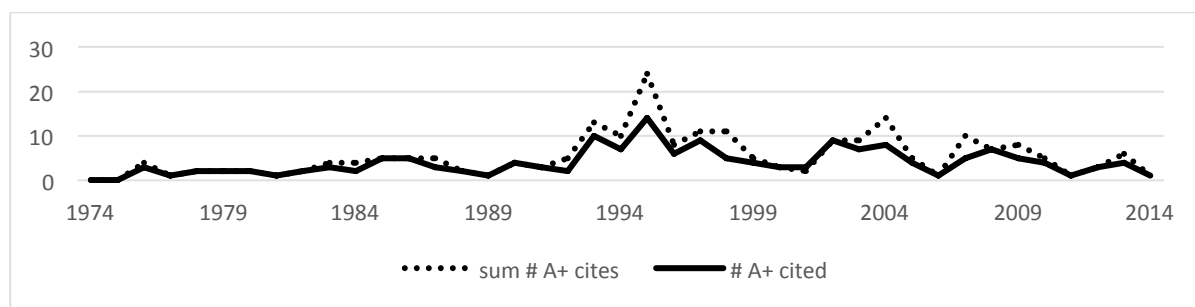
Figure 30: Number of A+ cited articles and sum of A+ citations (reflecting more than one A+ citation per A+ cited article)

In a next step, we establish a time-link between the publication year of citing A+ journal articles and the publication year of the cited *JEEM* articles. Figure 31 shows *JEEM* publication years on the x-axis, while the y-axis shows the publication year of the A+ article containing the citation.[13] Surprisingly, *JEEM* articles were not cited in A+ articles before 1996. This year constitutes a turning point for the journal's importance within the economics world. A large share of citations take place in the 21st century (176 out of all 218 A+ citations [81%] are above the 1999 line). Counting the total cites per decade of *JEEM* publications yields 9 citations for articles from the 1970s and 31 for the 1980s. The 1990s as the journal's most influential phase for the general economics world show 96 citations. There are 82 references to 21st century articles.
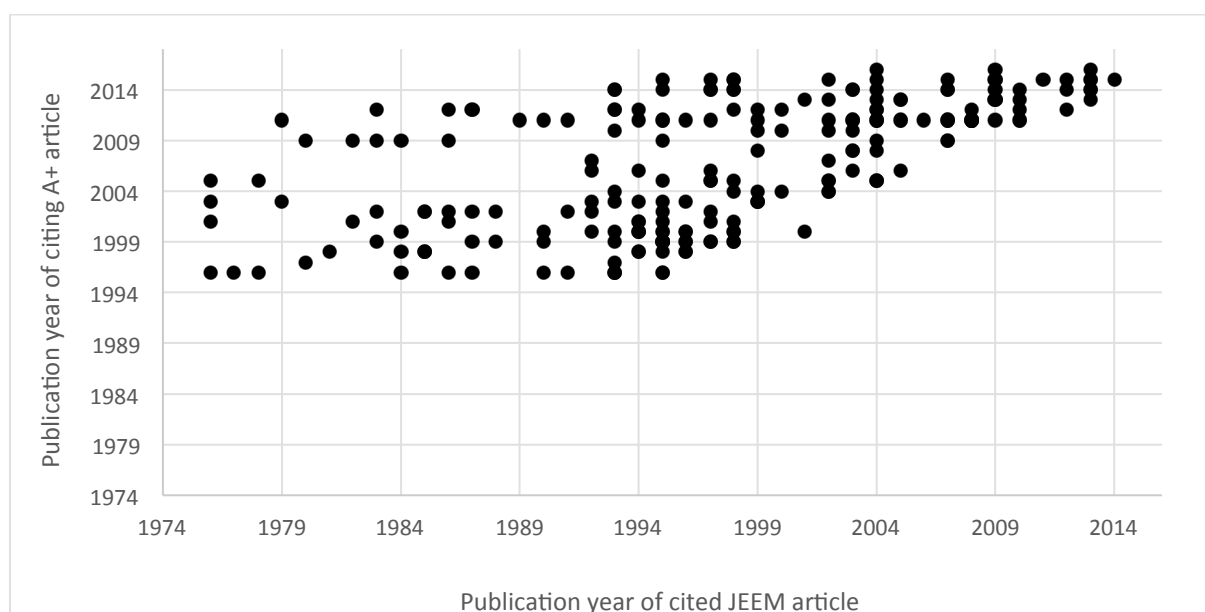
Figure 31: Year of publication in JEEM *and year of citation by A+ articles*

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[13] The graph does not display cases where there is more than one A+ article from year X citing a *JEEM* article from year Y.

In Figure 32 we take the opposite course and display the average time lag in years before the first A+ citation for A+ cited articles from each *JEEM* publication year.[14] Since the year 2000, the average delay before A+ citation is less than 10 years and steadily decreases to less than 5 years by 2014. Environmental economics seems to be not only of increasing importance for the economics world in this century, its diffusion rate also appears to be speeding up.[15]
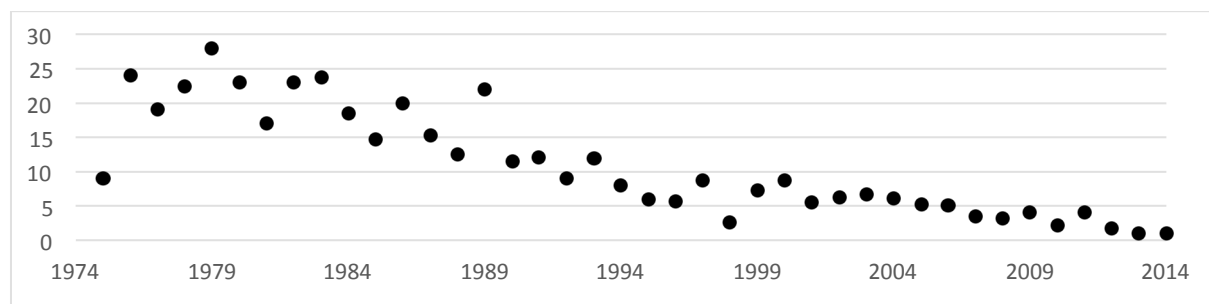
Figure 32: Average number of years before first A+ citation (x-axis: publication year in JEEM, y-axis: average delay until first A+ citation)

5.2 Assessing the importance of article dimensions for A+ citation probability

After describing the overall *JEEM* citation patterns encountered in A+ journals, we now investigate the way in which article dimensions correlate with external influence as expressed by A+ citation status. Of all the 1672 articles, there are 162 cited by A+ journals for which the dependent variable is equal to one. We have aggregated most sub-categories since many of them contain only a few A+ cited articles. Another reason for aggregation is the collinearity issues that may arise, say, when the content is *fishery* and the classification under environmental media is *fish* as a resource.

We include explanatory dummy variables for content (16), methods (5), environmental media: pollutants & resources (6), cross-cutting issues (5), regional dimension (5), and decades (3) to absorb unobservable influence over time. Finally, we also control for the number of pages per article. Since only dummy variables enter the model (except for the number of pages), we have to omit baseline cases for each dimension. We chose a highly representative article (based on the relative proportion of categories among all *JEEM* articles, see Appendix A) that was published in the journal's most recent decade (2005-2014) with *costs and benefits of pollution control*, *non-market valuation – general methodological improvements* as the baseline category in the content dimension, no cross-cutting issues involved, with a *static theory model* as method, and with neither a particular environmental medium (option *none*) nor a particular regional dimension *(*option *general).*

We used OLS and Maximum Likelihood (Probit and Logit) to test the model for robustness of results (Table I). Generally speaking, the linear probability model and ML estimation deliver congruent results for the significant factors. In terms of content, only the category *market-based approaches and policy comparisons* shows a positive and significant effect in all three

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[14] Again, we only include data for *JEEM* articles that have been cited in A+ articles.

[15] However, since we also count A+ citations relating to the work-paper versions of articles, one possible explanation could be that these versions are available earlier than official publications and thus reduce the time-lag before citation.

models, increasing the probability for A+ citation (other things being equal) by about 10% compared to the baseline case. *Other natural resources* shows positive coefficients that are significant only in the OLS and Probit model and only at the ten percent significance level. Despite its growing importance, *climate change economics* shows no significant correlation with A+ citation. The same holds for all cross-cutting issues, which is surprising given the growing general interest in *interdisciplinary approaches and ecological economics*. As for methods, there are consistently significant coefficients for *econometric and statistical methods* and especially *experimental methods* that imply a positive effect compared to *theoretical models*. *Non-market valuation methods,* on the other hand, shows no significant effect in any of the three estimation models. Among studies that investigate particular environmental media, the probability for A+ citation is only significantly larger than for articles without reference to particular environmental media in the cases of *air pollution and greenhouse gases*. We find a negative correlation for *water pollution* and *other pollutants* (such as pesticides) at a high significance level of one percent. The coefficients for the regional dimension suggest that a specific regional context is not relevant for A+ citation. The estimates confirm the graphical evidence that *JEEM*'s second and third decades were the most influential ones for the economics world. One final observation is that A+ cited articles tend to have slightly more pages than the average *JEEM* article.

