Waste Management in the European Union: Funding, Policy Priorities and Scientific Research

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Abstract

Significant changes are needed for sustainable waste management, which requires ground-breaking research. The European Union (EU) has used competitive funding instruments as tools for development and implementation of its policies. This paper explores whether there are indications that researchers on waste issues in Europe have adjusted their research topics to funding availability and prevalent policy priorities. LIFE is a main funding instrument for environmental, including waste issues. Thus, via a survey of LIFE projects (as expression of policy and funding priorities) and published research articles (as an expression of scientists' research interests), the development of the interest in different waste themes is compared in the two data sets in the period 1992-2016. A consistent correlation pattern between LIFE projects and published articles is not observed in all waste themes. However, there is evidence in the data that policy developments influence researchers' choices of waste topics, although this influence seems to be mitigated by other parameters in the research context. Therefore, policy makers should reconsider the type of funding instruments that they should use to promote truly innovative research leading to ideally a zero-waste society.

Keywords
Waste management; policy priorities; funding; scientific research; European Union

1. Introduction

Waste has been a major environmental issue of concern for our contemporary societies for several decades. In the European Union (EU), this has been the case for almost five decades, as the adoption of relevant policies suggest. Between 2010 and 2014, the total amount of waste generated (excluding mineral waste) in the EU increased slightly (by 2%), although successes have also been reported in some sectors (EEA, 2017). Thus, waste management continues being an issue in Europe, now being connected with resource efficiency. The themes within waste management that have been emphasized in the EU have developed over time as waste management policy priorities reveal. In addition, in 1992, the EU established a funding instrument – LIFE – dedicated to environmental concerns, one of which is waste management, aiming to promote the implementation of EU environmental policy priorities. At the same time, it comprises an important source of funding for environmental (including waste management) research and applications in Europe, along with other more recent funding programmes (like Horizon 2020).

According to many, funding is an important (although not the only) external parameter that influences scientific research in Europe, by influencing researchers' choice of research questions or way of approaching a topic.

This paper wishes to explore if EU environmental policy and funding priorities influences waste-related research in Europe, by focusing specifically on selected waste research topics. The main research question addressed here is whether the research topics selected by scientists correlate with the EU policy and funding priorities.

2. Waste management policy in Europe

Waste has been a concern of European policy makers since the 1970s. The first European directive that referred to waste was introduced in 1975. Since the 1990s and later in 2000s, several pieces of legislation have been passed regarding different waste streams or waste management methods. Table 1 below lists the main pieces of European Union (EU) legislation that focus on waste management issues.

Table 1: European Union main waste-related legislation

Year	Legislation
2014	Commission Regulation (EU) No 1357/2014 of 18 December 2014 replacing Annex III to Directive 2008/98/EC
2014	Commission Decision (EU) No 2014/955/EU of 18 December 2014 amending definition of hazardousness
2013	Regulation (EC) No 1013/2006 of the European Parliament and of the Council of 14 June 2006 on shipments of waste
2011	Directive 2011/70 - safe management of nuclear waste
2008	Waste Framework Directive, or Directive 2008/98/EC
2002	Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE)
2000	Directive 2000/53/EC of the European Parliament and of the Council of 18 September 2000 on end-of life vehicles
2000	Decision 2000/532/EC establishing a list of wastes
2000	Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste
2000	Directive 2000/59/EC of the European Parliament and of the Council of 27 November 2000 on port reception facilities
1999	Directive 1999/31/EC on the landfill of waste
1996	Council Directive 96/61/EC concerning integrated pollution prevention and control (IPPC)
1996	Council Directive 96/59/EC of 16 September 1996 on the disposal of polychlorinated biphenyls and polychlorinated terphenyls (PCB/PCT)
1994	European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste
1993	Basel Convention on Transfer of Waste Council Decision 93/98/EEC
1991	Directive 91/689/EEC on hazardous waste
1991	Council Directive 91/157/EEC of 18 March 1991 on batteries and accumulators
1991	Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment
1986	Council Directive 86/278/EEC of 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture
1975	Directive 75/439/EEC on waste oils disposal
1975	Directive 75/442/EEC on waste