One potential source of endogeneity may be the eventuality of *JEEM* article (co-) authors later publishing an A+ article and citing the previous *JEEM* article therein. In that case, the explanatory power of our classification for A+ citation probability might be affected. Accordingly, we refer to cases as "pure self-citation" where the only A+ citation stems from an A+ article by the author (or one of the co-authors) of the *JEEM* article cited. We have not counted them as A+ citations in columns 4-7 of Table I, thus reducing the number of A+ cited articles by 15 from 162 to 147 (-9%). In principle, the coefficients indicate robustness in the estimation results. However, the effect for the investigation of *air pollution and greenhouse gases* becomes insignificant in both the Probit and the Logit models. The marginal effect of a *multi-country dimension* or a *European* context is significant at the ten-percent level in the ML models.

Table I: Regression of A+ citation status on (aggregated) article classification categories.

Dependent Variable:	A+ citation			A+ citation, excluding self-citation		
	OLS	Probit	Logit	OLS	Probit	Logit
Content						
NRE RENEWABLES	0.034	0.036	0.041	0.028	0.03	0.037
NRE NON-RENEWABLES	0.058*	0.08	0.082	0.060*	0.077	0.082
NRE OTHER	0.106*	0.146*	0.155	0.110**	0.144*	0.159
CLIMATE CHANGE ECS.	0.071	0.095	0.091	0.077	0.103	0.102
ENERGY ECONOMICS	0.066	0.074	0.082	0.07	0.086	0.092
CBA/NMV APPLIED	0.050*	0.054	0.057	0.041	0.044	0.049
CBA/NMV COST EST.	-0.011	-0.012	-0.003	0.006	0.006	0.016
INT. ECS, INN., GROWTH	0.041	0.053	0.057	0.04	0.051	0.056
EPI C&C, STANDARDS	-0.018	-0.026	-0.016	-0.028	-0.035	-0.027
EPI MARKET-BASED	0.090***	0.108**	0.111**	0.088***	0.102**	0.109**
EPI POLITICAL ECON.	-0.006	-0.013	-0.018	-0.003	-0.007	-0.01
EPI ENV. BEHAVIOUR	0.027	0.044	0.041	-0.008	-0.001	0.004
EPI OTHER	0.016	0.021	0.014	0.023	0.028	0.025
FIRM LEVEL MGMT.	0.018	0.027	0.033	-0.002	-0.007	0.007
OTHER	0.094	0.131	0.13	0.105	0.144	0.146
Method						
ECONOMETRIC	0.066**	0.069**	0.065**	0.053**	0.050**	0.047*
NON-MARKET VALUAT.	0.018	0.028	0.028	0.005	0.01	0.014
SIMULATION MODELS	-0.001	0.003	0.006	-0.022	-0.017	-0.014
EXPERIMENTAL	0.157**	0.164**	0.160**	0.127**	0.128*	0.122*
Pollutant & Media						
AIR POLLUTION & GHG	0.059**	0.049*	0.046*	0.049*	0.039	0.036
WATER	-0.068***	-0.055***	-0.050***	-0.048**	-0.040**	-0.036**
LAND	0.028	0.023	0.026	0.023	0.018	0.02
PEST & OTHER	-0.065**	-0.057***	-0.054***	-0.053*	-0.046**	-0.044**
RESOURCES	-0.012	-0.011	-0.013	0.004	0.002	0
Cross-cutting issues						
ENERGY ISSUES	0.009	0.014	0.013	-0.016	-0.012	-0.006
RISK & UNCERTAINTY	-0.008	-0.005	-0.006	-0.018	-0.015	-0.014
DISCOUNTING	0.063	0.069	0.074	0.037	0.042	0.042
INTERDISCIPLINARY	0.039	0.051	0.044	0.019	0.029	0.022
Regional dimension						
US & CANADA	0.017	0.017	0.013	0.02	0.021	0.015
EUROPE	-0.038	-0.039	-0.038	-0.038	-0.048*	-0.046*
MULTI-COUNTRY	-0.059	-0.041*	-0.034	-0.061	-0.038*	-0.034*
OTHER COUNTRY	-0.047	-0.033	-0.031	-0.047	-0.03	-0.03
Other factors						
DECADE 74-84	0.007	-0.002	-0.002	0.005	-0.003	-0.002
DECADE 85-94	0.071***	0.077***	0.075***	0.068***	0.073***	0.071***
DECADE 95-04	0.078***	0.078***	0.073***	0.075***	0.075***	0.069***
NO. OF PAGES	0.003*	0.002*	0.002*	0.003*	0.002*	0.002*
Adj./Pseudo R-squared	0.093	0.093	0.093	0.056	0.097	0.095
Prob > F , Prob > Chi^2	0.00	0.00	0.00	0.00	0.00	0.00

*Coefficients for Probit/Logit are marginal effects (mfx). N=1672. (p-values: *** <0.01, ** < 0.05, *< 0.1)*

6 Conclusions

In this paper we have indicated the most important trends observable in *JEEM* from 1974-2014 and provided a detailed investigation of the environmental and resource economics research published by the journal in that period. The same classification scheme was also applied to the 100 most frequently cited articles in four other major journals in the subfield. Graphs and diagrams illustrate the content, research methods, environmental media, cross-cutting issues, and the regional dimension of the articles and provide insights into shifts of emphasis within each category.

The assessment points up the changes both in *JEEM* and in the environmental and resource economics subfield as the 21st century approaches, indicating greater content diversity and a shift in research emphasis towards issues posed by climate change and energy usage. The changing complexion of methodological approaches reveals not only the increasing importance of statistical approaches and non-market valuation applications, but also the increasing popularity of experimental methods. Despite a growing focus on greenhouse gases, *JEEM* remains a prime discussion platform for all forms of environmental media and pollution, especially natural resources. Moreover, applications to specific regional contexts seem to have become the standard case for future research. The diffusion of environmental economics research into major general-interest economics (A+) journals and the attendant influence exercised by the characteristics of *JEEM* articles shows that only a small selection of factors appear to be relevant, among them *market-based approaches and policy comparisons*, *econometric and statistical methods,* and *experimental* approaches, as well as cases of externalities from *air pollution and greenhouse gases*.

Speculating on future trends, we would first expect there to be an increasing proportion of papers dedicated to environmental problems in developing countries and countries in transition. Emerging economies will be of special importance as in these countries economic development goes hand in hand with improved data availability. Secondly, we anticipate a larger number of empirical papers using Big Data, especially on behavior by firms and households. Third, the availability of GIS and satellite data will help to locate pollution sources. High-frequency ambient pollution data can be used to recover emissions from both point and non-point sources, and the combination of different kinds of data (economic, geographic, biological and the like) may help different disciplines to hitch up together and make interdisciplinary work a more tangible proposition. Fourth, there is a general trend away from lab and towards field experiments when addressing practical issues posed by policy design. However, we do not know whether field experiments will ultimately prevail as they are expensive to conduct and institutional and ethical rules will limit their feasibility. Finally, we expect the continued publication of theoretical papers, albeit to a smaller extent, as both new institutional settings and new behavioral models require rigorous theoretical analyses as a source of hypotheses for empirical work. As humanity approaches the planetary boundaries and has in some cases already crossed those limits due to the rapid growth of human activities (Rockström et al., 2009), the urgent need for environmental and resource economics as a discipline and for journals like *JEEM* and its competitors as research outlets could hardly be plainer.

References

Maximilian **AUFFHAMMER** (2009): The State of Environmental and Resource Economics: A Google Scholar Perspective, *Review of Environmental Economics and Policy*, 3 (2), 251-269.

David **BROOKSHIRE,** David **SCROGIN** (2000): Reflections upon 25 Years of the Journal of Environmental Economics and Management, *Journal of Environmental Economics and Management*, 39, 249-263.

Richard **CARSON**, Robert **MITCHELL**, Michael **HANEMANN**, Raymond **KOPP**, Stanley **PRESSER**, Paul **RUUD** (2003): Contingent Valuation and Lost Passive Use: Damages from the Exxon Valdez Oil Spill, *Environmental and Resource Economics*, 25(3), 267-286.

Colin **CLARK**, Gordon **MUNRO** (1975): The economics of fishing and modern capital theory: A simplified approach, *Journal of Environmental Economics and Management*, 2(2), 92-106.

Pierre-Philippe **COMBES**, Laurent **LINNEMER** (2010): Inferring Missing Citations: A Quantitative Multi-Criteria Ranking of all Journals in Economics, halshs-00520325 (Online https://halshs.archives-ouvertes.fr/halshs-00520325 [29.05.2017]).

Robert **COSTANZA**, David **STERN**, Brendan **FISHER**, Lining **HE** and Chunbo **MA** (2004): Influential publications in ecological economics: a citation analysis, *Ecological Economics*, 50(3-4), 261-292.

Robert **COSTANZA**, Richard **HOWARTH**, Ida **KUBISZEWSKI**, Shuang **LIU**, Chunbo **MA,** Gael **PLUMECOCQ**, David **STERN** (2016): Influential publications in ecological economics revisited, *Ecological Economics*, 123, 68-76.

Robert **DEACON**, David **BROOKSHIRE**, Anthony **FISHER**, Allen **KNEESE**, Charles **KOLSTAD**, David **SCROGIN**, V. Kerry **SMITH**, Michael **WARD** and James **WILEN** (1998): Research Trends and Opportunities in Environmental and Natural Resource Economics, *Environmental and Resource Economics*, 11(3-4), 383-397.

Kristie **ENGEMANN** and Howard **WALL** (2009): A Journal Ranking for the Ambitious Economist, *Federal Reserve Bank of St. Louis Review*, 91(3), pp. 127-39.

Anthony **FISCHER** and Michael **WARD** (2000): Trends in Natural Resource Economics in JEEM 1974-1 997: Breakpoint and Nonparametric Analysis, *Journal of Environmental Economics and Management*, 39, 264-281.

Daniel **HAMERMESH** (2013): Six Decades of Top Economics Publishing: Who and How?, *Journal of Economic Literature*, 51(1), 162-172.

Andreas **HOEPNER**, Benjamin **KANT**, Bert **SCHOLTENS**, Pei-Shan **YU** (2012): Environmental and ecological economics in the 21st century: An age adjusted citation analysis of the influential articles, journals, authors and institutions, *Ecological Economics*, 77, 193-206.

Pantelis **KALAITZIDAKIS**, Theofanis **MAMUNEAS**, Thanasis **STENGOS** (2003): Rankings of Academic Journals and Institutions in Economics, *Journal of the European Economic Association*, 1(6), 1346–1366.

Pantelis **KALAITZIDAKIS**, Theofanis **MAMUNEAS**, Thanasis **STENGOS** (2010): An updated Ranking of Academic Journals in Economics, *The Rimini Centre for Economic Analysis Working Paper 15(10)* (Online: www.rcfea.org/RePEc/pdf/wp15_10.pdf *[31.05.2017]).*

Lea **KOSNIK** (2015): What Have Economists Been Doing for the Last 50 Years? A Text Analysis of Published Academic Research from 1960-2010, *Economics: The Open-Access, Open-Assessment E-Journal,* 9(2015-13), 1–38 (Online: http://dx.doi.org/10.5018/economics-ejournal.ja.2015-13 [31.05.2017]).

Chunbo **MA** and David **STERN** (2006): Environmental and ecological economics: A citation analysis, *Ecological Economics*, 58(3), 491-506.

Maksym **POLYAKOV**, Morteza **CHALAK**, Sayed **IFTEKHAR**, Ram **PANDIT**, Sorada **TAPSUWAN**, Fan **ZHANG** and Chunbo **MA** (2017): Authorship, Collaboration, Topics, and Research Gaps in Environmental and Resource Economics 1991–2015, *Environmental and Resource Economics*, 1-23.

Johan **ROCKSTRÖM**, Will **STEFFEN**, Kevin **NOONE**, Åsa **PERSSON**, F. Stuart **CHAPIN**, III, Eric **LAMBIN**, Timothy M. **LENTON**, Marten **SCHEFFER**, Carl **FOLKE**, Hans Joachim **SCHELLNHUBER**, Björn **NYKVIST**, Cynthia A. **De Wit**, Terry **Hughes**, Sander **VAN DER LEEUW**, Henning **Rodhe**, Sverker **SÖRLIN**, Peter K. **SNYDER**, Robert **COSTANZA**, Uno **SVEDIN**, Malin **FALKENMARK**, Louise **KARLBERG**, Robert W. **CORELL**, Victoria J. **FABRY**, James **HANSEN**, Brian **WALKER**, Diana **LIVERMAN**, Katherine **RICHARDSON**, Paul **CRUTZEN** and Jonathan **FOLEY** (2009): Planetary boundaries: exploring the safe operating space for humanity, *Ecology and Society*, 14(2), 32.

Michael **SCHYMURA** and Andreas **LÖSCHEL** (2014): Incidence and extent of co-authorship in environmental and resource economics: evidence from the Journal of Environmental Economics and Management, *Scientometrics*, 99(3), 631-661.

Jason **SHOGREN** and Garey **DURDEN** (1991): The First 15 Years: Contributors and Contributions to the Journal of Environmental Economics and Management - 1974 – 1988, *Journal of Environmental Economics and Management*, 25, 205-209.

V. Kerry **SMITH** (1981): CO_2, climate, and statistical inference: A note on asking the right questions, *Journal of Environmental Economics and Management*, 8(4), 391-394.

V. Kerry **SMITH** (2000): JEEM and Non-market Valuation: 1974-1998, *Journal of Environmental Economics and Management*, 39, 351-374.

Klaus **WOHLRABE** and Katharina **RATH** (2015): Trends in economics publications represented by JEL categories between 2007 and 2013, *Munich Personal RePEc Archive Paper*, No. 66722.

Appendix A

A.1: Classification of *JEEM* articles and presence in A+ cited articles

Category / Content	# *JEEM* articles (abs.)	# *JEEM* articles (%)	thereof: A+ cited (abs.)	thereof: A+ cited (%)
A. Natural resource economics	**450**	**27%**	**43**	**10%**
Renewable resources and conservation (Q2)	275	16%	22	8%
General, methods, demand & supply (Q20, Q21)	55	3%	5	9%
Fishery, aquaculture (Q22)	102	6%	9	9%
Forestry (Q23)	50	3%	2	4%
Land as a renewable resource and its conservation (Q24)	26	2%	1	4%
Water (Q25)	37	2%	5	14%
Applications to other areas: recreational aspects of natural resources (Q26), issues in international trade (Q27), government policy (Q28)	5	0%	0	0%
Non-renewable resources	127	8%	14	11%
General, methods, demand & supply (Q30, Q31)	68	4%	6	9%
Applications to ores	12	1%	3	25%
Applications to nonrenewable energy resources (oil, coal, gas)	17	1%	2	12%
Applications to minerals (incl. rare earth minerals)	5	0%	1	20%
Applications to biodiversity	21	1%	2	10%
Other: resources and economic development (Q32), booms (Q33), national and international conflicts (Q34), international trade (Q37), government policy (Q38), other (Q38)	4	0%	0	0%
Other natural resources	48	3%	7	15%
Secondary materials and recycling	25	1%	6	24%
Pesticide and anti-bacteria	12	1%	0	0%
Entropy laws and mass stability	7	0%	0	0%
Other	4	0%	1	25%
B. Climate change economics	**70**	**4%**	**10**	**14%**
General methods	20	1%	3	15%
Damages through climate change and adaptation	15	1%	3	20%
Mitigation of climate change	35	2%	4	11%
C. Energy economics	**50**	**3%**	**15**	**30%**
Primary energy production: resources, oil, gas, petrolium, hydropower	7	0%	0	0%
Electricity	12	1%	1	8%
Heat	1	0%	0	0%
Traffic and transport	27	2%	7	26%
Energy and the macroeconomy (Q43), energy forecasting (Q47)	3	0%	0	0%
D. Costs and benefits of pollution control, non-market valuation	**483**	**29%**	**41**	**8%**
General, methodological improvements	256	15%	17	7%
Methods applied to elicit benefits and damages in	175	10%	15	9%
Air pollution	52	3%	10	19%
Water pollution	28	2%	2	7%
Noise	3	0%	0	0%
Hazardous waste	9	1%	4	44%
Nuclear power	4	0%	0	0%