As can be observed, in the 1990s, legislating on waste issues proliferated since the Single European Act in 1986 provided a firm ground for EU environmental policy making. In this period, several directives were adopted regarding a range of waste streams (e.g. hazardous waste, accumulators, packaging and packaging waste, polychlorinated biphenyls and polychlorinated terphenyls (PCB/PCT), while more integrated approaches were proposed (e.g. Integrated Pollution Prevention and Control Directive), aiming to limit landfilling of waste and signaling the preference to more systemic approaches. The Treaty of Amsterdam (1997) emphasized the significance of concept of sustainable development (Pooschi, 1998). Since 2000, although some further waste streams (e.g. Waste Electrical and Electronic Equipment (WEEE) and End-of-life vehicles (ELV)) and specific waste management processes (e.g. incineration, port reception facilities) were regulated, there was a shift towards more integrated and holistic approaches, culminating to the Waste Framework Directive in 2008, emphasizing the hierarchy of waste priorities. The 2010s are a continuation of previous trends, amending previous directives as needed and promoting prevention and reuse by further separating waste streams, resource efficiency – doing

more with less – and a circular economy (Directorate-General for Communication (European Commission), 2014; European Commission, 2018a).

In this period, we can see the move of the EU from an emphasis on legal action to more "supporting – enticing" approaches aiming to involve Member States and stakeholders in the enhancement of the "waste problem", always aiming towards a greener and more competitive economy as the quote below indicates.

> "Eco-design, waste prevention, recycling and reuse can bring net annual savings for EU businesses of up to 600 Bilion, while also bringing significant reductions in the EU's greenhouse gas emissions." (Directorate-General for Communication (European Commission), 2014, p. 15)

This change is also embedded in the conception of Europe as a knowledge society and knowledge-based economy (European Commission, 2010). Europe's strategy for economic transformation – as expressed in *Europe 2020* - depends on the centrality of knowledge creation and application, innovation and smart growth. For this reason, *Europe 2020* foresees increased funding for research and innovation that can also create growth and jobs. (see also Gunn and Mintrom, 2016).

3. Funding for the environment in the European Union & the LIFE programme

The European Union has used funding as a significant tool to promote its environmental policy priorities. The 5th Environmental Action Program "Towards Sustainability", which covered the period 1993-2001, specifically pointed to the need of broadening the instruments that could be used to promote environmental protection and sustainable development, to include (aside of legislation) market-based approaches and financial instruments (European Community, 1993). The LIFE programme is a main EU funding instrument dedicated to nature protection and environmental issues aiming to promote EU environmental policy priorities as these were reflected in the EU 5th (1993-2001), 6th (2002 – 2012) and 7th (2013 – 2020) Environmental Action Programmes (EAPs).

The LIFE funding programme (from now on "LIFE") was instituted in 1992 and continues until today. Presently, despite the existence of other funding programmes (like Horizon2020) that support environmental and sustainable development projects, the LIFE programme, continues being fundamental in the EU's environmental protection and sustainable development efforts, as it funds pilot applications and innovations. LIFE has evolved along with the EU environmental policy approach. LIFE I (1992-1995) focused on projects relating to polluting industries, waste reduction and recycling, rehabilitation of polluted sites, urban transport, and sustainable development in agriculture, transport and tourism. LIFE II (1996 – 1999) placed increased emphasis on nature conservation, while the "environment" pillar of the program emphasized innovation and policy implementation in clean technologies, waste management, water pollution reduction, and the integration of environmental concerns in urban and town planning, among other topics. LIFE III (2000 – 2006) continued in the same spirit, but further emphasized multinational cooperation and networking. LIFE+ (2007-2013) extended the former focus on nature conservation in line with the Habitats and Birds Directives, by aiming for halting biodiversity loss in the EU. It also placed an increased emphasis on environmental policy implementation and innovation (in terms of technologies, methods and instruments) and on communication (by establishing a new component that co-financed awareness raising environmental projects) (European Commission, 2018b). The extension of LIFE+ (LIFE 2014-2020) places increased emphasis on climate change mitigation and adaptation, and clearly states that it aims to catalyze policy development and promote innovative environmental and climate change technologies. Resource efficiency and a low carbon economy are main targets of this programme, and integrated projects – that promote the integration of environmental and climate concerns in all EU policies – are introduced. An emphasis on innovation continues.

Specifically for waste, LIFE started by focusing on projects that ensure the proper waste management of waste streams and promote the waste hierarchy (LIFE II), and evolved to the objectives of "sustainable management and use of natural resources and waste" and "waste prevention, recovery and recycling with a focus on life-cycle thinking, eco-design and the development of recycling markets" in LIFE + (Regulation EC/614/2007). The recent regulation for LIFE (Regulation 1293/2013) under the priority area "Environment and Resource Efficiency" identifies the following thematic priorities: integrated approaches to waste plans and programmes; emphasis on prevention, re-use and recycling; and resource efficiency throughout the life cycle of products and consumption patterns.

4. Funding and science: Useful points for reflection

The relation of policy priorities, funding and science - research has been the focus of interest of several scientists, especially as the scientific research scene is changing. And it is an issue worth investigating since science is the human activity through which humanity explores, learns and develops new knowledge and understanding of the world, and finds new approaches and solutions to social concerns. In the contemporary knowledge society and economy, science and research are called to provide innovative solutions to immediate, social problems (i.e. problems identified as important by policy makers and society). Consequently, applied, instrumental and entrepreneurial research (Editorial, 2009) have gained importance.

Policies influence research (including environmental and waste-related research) agendas as they alter educational/research institutions and the context in which they operate (Batory & Lindstrom, 2011). Dale (2008) explores how the meaning of "knowledge" in the EU – via its different Treaties – has changed over time, and how the university from a place of knowledge generation has turned to a mechanism "to drive forward the growth and jobs agenda". Gunn and Mintrom (2016) discuss the potential limitation of university autonomy and of "the control academics have over their research". Vanloqueren and Baret (2009) state that "…policies influence technological paradigms in 4 different ways: choice of research orientations, relationship between public and private sectors, the power of lobbies, and the role of media and lobbies."

Furthermore, the funding context of research has changed from mainly dependent on recurrent funding – not earmarked for specific research projects – to external, competitive funding for specific research activities (Laudel, 2006). This shift leads funders and scientists to favor research on incremental innovations (as they are safer choices) and research with short term and measurable outputs, since basic or ground-breaking research, or research with long-term impacts have smaller possibilities of success. Heinze et al. (2009) state:

> "The group leader recalled that one always needs preliminary results in order to compete for external funds."
>
> "… whilst the conservative procedures adopted by research funding agencies for allocating grants may be appropriate for 'normal science' in established disciplines, they create many problems for scientists with original research ideas."

The conservative bias of peer review mechanisms also contributes to excluding ground-breaking research from access to funding sources (Heinze, 2008). In this process, research is increasingly being viewed/treated as "a competitive, self-interested, instrumental, outputs-oriented process" (Roberts, 2007). Vanloqueren & Baret (2009) identified science policies, private sector research, public sector research, path dependence (e.g. initial conditions that may influence the success of the dominant technology or paradigm) and "lock in" situations (i.e. the exclusion of alternative ones) as parameters that may affect the type and level of innovation possible. Flexible funding mechanisms may be more conducive to ground-breaking, "playful" research.

In this new research context, scientists need to adopt an "art of getting funded". They apply different strategies in order to enhance their possibilities of getting funding for their research, as Laudel (2006) indicates: strategies "targeting the resource base" (i.e. targeting "easy" or "appropriate" or all funding sources) or strategies "targeting the research content" (i.e. selecting externally predetermined topics, diversifying research, avoiding risky research or "hot" topics).