Category	Count	%	Count	%
Solid waste	5	0%	0	0%
Land degradation	21	1%	2	10%
Biodiversity loss	12	1%	2	17%
Recreational activities	41	2%	2	5%
Other	15	1%	0	0%
Measuring the costs of pollution control, estimating abatement costs	34	2%	3	9%
Other	3	0%	0	0%
E. International economics, innovation, and growth	**152**	**9%**	**13**	**9%**
Macroeconomic impacts, growth, and GDP	39	2%	3	8%
Innovation and technological change	27	2%	4	15%
International econonomic issues	74	4%	5	7%
Development issues	12	1%	1	8%
F. Analysis of environmental policy instruments	**412**	**25%**	**41**	**10%**
Command and control policies, environmental standards	59	4%	3	5%
Market-based approaches and policy comparisons	211	13%	28	13%
Liability rules	19	1%	0	0%
Environmental behavior, public goods, voluntary approaches	45	3%	2	6%
Political economy aspects	36	2%	5	11%
Other	42	3%	3	7%
G. Environmental management at firm level	**35**	**2%**	**3**	**9%**
H. Equity and justice	**9**	**1%**	**1**	**11%**
I. Other	**11**	**1%**	**2**	**18%**
Methods				
Theoretical methods	**1042**	**62%**	**83**	**8%**
Static theory (including 2-3-period models)	443	26%	38	9%
Dynamic theory, infinite horizon models	421	25%	36	9%
Theoretical foundations of non-market valuation and cost-benefit analysis	154	9%	8	5%
Other theory	26	2%	1	4%
Econometric and statistical methods (with market and other data)	**447**	**27%**	**59**	**13%**
Non-market valuation	**203**	**13%**	**19**	**9%**
Hedonic pricing	42	3%	6	14%
Other revealed preferences	55	3%	3	5%
Stated preferences (using surveys)	120	7%	10	8%
Mathematical and simulation modeling	**172**	**10%**	**16**	**9%**
Experimental methods	**50**	**3%**	**11**	**21%**
Lab experiments	43	3%	9	21%
Field experiments	9	1%	2	22%
Environmental media: pollutants & resources	0%			
Pollutants	**586**	**35%**	**66**	**11%**
Air pollution and greenhouse gases	263	16%	40	15%
Sulfur	62	4%	12	19%
NO_x	37	2%	6	16%
CO	18	1%	4	22%
PM	41	2%	11	27%
CFCs	1	0%	0	0%

Ozone	13	1%	4	31%
CO2 and general references to greenhouse gases	95	6%	12	13%
General air pollution	73	4%	10	14%
Other air pollution (e.g. VOCs)	14	1%	1	7%
Water Pollution	113	7%	5	4%
C-H compounds	9	1%	0	0%
CL compounds	1	0%	1	100%
Fertilizers	7	0%	0	0%
Solid waste	2	0%	0	0%
Heavy metals	4	0%	1	25%
General water pollution	84	5%	3	4%
Other water pollution	10	1%	0	0%
Land Pollution	146	9%	19	13%
Solid waste	46	3%	10	22%
Degradation of landscapes	63	4%	5	8%
Other land pollution (e.g. hazardous wastes)	38	2%	5	13%
Other pollutants (e.g. pesticides)	64	4%	2	3%
Resources	**443**	**26%**	**42**	**9%**
Fisheries	140	8%	13	9%
Forests	73	4%	1	1%
Recreation, landscape	55	3%	2	4%
Water as a resource	38	2%	5	13%
Wildlife, biodiversity	43	3%	4	9%
Secondary materials, waste recycling	36	2%	7	19%
Coal	15	1%	2	13%
Oil	40	2%	6	15%
Gas	15	1%	2	13%
Ores	23	1%	2	9%
Minerals	11	1%	5	45%
Other resources (e.g. biofuels)	14	1%	1	7%
None	**807**	**48%**	**66**	**8%**
Cross-cutting issues	**448**	**27%**	**49**	**11%**
Climate change	112	7%	20	18%
Energy efficiency	29	2%	5	17%
Renewable energy sources	24	1%	3	13%
Nuclear	9	1%	0	0%
Risk, uncertainty, imperfect information	287	17%	23	8%
Discounting methods	33	2%	4	12%
Interdisciplinary approaches and ecological economics	57	3%	7	12%
Regional dimension				
General, no regional dimension	**941**	**56%**	**77**	**8%**
Specific regional dimension	**731**	**44%**	**85**	**12%**
U.S., Canada	537	32%	72	13%
Europe	58	3%	2	3%
China	10	1%	1	10%

Middle East	1	0%	0	0%
Rest of Asia	20	1%	1	5%
Latin America, Caribbean	19	1%	1	5%
Africa	11	1%	0	0%
Oceania	12	1%	2	17%
Multi-region analysis, comparative studies of countries	54	3%	5	9%
Other (e.g. at sea)	9	1%	1	11%

Figures for aggregated categories (e.g. Air Pollution) are not the sum of sub-categories but the number of articles that contain at least one of the sub-categories. Thus we rule out double counting for the aggregated category, e.g. when an article refers to Sulfur and PM, it still only counts as one article on Air Pollution, not two.

Category	Journal				
Content	JEEM	ERE	EE	LE	AJAE
A. Natural resource economics	**13**	**11**	**15**	**32**	**46**
Renewable resources and conservation (Q2)	10	7	13	30	43
General, methods, demand & supply (Q20, Q21)	2	0	9	2	14
Fishery, aquaculture (Q22)	4	0	1	5	0
Forestry (Q23)	2	0	2	8	4
Land as a renewable resource and its conservation (Q24)	0	0	0	9	23
Water (Q25)	1	7	1	6	2
Applications to other areas: recreational aspects of natural resources (Q26), issues in international trade (Q27), government policy (Q28)	1	0	0	0	0
Non-renewable resources	2	2	1	2	1
General, methods, demand & supply (Q30, Q31)	1	1	0	1	0
Applications to ores	0	0	0	0	0
Applications to nonrenewable energy resources (oil, coal, gas)	0	0	0	0	0
Applications to minerals (incl. rare earth minerals)	0	0	0	0	0
Applications to biodiversity	1	1	1	1	1
Other: resources and economic development (Q32), booms (Q33),national and international conflicts (Q34), international trade (Q37), government policy (Q38), other (Q38)	0	0	0	0	0
Other natural resources	1	2	1	0	2
Secondary materials and recycling	1	1	0	0	0
Pesticide and anti-bacteria	0	1	1	0	2
Entropy laws and mass stability	0	0	0	0	0
Other	0	0	0	0	0
B. Climate change economics	**7**	**14**	**4**	**3**	**1**
General methods	2	5	3	0	0
Damages through climate change and adaptation	1	4	1	0	0
Mitigation of climate change	4	5	0	3	1
C. Energy economics	**0**	**2**	**2**	**1**	**1**
Primary energy production: resources, oil, gas, petrolium, hydropower	0	1	0	1	0
Electricity	0	0	0	0	0
Heat	0	0	0	0	0
Traffic and transport	0	0	0	0	0
Energy and the macroeconomy (Q43), energy forecasting (Q47)	0	1	2	0	1
D. Costs and benefits of pollution control, non-market valuation	**44**	**47**	**42**	**57**	**26**
General, methodological improvements	33	32	16	22	11
Methods applied to elicit benefits and damages in	10	15	26	34	15
Air pollution	5	1	0	2	0
Water pollution	1	3	0	1	1
Hazardous waste	0	0	0	0	0
Nuclear power	0	0	0	0	0
Solid waste	0	0	0	0	0
Noise	0	1	0	1	0
Land degradation	3	5	16	17	2

Biodiversity loss	0	2	2	7	5
Recreational activities	1	3	8	6	3
Other	0	0	0	0	4
Measuring the costs of pollution control, estimating abatement costs	1	0	0	1	0
Other	0	0	0	0	0
E. International economics, innovation, and growth	**14**	**10**	**24**	**2**	**7**
Macroeconomic impacts, growth, and GDP	4	6	16	2	1
Innovation and technological change	5	3	3	0	3
International econonomic issues	5	1	4	0	1
Development issues	0	0	1	0	2
F. Analysis of environmental policy instruments	**18**	**13**	**10**	**1**	**9**
Command and control policies, environmental standards	2	0	0	0	0
Market-based approaches and policy comparisons	9	7	9	1	1
Liability rules	0	0	0	0	0
Environmental behavior, public goods, voluntary approaches	0	0	1	0	0
Political economy aspects	6	6	0	0	8
Other	1	0	0	0	0
G. Environmental management at firm level	**3**	**3**	**0**	**3**	**4**
H. Equity and justice	**0**	**0**	**1**	**0**	**0**
I. Other	**1**	**0**	**2**	**1**	**6**
Methods					
Theoretical methods	**49**	**39**	**52**	**36**	**34**
Static theory (including 2-3-period models)	16	7	4	7	20
Dynamic theory, infinite horizon models	18	12	2	10	6
Theoretical foundations of non-market valuation and cost-benefit analysis	15	7	10	10	5
Other theory	0	13	36	9	3
Econometric and statistical methods (with market and other data)	**31**	**33**	**30**	**34**	**51**
Non-market valuation	**31**	**24**	**8**	**39**	**24**
Hedonic pricing	5	1	1	12	2
Other revealed preferences	3	2	1	7	5
Stated preferences (using surveys)	23	21	6	20	17
Mathematical and simulation modeling	**10**	**12**	**16**	**6**	**12**
Experimental methods	**2**	**3**	**0**	**4**	**5**
Lab experiments	2	2	0	4	3
Field experiments	0	1	0	0	2
Environmental media: pollutants & resources	**119**	**160**	**182**	**141**	**121**
Pollutants	**39**	**68**	**60**	**45**	**33**
Air pollution and greenhouse gases	26	39	35	11	3
Sulfur	5	3	5	1	0
NO$_x$	4	2	5	1	0
CO	1	1	2	0	0
PM	3	4	1	2	0
CFCs	0	0	0	0	0
Ozone	0	3	1	0	0
CO2 and general references to greenhouse gases	0	3	1	0	0