5. Methodology

This paper explores whether there are indications that researchers on waste issues in the Europe have adjusted their research topics to funding availability and prevalent policy priorities. The main questions that are addressed in this study are: Which waste themes have been selected for research in the period 1992-2017, as these are reflected in published journal articles? The time period was selected to coincide with available data on LIFE projects. How do these themes correlate with the topics of LIFE waste projects – as a reflection of LIFE and EU environmental policy priorities? Does funding appear to relate with the selection of the research topic? Acknowledging the limitations of our assumptions, we have assumed that published research articles fairly represent research done; and that LIFE projects represent funding and policy priorities in the field of waste management. We consider these data an adequate first approximation of research done and EU funding and policy priorities respectively.

In order to address the first research question, the database ScienceDirect was used for retrieval of published research journal articles relating to waste issues in Europe in the period 1992-2016. The project database of LIFE projects was used for identification of projects related with waste themes. The same waste themes (i.e. industrial waste, hazardous waste, medical waste, packaging and plastic waste, end of life vehicles and tyres, construction and demolition waste, biowaste, solid waste, waste oil, waste paper, landfilling, waste use, waste collection, waste management, waste treatment) were selected so that the results from the two databases could be compared in terms of their evolution in the period 1992-2016. These themes were retrieved from the LIFE project database; only waste streams will be discussed below.

Two data sets were created: journal articles published in the period 1992-2016, LIFE projects funded in 1992-2016. Each data set included time series for each waste theme. Excel statistical tools were used for analysis and line graphs were developed. Percentages rather than absolute numbers (of projects with a specific theme over the total projects per year, or of published articles with a specific theme over total articles per year) were used in order to overcome the impact of the continuous proliferation of journals and published articles in our times (due to the existing "publish or perish" pressure).

6. Results

Only the results relating to waste streams will be discussed as the themes on the waste processes (e.g. collection, management, use, treatment) appeared to be very vague and probably used as keywords in many articles and projects. As indicated above, the relative interest (expressed in percentage) in each waste theme per year is examined in order to avoid the influence of the pressure to publish and the proliferation of academic journals which lead to constantly increasing absolute numbers of published papers. (For simplicity purposes, from now on we will refer to "published articles" or "LIFE projects" or similar terms to reflect these percentages.)

Comparisons of journal articles and LIFE projects data reveal that the time series of all waste streams do not evolve the same way. For some waste streams, there are similar patterns. For industrial waste and waste paper, the evolution of the data in the period 1992-2016 demonstrates a decreasing pattern for both journal articles and LIFE projects (see Figures 1 and 2 below). These are old policy themes, with waste paper a "non-policy issue" at this time.

Figure 1: Industrial waste: % articles and projects on this theme per year

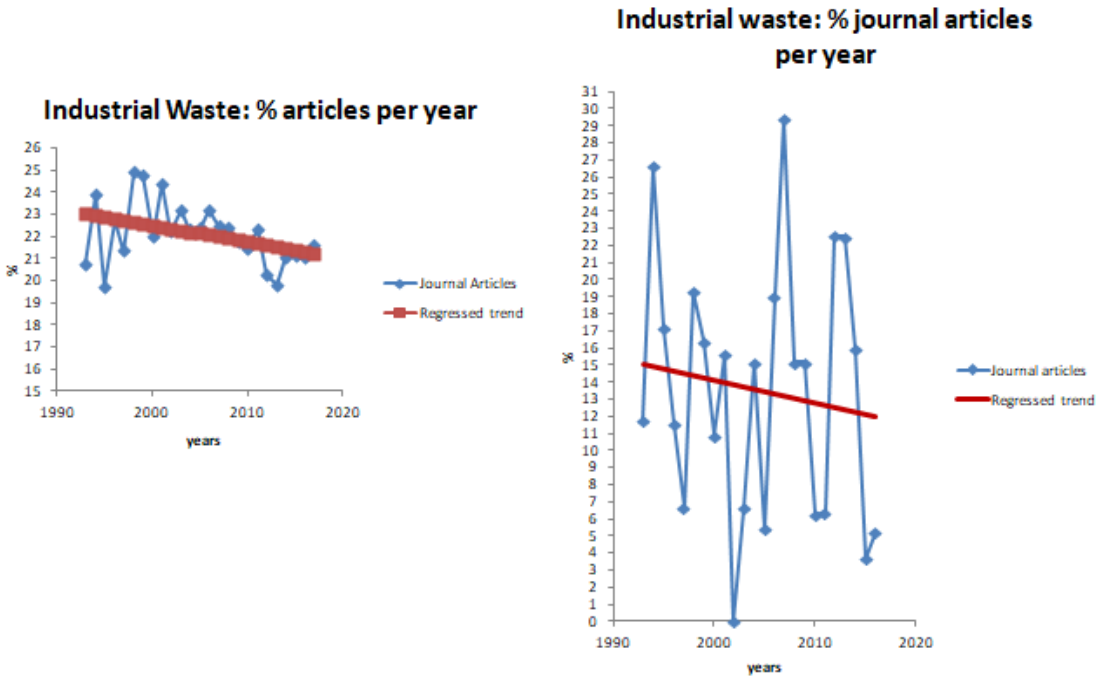
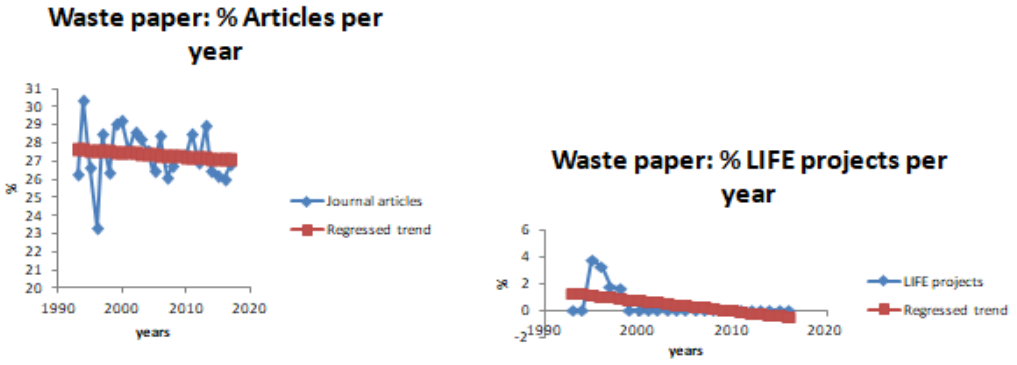
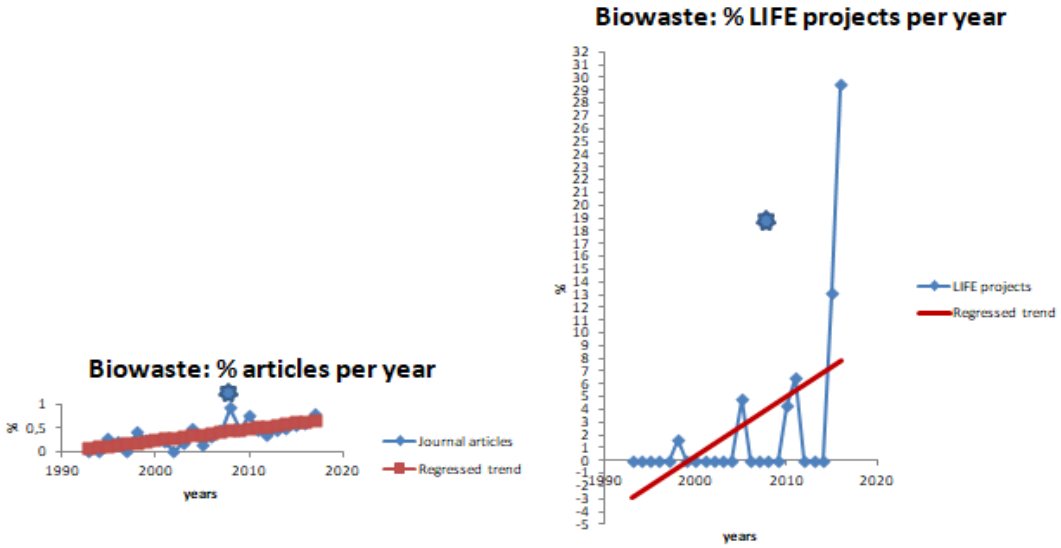