General air pollution	0	1	0	1	0
Other air pollution (e.g. VOCs)	10	18	17	3	3
Water Pollution	4	10	10	4	9
C-H compounds	1	1	0	1	0
CL compounds	0	0	0	0	0
Fertilizers	0	4	2	0	5
Solid waste	0	0	1	0	1
Heavy metals	0	0	0	0	0
General water pollution	3	4	7	3	3
Other water pollution	0	1	0	0	0
Land Pollution	8	14	12	26	12
Solid waste	1	1	0	1	0
Degradation of landscapes	2	11	11	23	12
Other land pollution (e.g. hazardous wastes)	5	2	1	2	0
Other pollutants (e.g. pesticides)	1	5	3	4	9
Resources	**26**	**58**	**81**	**79**	**39**
Fisheries	6	2	10	10	5
Forests	6	8	9	17	6
Recreation, landscape	3	9	12	28	14
Water as a resource	1	9	6	10	4
Wildlife, biodiversity	2	14	20	12	9
Secondary materials, waste recycling	2	1	0	1	0
Coal	0	3	5	0	0
Oil	1	3	6	0	1
Gas	2	3	5	0	0
Ores	2	0	1	0	0
Minerals	1	0	1	0	0
Other resources (e.g. biofuels)	0	6	6	1	0
None	**54**	**34**	**41**	**17**	**49**
Cross-cutting issues	**30**	**55**	**63**	**10**	**21**
Climate change	12	17	11	3	3
Energy efficiency	0	3	1	0	0
Renewable energy sources	1	6	1	0	0
Nuclear	0	2	0	0	0
Risk, uncertainty, imperfect information	13	11	5	2	18
Discounting methods	2	3	0	2	0
Interdisciplinary approaches and ecological economics	2	13	45	3	0
Regional dimension					
General, no regional dimension	45	44	53	24	28
Specific regional dimension	55	56	47	76	72
U.S., Canada	38	16	11	59	56
Europe	4	21	10	4	2
China	1	1	1	2	1
Middle East	0	0	0	0	0
Rest of Asia	2	0	1	3	4

Latin America, Caribbean	3	1	3	2	4
Africa	0	1	1	1	2
Oceania	0	5	3	1	0
Multi-region analysis, comparative studies of countries	5	11	17	4	3
Other (e.g. at sea)	2	0	0	0	0

Figures for aggregated categories (e.g. Air Pollution) are not the sum of sub-categories but the number of articles that contain at least one of the sub-categories. Thus we rule out double counting for the aggregated category , e.g. when an article refers to Sulfur and PM, it still only counts as one article on Air Pollution, not two.

Appendix B

B.1: Chi-squared tests for figures in section 3 (*JEEM* articles)

Key	
frequency	
expected frequency	
chi2 contribution	

Classification of content in *JEEM* articles (Figure 1)

Sub-category	Decade				Total
	1	**2**	**3**	**4**	
Natural resource economics	85	137	129	99	**450**
	80.5	102.3	128.1	139.1	**450.0**
	0.3	11.8	0.0	11.6	**23.6**
Costs and benefits of pollution control, non-market valuation	104	120	135	124	**483**
	86.4	109.8	137.5	149.3	**483.0**
	3.6	1.0	0.0	4.3	**8.9**
Climate change economics	1	5	18	46	**70**
	12.5	15.9	19.9	21.6	**70.0**
	10.6	7.5	0.2	27.4	**45.7**
Energy economics	6	6	8	30	**50**
	8.9	11.4	14.2	15.5	**50.0**
	1.0	2.5	2.7	13.7	**19.9**
Analysis of environmental policy Instruments	75	83	119	135	**412**
	73.7	93.6	117.3	127.4	**412.0**
	0.0	1.2	0.0	0.5	**1.7**
Environmental management at firm level	2	4	8	21	**35**
	6.3	8.0	10.0	10.8	**35.0**
	2.9	2.0	0.4	9.6	**14.8**
International economics, innovation and growth	18	21	54	59	**152**
	27.2	34.5	43.3	47.0	**152.0**
	3.1	5.3	2.7	3.1	**14.1**
Equity and justice / Other content	8	4	5	3	**20**
	3.6	4.5	5.7	6.2	**20.0**
	5.5	0.1	0.1	1.6	**7.3**
Total	**299**	**380**	**476**	**517**	**1,672**
	299.0	**380.0**	**476.0**	**517.0**	**1,672.0**
	26.9	**31.3**	**6.1**	**71.7**	**136.0**

Pearson chi2(21) = 136.0357, Pr = 0.000

No change in significance level even when we omit Climate Change (CCE), as it only enters appears in the third decade

Natural resource economics (Figure 2)

Sub-category	Decade				Total
	1	**2**	**3**	**4**	
Renewable resources	40	79	85	71	**275**
	51.9	83.7	78.8	60.5	**275.0**
	2.7	0.3	0.5	1.8	**5.3**
Non-renewable resources	25	48	36	18	**127**
	24.0	38.7	36.4	27.9	**127.0**
	0.0	2.3	0.0	3.5	**5.8**
Other resources	20	10	8	10	**48**
	9.1	14.6	13.8	10.6	**48.0**
	13.2	1.5	2.4	0.0	**17.1**
Total	**85**	**137**	**129**	**99**	**450**
	85.0	**137.0**	**129.0**	**99.0**	**450.0**
	16.0	**4.0**	**2.9**	**5.4**	**28.2**
Pearson chi2(6) = 28.2367, Pr = 0.000					

Natural resource economics – renewable resources (Figure 3)

Sub-category	Decade				Total
	1	**2**	**3**	**4**	
General, methods, demand & supply	13	16	11	15	**55**
	8.0	15.8	17.0	14.2	**55.0**
	3.1	0.0	2.1	0.0	**5.3**
Fishery, aquaculture	17	27	29	29	**102**
	14.8	29.3	31.5	26.3	**102.0**
	0.3	0.2	0.2	0.3	**1.0**
Forestry	4	18	21	7	**50**
	7.3	14.4	15.5	12.9	**50.0**
	1.5	0.9	2.0	2.7	**7.1**
Water	2	11	13	11	**37**
	5.4	10.6	11.4	9.6	**37.0**
	2.1	0.0	0.2	0.2	**2.6**
Land	3	5	9	9	**26**
	3.8	7.5	8.0	6.7	**26.0**
	0.2	0.8	0.1	0.8	**1.9**
Other	1	2	2	0	**5**
	0.7	1.4	1.5	1.3	**5.0**
	0.1	0.2	0.1	1.3	**1.7**
Total	**40**	**79**	**85**	**71**	**275**
	40.0	**79.0**	**85.0**	**71.0**	**275.0**
	7.3	**2.2**	**4.8**	**5.3**	**19.5**
Pearson chi2(15) = 19.5389, Pr = 0.190					

Non-renewable resources (Figure 4)

Sub-category	Decade				Total
	1	2	3	4	
General, methods, demand & supply	15	28	14	11	**68**
	13.4	25.7	19.3	9.6	**68.0**
	0.2	0.2	1.4	0.2	**2.0**
Biodiversity	3	2	11	5	**21**
	4.1	7.9	6.0	3.0	**21.0**
	0.3	4.4	4.3	1.4	**10.4**
Non-renewable energy resources	5	5	6	1	**17**
	3.3	6.4	4.8	2.4	**17.0**
	0.8	0.3	0.3	0.8	**2.2**
Minerals / ores / other	2	13	5	1	**21**
	4.1	7.9	6.0	3.0	**21.0**
	1.1	3.2	0.2	1.3	**5.8**
Total	**25**	**48**	**36**	**18**	127
	25.0	**48.0**	**36.0**	**18.0**	127.0
	2.4	**8.2**	**6.2**	**3.7**	20.5
	Pearson chi2(9)= 20.4872, Pr = 0.015				

Other natural resources is not discussed in the main body of the paper due to the small number of cases.