Figure 2: Waste paper: % articles and projects on this theme per year



Biowaste is the only theme which shows an increasing trend in both data sets (see Figure 3). However, the Waste Framework Directive (2008/98/EC) introduced specific targets for the diversion of biowaste from landfills, making this issue a "hot" issue especially as it relates with green house gas generation.

Figure 3: Biowaste: % articles and projects on this theme per year



For other themes, there are inconsistent trends. Researhers' interest as revealed from published articles in hazardous waste, waste oil and landfilling remains basically stable. However, LIFE projects on these themes are decreasing over time. (indicatively see Figures 4 and 5 below). It is interesting to note that the main relevant Directives were introduced before 1992. However, these are issues of continued significance in both the field and the EU policy scene.

Figure 4: Hazardous waste: % of articles and LIFE projects on this theme per year

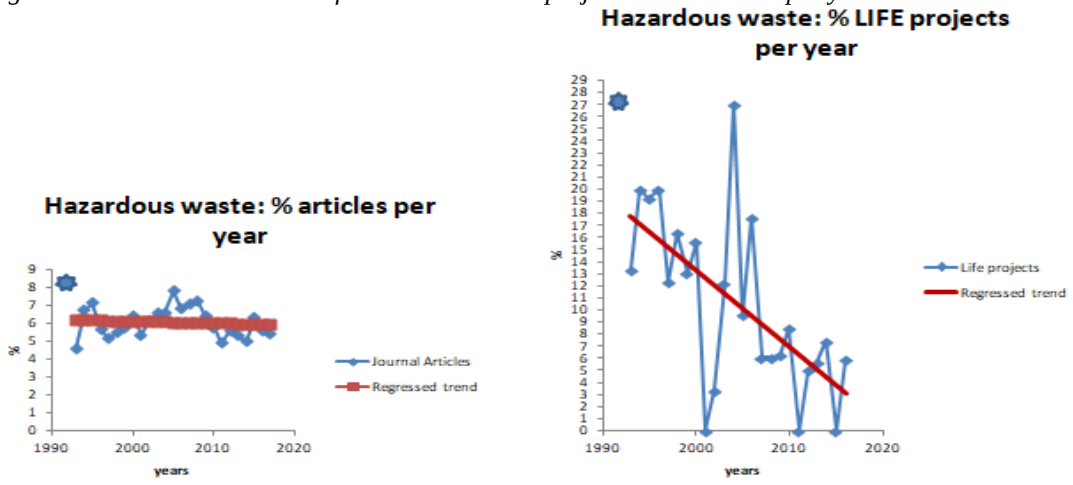
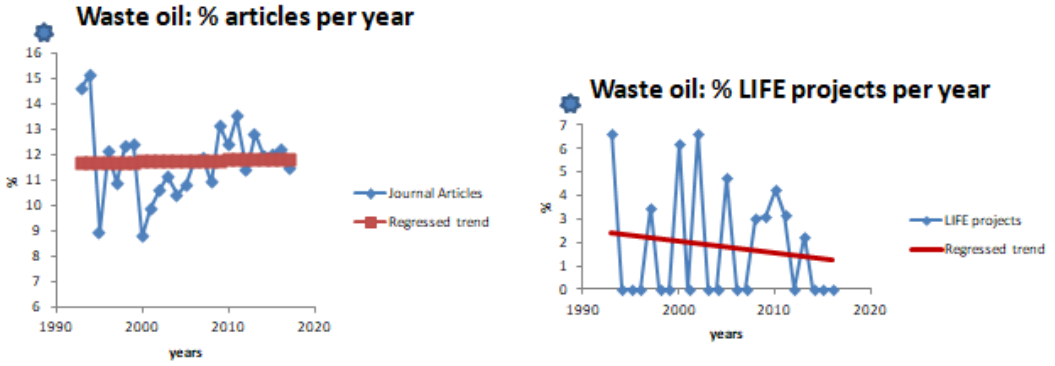


Figure 5: Waste oil: % of articles and LIFE projects on this theme per year



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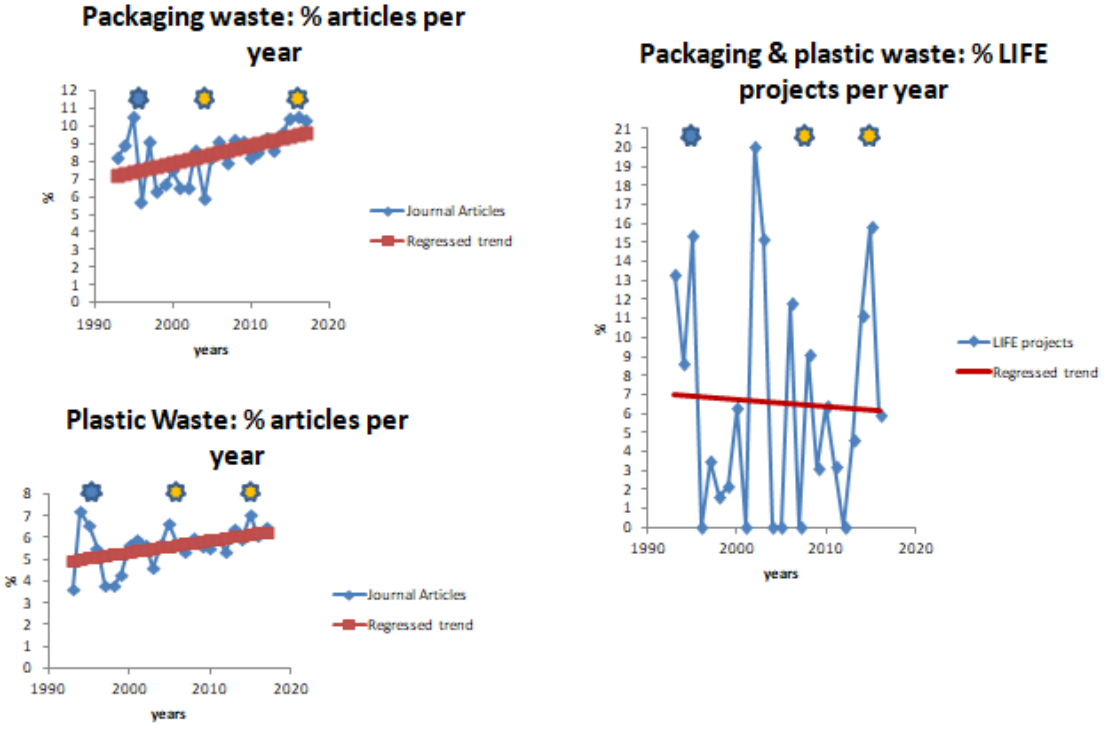
Published articles on medical waste are decreasing, but LIFE projects remain basically stable but very low.

Diverging trends are revealed for packaging and plastic waste: published articles are increasing but LIFE projects are basically stable (see Figure 6 below). The Packaging Directive was passed in 1994, while it was amended in 2004 and 2005, and most recently in 2015 (Directive (EU) 2015/720).