Climate change economics (Figure 5)

Sub-category	Decade				Total
	1	2	3	4	
General methods	-	-	2	15	**17**
	-	-	4.8	12.2	**17.0**
	-	-	1.6	0.6	**2.3**
Damages through climate change and adaptation	-	-	6	9	**15**
	-	-	4.2	10.8	**15.0**
	-	-	0.8	0.3	**1.0**
Mitigation of climate change	-	-	10	22	**32**
	-	-	9.0	23.0	**32.0**
	-	-	0.1	0.0	**0.2**
Total	**-**	**-**	**18**	**46**	64
	-	**-**	**18.0**	**46.0**	64.0
	-	**-**	**2.5**	**1.0**	3.5
	Pearson chi2(2) = 3.4519, Pr = 0.178				
	The first two decades are omitted owing to content novelty				

Energy economics (Figure 6)

Sub-category	Decade				Total
	1	**2**	**3**	**4**	
Traffic and transport	3		24		**27**
	6.5		20.5		**27.0**
	1.9		0.6		**2.5**
Electricity	1		11		**11**
	2.9		9.1		**11.0**
	1.2		0.4		**14.3**
Primary energy production /	8		3		**11**
energy and the macroeconomy,	2.6		8.4		**11.0**
energy forecasting / heat	10.9		3.4		**14.3**
Total	**12**		**38**		**50**
	12.0		**38.0**		**50.0**
	14.0		**4.4**		**18.4**

Costs and benefits of pollution control, non-market valuation (Figure 7)

Sub-category	Decade				Total
	1	**2**	**3**	**4**	
General, methodological improvements	32	81	82	61	**256**
	55.1	63.6	71.6	65.7	**256.0**
	9.7	4.8	1.5	0.3	**16.3**
Methods applied to elicit benefits and damages	62	28	46	54	**190**
	40.9	47.2	53.1	48.8	**190.0**
	10.9	7.8	1.0	0.6	**20.2**
Measuring the cost of pollution control, estimating abatement costs	10	11	7	9	**37**
	8.0	9.2	10.3	9.5	**37.0**
	0.5	0.4	1.1	0.0	**2.0**
Total	**104**	**120**	**135**	**124**	**483**
	104.0	**120.0**	**135.0**	**124.0**	**483.0**
	21.1	**12.9**	**3.6**	**0.9**	**38.5**

Costs and benefits of pollution control, non-market valuation - methods applied to elicit benefits and damages (Figure 8)

Sub-category	Decade				Total
	1	**2**	**3**	**4**	
Air pollution	25	7	8	12	**52**
	17.0	7.7	12.6	14.8	**52.0**
	3.8	0.1	1.7	0.5	**6.1**
Biodiversity loss	1	2	5	4	**12**
	3.9	1.8	2.9	3.4	**12.0**
	2.2	0.0	1.5	0.1	**3.8**
Hazardous waste	1	1	4	3	**9**
	2.9	1.3	2.2	2.6	**9.0**
	1.3	0.1	1.5	0.1	**3.0**
Land degradation	7	3	4	7	**21**
	6.9	3.1	5.1	6.0	**21.0**
	0.0	0.0	0.2	0.2	**0.4**
Noise	2	1	0	0	**3**
	1.0	0.4	0.7	0.9	**3.0**
	1.1	0.7	0.7	0.9	**3.3**
Nuclear power	1	0	1	2	**4**
	1.3	0.6	1.0	1.1	**4.0**
	0.1	0.6	0.0	0.7	**1.3**
Other	3	2	1	9	**15**
	4.9	2.2	3.6	4.3	**15.0**
	0.7	0.0	1.9	5.3	**7.9**
Recreational activities	10	5	16	10	**41**
	13.4	6.0	9.9	11.7	**41.0**
	0.9	0.2	3.7	0.2	**5.0**
Solid waste	2	1	1	1	**5**
	1.6	0.7	1.2	1.4	**5.0**
	0.1	0.1	0.0	0.1	**0.3**
Water pollution	10	6	6	6	**28**
	9.1	4.1	6.8	8.0	**28.0**
	0.1	0.9	0.1	0.5	**1.5**
Total	**62**	**28**	**46**	**54**	190
	62.0	**28.0**	**46.0**	**54.0**	**190.0**
	10.1	**2.6**	**11.4**	**8.5**	**32.7**

Pearson chi2(27) = 32.6546, Pr = 0.209

International economics, innovation, and growth (Figure 9)

Sub-category	Decade				Total
	1	2	3	4	
International economic issues	4	12	26	32	**74**
	8.8	10.2	26.3	28.7	**74.0**
	2.6	0.3	0.0	0.4	**3.3**
Macroeconomic impacts, growth, and GDP	7	5	15	12	**39**
	4.6	5.4	13.9	15.1	**39.0**
	1.2	0.0	0.1	0.7	**2.0**
Innovation and technological change	2	3	8	14	**27**
	3.2	3.7	9.6	10.5	**27.0**
	0.4	0.1	0.3	1.2	**2.0**
Development issues	5	1	5	1	**12**
	1.4	1.7	4.3	4.7	**12.0**
	9.0	0.3	0.1	2.9	**12.3**
Total	**18**	**21**	**54**	**59**	**152**
	18.0	**21.0**	**54.0**	**59.0**	**152.0**
	13.3	**0.7**	**0.5**	**5.1**	**19.6**
Pearson chi2(9) = 19.5881, Pr = 0.021					

Analysis of environmental policy instruments (Figure 10)

Sub-category	Decade				Total
	1	2	3	4	
Command and control policies, environmental standards	10	15	20	14	**59**
	10.7	11.9	17.0	19.3	**59.0**
	0.1	0.8	0.5	1.5	**2.9**
Market-based approaches, policy comparisons	47	45	57	62	**211**
	38.4	42.5	60.9	69.1	**211.0**
	1.9	0.1	0.3	0.7	**3.1**
Environmental behavior, public goods, voluntary approaches	2	6	13	24	**45**
	8.2	9.1	13.0	14.7	**45.0**
	4.7	1.0	0.0	5.8	**11.5**
Political economy aspects	6	2	15	13	**36**
	6.6	7.3	10.4	11.8	**36.0**
	0.0	3.8	2.0	0.1	**6.0**
Liability rules	4	5	4	6	**19**
	3.5	3.8	5.5	6.2	**19.0**
	0.1	0.4	0.4	0.0	**0.9**
Other	6	10	10	16	**42**
	7.6	8.5	12.1	13.8	**42.0**
	0.4	0.3	0.4	0.4	**1.4**

Total	**75**	**83**	**119**	**135**	**412**
	75.0	83.0	119.0	135.0	412.0
	7.1	6.4	3.6	8.5	25.7

Pearson chi2(15) = 25.6744, Pr = 0.042

Methods (Figure 11)

Sub-category	Decade				Total
	1	**2**	**3**	**4**	
Experimental	1	7	19	23	**50**
	8.6	11.3	14.7	15.5	**50.0**
	6.7	1.6	1.3	3.7	**13.3**
Econometric and statistical	70	61	131	185	**447**
	76.6	101.1	131.0	138.3	**447.0**
	0.6	15.9	0.0	15.8	**32.3**
Non-market valuation	23	48	73	59	**203**
	34.8	45.9	59.5	62.8	**203.0**
	4.0	0.1	3.1	0.2	**7.4**
Mathematical and simulation modeling	43	38	44	47	**172**
	29.5	38.9	50.4	53.2	**172.0**
	6.2	0.0	0.8	0.7	**7.8**
Theoretical	191	279	294	278	**1,042**
	178.6	235.7	305.4	322.3	**1,042.0**
	0.9	7.9	0.4	6.1	**15.3**
Total	**328**	**433**	**561**	**592**	1,914
	328.0	**433.0**	**561.0**	**592.0**	1,914.0
	18.3	**25.6**	**5.6**	**26.5**	76.0

Pearson chi2(12) = 76.0471, Pr = 0.000

Theoretical methods (Figure 12)

Sub-category	Decade				Total
	1	**2**	**3**	**4**	
Dynamic theory	86	110	112	113	**421**
	77.4	112.9	118.6	112.1	**421.0**
	0.9	0.1	0.4	0.0	**1.4**
Theoretical foundations of non-market valuation and cost-benefit analysis	26	52	49	27	**154**
	28.3	41.3	43.4	41.1	**154.0**
	0.2	2.8	0.7	4.8	**8.5**
Other (e.g. verbal descriptions)	9	15	2	0	**26**
	4.8	7.0	7.3	6.9	**26.0**
	3.7	9.2	3.9	6.9	**23.8**

Static theory	71	103	131	138	**443**
	81.5	118.8	124.8	118.0	**443.0**
	1.3	2.1	0.3	3.4	**7.2**
Total	**192**	**280**	**294**	**278**	**1,044**
	192.0	**280.0**	**294.0**	**278.0**	**1,044.0**
	6.2	**14.2**	**5.3**	**15.1**	**40.8**

Pearson chi2(9) = 40.7908, Pr = 0.000

Non-market valuation Methods (Figure 13)

Sub-category	Decade				Total
	1	2	3	4	
Hedonic pricing	9	12	9	12	**42**
	4.6	10.5	14.9	12.0	**42.0**
	4.1	0.2	2.3	0.0	**6.7**
Other revealed preferences	7	14	21	13	**55**
	6.1	13.7	19.5	15.7	**55.0**
	0.1	0.0	0.1	0.5	**0.7**
Stated preferences	8	28	47	37	**120**
	13.3	29.9	42.6	34.3	**120.0**
	2.1	0.1	0.5	0.2	**2.9**
Total	**24**	**54**	**77**	**62**	**217**
	43.0	**54.0**	**77.0**	**62.0**	**217.0**
	6.3	**0.4**	**2.9**	**0.7**	**10.3**

Pearson chi2(6) = 10.2612, Pr = 0.114

Environmental media: pollutants and resources (Figure 14)

Sub-category	Decade				Total
	1	2	3	4	
Air pollution	56	31	58	118	**263**
	51.4	57.0	72.3	82.2	**263.0**
	0.4	11.9	2.8	15.6	**30.7**
Land pollution	32	24	42	48	**146**
	28.5	31.6	40.2	45.6	**146.0**
	0.4	1.8	0.1	0.1	**2.5**
None	134	212	233	228	**807**
	157.8	174.9	222.0	252.3	**807.0**
	3.6	7.9	0.5	2.3	**14.3**
Other pollution	18	12	9	25	**64**
	12.5	13.9	17.6	20.0	**64.0**
	2.4	0.3	4.2	1.2	**8.1**
Resources	82	99	135	127	**443**
	86.6	96.0	121.8	138.5	**443.0**
	0.2	0.1	1.4	1.0	**2.7**

	1	2	3	4	Total
Water pollution	37	20	28	28	**113**
	22.1	24.5	31.1	35.3	**113.0**
	10.1	0.8	0.3	1.5	**12.7**
Total	**359**	**398**	**505**	**574**	**1,836**
	359.0	**398.0**	**505.0**	**574.0**	**1,836.0**
	17.1	**22.7**	**9.4**	**21.7**	**71.0**

Pearson chi2(15) = 71.0098, Pr = 0.000

Environmental media - air pollution (Figure 15)

Sub-category	Decade				Total
	1	**2**	**3**	**4**	
General air pollution	-	-	12	27	**39**
	-	-	12.3	26.7	**39.0**
	-	-	0.0	0.0	**0.0**
CO2 and general referrals to greenhouse gases	-	-	22	66	**88**
	-	-	27.8	60.2	**88.0**
	-	-	1.2	0.6	**1.7**
Local air pollution (Sulfur / NOx / CO / PM / CFCs / Ozone / Other air pollution)	-	-	25	35	**60**
	-	-	18.9	41.1	**60.0**
	-	-	1.9	0.9	**2.8**
Total	**-**	**-**	**59**	**128**	**176**
	-	**-**	**59.0**	**128.0**	**176.0**
	-	**-**	**3.2**	**1.5**	**8.1**

Pearson chi2(6) = 4.6027, Pr = 0.100

We restrict the test to the last two decades since CO2 and general references to greenhouse gases made their first appearance in the journal in its third decade.

Water pollution (Figure 16)

Sub-category	Decade				Total
	1	**2**	**3**	**4**	
C-H compounds	7		2		**9**
	4.5		4.5		**9.0**
	1.3		1.4		**2.7**
Fertilizers	4		3		**7**
	3.5		3.5		**7.0**
	0.1		0.1		**0.1**
General water pollution	43		41		**84**
	42.4		41.6		**84.0**
	0.0		0.0		**0.0**
Heavy metals	2		2		**4**
	2.0		2.0		**2.0**
	0.0		0.0		**0.0**

CL compounds / solid waste / other	3	10	**13**
	6.6	6.4	**13.0**
	1.9	2.0	**3.9**
Total	**59**	**58**	**117**
	59.0	**58.0**	**117.0**
	3.3	**3.4**	**6.7**

Pearson chi2(4) = 6.7294, Pr = 0.151

Given the small number of cases we use two-decade instead of one-decade periods

Land pollution (Figure 17)

Sub-category	Decade				Total
	1	**2**	**3**	**4**	
Other land pollution (e.g. hazardous waste)	2	7	17	12	**38**
	8.3	6.2	11.1	12.4	**38.0**
	4.8	0.1	3.1	0.0	**8.0**
Degradation of landscapes	12	12	14	25	**63**
	13.7	10.3	18.1	20.6	**63.0**
	0.2	0.3	1.1	1.0	**2.3**
Solid waste	18	5	12	11	**46**
	10.0	7.5	13.5	15.0	**46.0**
	6.4	0.8	0.2	1.1	**8.4**
Total	**32**	**24**	**43**	**48**	**147**
	32.0	**24.0**	**43.0**	**48.0**	**147.0**
	11.3	**1.2**	**4.3**	**2.0**	**18.9**

Pearson chi2(6) = 18.9460, Pr = 0.004

Resources (Figure 18)

Sub-category	Decade				Total
	1	**2**	3	**4**	
Fisheries	25	31	40	44	**140**
	27.4	29.7	41.5	41.5	**140.0**
	0.2	0.1	0.1	0.2	**0.5**
Forests	8	19	29	17	**73**
	14.3	15.5	21.6	21.6	**73.0**
	2.7	0.8	2.5	1.0	**7.1**
Non-renewable energy resources / other resources (e.g. biofuels)	19	25	15	27	**86**
	16.8	18.2	25.5	25.5	**86.0**
	0.3	2.5	4.3	0.1	**7.2**
Recreation, landscape	18	4	20	18	**60**
	11.7	12.7	17.8	17.8	**60.0**
	3.4	6.0	0.3	0.0	**9.6**

Secondary materials, waste recycling	17	3	6	10	**36**
	7.0	7.6	10.7	10.7	**36.0**
	14.1	2.8	2.0	0.0	**19.0**
Water as a resource	0	12	13	13	**38**
	7.4	8.1	11.3	11.3	**38.0**
	7.4	1.9	0.3	0.3	**9.9**
Wildlife, biodiversity	6	7	18	12	**43**
	8.4	9.1	12.7	12.7	**43.0**
	0.7	0.5	2.2	0.0	**3.4**
Total	**93**	**101**	**141**	**141**	**476**
	93.0	**101.0**	**141.0**	**141.0**	**476.0**
	28.8	**14.6**	**11.6**	**1.6**	**56.6**

Pearson chi2(18) = 56.6355, Pr = 0.000

Cross-cutting issues (Figure 19)

Sub-category	Decade				Total
	1	**2**	**3**	**4**	
Climate change	1	7	31	73	**112**
	14.8	26.0	26.8	44.3	**112.0**
	12.9	13.9	0.6	18.6	**46.0**
Discounting methods	6	10	3	14	**33**
	4.4	7.7	7.9	13.1	**33.0**
	0.6	0.7	3.0	0.1	**4.4**
Energy efficiency / renewable energy sources / nuclear	7	7	4	44	**62**
	8.2	14.4	43.9	24.5	**62.0**
	0.2	3.8	7.9	15.5	**27.4**
Interdisciplinary approaches and ecological economics	12	17	17	11	**57**
	7.6	13.2	13.7	22.6	**57.0**
	2.6	1.1	0.8	5.9	**10.4**
Risk, uncertainty, imperfect information	47	87	77	77	**287**
	38.0	66.7	66.8	68.8	**287.0**
	2.1	6.2	1.0	1.0	**21.7**
Total	**73**	**128**	**132**	**218**	**551**
	73.0	**128.0**	**132.0**	**218.0**	**551.0**
	18.4	**25.7**	**13.4**	**52.4**	**110.0**

Pearson chi2(12) = 109.9723, Pr = 0.000

Country dimension (Figure 20)

Sub-category	Decade				Total
	1	**2**	**3**	**4**	
General	172	254	274	241	**941**
	168.3	213.9	267.9	291.0	**941.0**
	0.1	7.5	0.1	8.6	**16.3**

	1	2	3	4	Total
Multi-region analysis and comparative studies of countries	3	8	12	31	**54**
	9.7	12.3	15.4	16.7	**54.0**
	4.6	1.5	0.7	12.3	**19.1**
Other country	11	13	42	74	**140**
	25.0	31.8	39.9	43.3	**140.0**
	7.9	11.1	0.1	21.8	**40.9**
U.S., Canada	113	105	148	171	**537**
	96.0	122.0	152.9	166.0	**537.0**
	3.0	2.4	0.2	0.1	**5.7**
Total	**299**	**380**	**476**	**517**	**1,672**
	299.0	**380.0**	**476.0**	**517.0**	**1,672.0**
	15.5	**22.5**	**1.2**	**42.8**	**82.0**

Pearson chi2(9) = 81.9859, Pr = 0.000

Regional dimension – other country (Figure 21)

Sub-category	**Decade**				**Total**
	1	**2**	**3**	**4**	
Africa	1	2	7	1	**11**
	0.9	1.0	3.3	5.8	**11.0**
	0.0	0.9	4.1	4.0	**9.1**
China / rest of Asia	1	1	7	21	**30**
	2.4	2.8	9.0	15.9	**30.0**
	0.8	1.1	0.4	1.7	**4.0**
Europe	5	4	16	33	**58**
	4.6	5.4	17.4	30.7	**58.0**
	0.0	0.4	0.1	0.2	**0.7**
Latin America, Caribbean	1	0	8	10	**19**
	1.5	1.8	5.7	10.0	**19.0**
	0.2	1.8	0.9	0.0	**2.9**
Middle East / Oceania / other regions	3	6	4	9	**22**
	1.7	2.0	6.6	11.6	**22.0**
	0.9	7.7	1.0	0.6	**10.2**
Total	**11**	**13**	**42**	**74**	140
	11.0	**13.0**	**42.0**	**74.0**	140.0
	1.9	**11.9**	**6.7**	**6.4**	26.9

Pearson chi2(12) = 26.8974, Pr = 0.008

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┌──────────────────────────┐
│ Key                      │
├──────────────────────────┤
│     frequency            │
│ expected frequency       │
│ chi2 contribution        │
└──────────────────────────┘
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Articles classified by content (Figure 24)

Sub-category	AJAE	EE	Journal ERE	JEEM	LE	Total
Costs and benefits of pollution control, non-market valuation	26	42	47	44	57	**216**
	43.2	43.2	43.2	43.2	43.2	**216.0**
	6.8	0.0	0.3	0.0	4.4	**11.6**
Climate change economics	1	4	14	7	3	**29**
	5.8	5.8	5.8	5.8	5.8	**29.0**
	4.0	0.6	11.6	0.2	1.4	**17.7**
Energy economics	1	2	2	0	1	**6**
	1.2	.12	1.2	1.2	1.2	**6.0**
	0.0	0.5	0.5	1.2	0.0	**2.3**
Analysis of environmental policy instruments	9	10	13	18	1	**51**
	10.2	10.2	10.2	10.2	10.2	**51.0**
	0.1	0	0.8	6.0	8.3	**15.2**
Environmental management at firm level	4	0	3	3	3	**13**
	2.6	2.6	2.6	2.6	2.6	**13.0**
	0.8	2.6	0.1	0.1	0.1	**3.5**
International economics, innovation and growth	7	24	10	14	2	**57**
	11.4	11.4	11.4	11.4	11.4	**57.0**
	1.7	13.9	0.2	0.6	7.8	**24.1**
Natural resource economics	46	15	11	13	32	**117**
	23.4	23.4	23.4	23.4	23.4	**117.0**
	21.8	3.0	6.6	4.6	3.2	**39.2**
Equity and justice / other content	6	3	0.	1	1	**11**
	2.2	2.2	2.2	2.2	2.2	**11.0**
	6.6	0.3	2.2	0.7	0.7	**10.4**
Total	**100**	**100**	**100**	**100**	**100**	500
	100.0	**100.0**	**100.0**	**100.0**	**100.0**	500.0
	41.8	**21.0**	**22.2**	**13.4**	**25.7**	124.1

Pearson chi2(28) = 124.1119, Pr = 0.000

Costs and benefits of pollution control, non-market valuation (Figure 25)

Sub-category	Journal					Total
	AJAE	EE	ERE	JEEM	EE	
General, methodological improvements	11	16	32	33	22	**114**
	13.7	22.2	24.8	23.2	30.1	**114.0**
	0.5	1.7	2.1	4.1	2.2	**10.6**
Methods applied to elicit benefits and da-	15	26	15	11	35	**102**
mages / Measuring the costs of pollution	12.3	19.8	22.2	20.8	26.9	**102.0**
control, estimating abatement osts	0.6	1.9	2.3	4.6	2.4	**11.9**
Total	**26**	**42**	**47**	**44**	**57**	216
	26.0	**42.0**	**47.0**	**44.0**	**57.0**	216.0
	1.1	**3.6**	**4.4**	**8.7**	**4.6**	22.5
Pearson chi2(4) = 22.5130, Pr = 0.000						

Methods utilized for analysis (Figure 26)

Sub-category	Journal					Total
	AJAE	EE	ERE	JEEM	LE	
Experimental	5	0	3	2	4	**14**
	3.0	2.6	2.6	2.9	2.8	**14.0**
	1.3	2.6	0.1	0.3	0.5	**4.7**
Econometric and statistical	51	30	33	31	34	**179**
	38.8	32.9	33.6	37.3	36.4	**179.0**
	3.8	0.3	0.0	1.1	0.2	**5.3**
Other (other theory)	3	36	13	0	9	**61**
	13.2	11.2	11.4	12.7	12.4	**61.0**
	7.9	54.7	0.2	12.7	0.9	**76.4**
Mathematical and simulation modeling	12	16	12	10	6	**56**
	12.2	10.3	10.5	11.7	11.4	**56.0**
	0.0	3.1	0.2	0.2	2.5	**6.1**
Theoretical	31	16	25	49	27	**148**
	32.1	27.2	27.8	30.8	30.1	**148.0**
	0.0	4.6	0.3	10.7	0.3	**16.0**
Non-market valuation	23	8	22	28	37	**118**
	25.6	21.7	22.1	24.6	24.0	**118.0**
	0.3	8.7	0.0	0.5	7.1	**16.5**
Total	**125**	**106**	**108**	**120**	**117**	576
	125.0	**106.0**	**108.0**	**120.0**	**117.0**	576.0
	13.3	**74.0**	**0.8**	**25.5**	**11.5**	125.0
Pearson chi2(20) = 124.978, Pr = 0.000						

Environmental media: pollutants & resources (Figure 27)

Sub-category			Journal			Total
	AJAE	EE	ERE	JEEM	LE	
Air pollution	3	21	26	18	10	**78**
	14.6	16.2	16.6	14.0	16.7	**78.0**
	9.2	1.5	5.4	1.1	2.7	**19.8**
Land pollution	12	12	14	8	26	**72**
	13.4	14.9	15.3	13.0	15.4	**72.0**
	0.2	0.6	0.1	1.9	7.3	**10.0**
None	49	41	34	54	17	**195**
	36.4	40.4	41.4	35.1	41.7	**195.0**
	4.3	0.0	1.3	10.2	14.6	**30.5**
Other pollution	9	3	5	1	4	**22**
	4.1	4.6	4.7	4.0	4.7	**22.0**
	5.8	0.5	0.0	2.2	0.1	**8.7**
Resources	29	38	36	21	65	**189**
	35.3	39.1	40.1	34.0	40.4	**189.0**
	1.1	0.0	0.4	5.0	14.9	**21.5**
Water pollution	8	7	10	4	4	**33**
	6.2	6.8	7.0	5.9	7.1	**33.0**
	0.5	0.0	1.3	0.6	1.3	**3.8**
Total	**110**	**122**	**125**	**106**	**126**	589
	110.0	**122.0**	**125.0**	**106.0**	**126.0**	589.0
	21.2	**2.6**	**8.5**	**21.0**	**41.0**	94.3

Pearson chi2(20) = 94.3244, Pr = 0.000

Cross-cutting issues (Figure 28)

Sub-category			Journal			Total
	AJAE	EE	ERE	JEEM	EE	
Climate change	3	9	9	6	3	**30**
	4.1	11.8	8.0	4.1	2.0	**30.0**
	0.3	0.6	0.1	0.9	0.6	**2.5**
Energy	0	2	7	1	0	**10**
	1.4	3.9	2.7	1.4	0.7	**10.0**
	1.4	0.9	7.0	0.1	0.7	**10.0**
Interdisciplinary appraoches and ecological economics	0	45	15	4	5	**69**
	9.5	27.1	18.5	9.5	4.5	**69.0**
	9.5	11.9	0.7	3.2	0.1	**25.2**
Risk, uncertainty, imperfect information	18	4	10	10	2	**44**
	6.0	17.3	11.8	6.0	2.9	**44.0**
	23.7	10.2	0.3	2.6	0.3	**37.0**
Total	**21**	**60**	**41**	**21**	**10**	153
	21.0	**60.0**	**41.0**	**21.0**	**10.0**	153.0
	34.8	**23.7**	**8.0**	**6.7**	**1.5**	74.8

Regional dimension (Figure 29)

Sub-category			Journal			Total
	AJAE	**EE**	**ERE**	**JEEM**	**EE**	
General	28	53	44	45	24	**194**
	38.8	38.8	38.8	38.8	38.8	**194.0**
	3.0	5.2	0.7	1.0	5.6	**15.5**
Multi-region analysis	3	17	11	5	4	**40**
	8.0	8.0	8.0	8.0	8.0	**40.0**
	3.1	10.1	1.1	1.1	2.0	**17.5**
Other country	13	19	29	12	13	**86**
	17.2	17.2	17.2	17.2	17.2	**86.0**
	1.0	0.2	8.1	1.6	1.0	**11.9**
U.S., Canada	56	11	16	38	59	**180**
	36.0	36.0	36.0	36.0	36.0	**180.0**
	11.1	17.4	11.1	0.1	14.7	**54.4**
Total	**100**	**100**	**100**	**100**	**100**	**500**
	100.0	**100.0**	**100.0**	**100.0**	**100.0**	**500.0**
	18.3	**32.9**	**21.0**	**3.8**	**23.4**	**99.3**

Pearson chi2(12) = 99.3319, Pr = 0.000