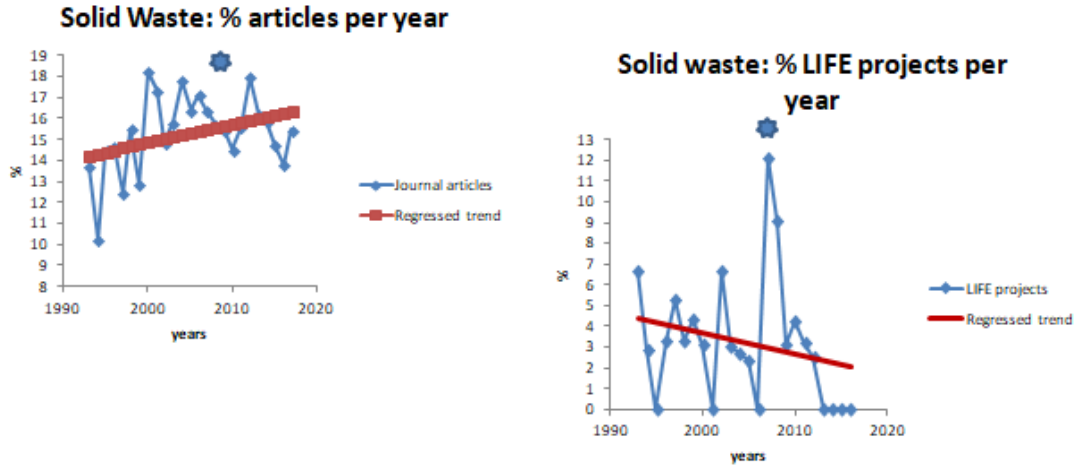
Figure 6: Packaging and plastic waste: % of articles and LIFE projects on this theme per year



Researchers' interest in end of life vehicles (ELV) remains stable, but in tyres, it is decreasing. However, LIFE projects on end of life vehicles and tyres are increasing. In comparison, published articles on construction and demolition waste (CDW) – a bulky waste stream of continued concern – are increasing, while relevant LIFE projects remain practically stable.

Researchers' interest in solid waste remains significant and is increasing, while LIFE projects on this theme are decreasing (see Figure 7). However, one can see the influence of the adoption of the Waste Framework Directive in 2008.

Figure 7: Solid waste: % of articles and LIFE projects on this theme per year



7. Discussion

The results above do not reveal a consistent correlation pattern between published articles and LIFE projects across waste themes. Implemented LIFE projects, although they depend also on the availability of "good" proposals according to the evaluation criteria, as expected show a relation with the adoption of relevant policies. However, some interesting conclusions can be drawn in relation to the influence of policy priorities on research topic choices and scientists' adaptation strategies to the new scientific research scene.

It can be observed that when a directive passes, there is usually increased research activity the years before (e.g. see packaging and plastic waste and solid waste), and if there is subsequent legislative action (new relevant directives or amendments) research activity increases afterwards. Biowaste, a "new" theme that is of policy interest today shows a low level of interest and an increasing trend in both published articles and LIFE projects. It appears that "old" themes in terms of policy interest (like waste paper, hazardous waste and waste oil) attract similar (sometimes high) or slightly decreasing levels of research interest throughout these years. This may be attributed to the "costly" process of changing research trajectories or the interests of private research and development funds (Vanloqueren & Baret, 2009). It is noteworthy that the interest in waste use continues to increase in the context of LIFE (increasing LIFE projects), but published articles are slightly decreasing. These trends may reflect the emphasis on the first stages of the waste hierarchy in the recent EAP, which however may imply a shift in scientists' research trajectories which requires time and money. Thus, the influence of EU policy priorities in the field is probable, but it is mitigated by other parameters in the research context.

From the presented data, it cannot be concluded that funding is a determining factor of research in the waste field in Europe. However, its influence is possible since policy developments seem to influence research and research topics and the EU has used funding instruments as a main tool for promoting research around its policy priorities. In order to draw safer conclusions on the influence of funding on research, further and more qualitative research is needed. However, it should not be forgotten that scientists' decision on research content is multiparametric, also influenced from several other organizational and institutional factors (Heinze et al., 2009).

Finally, these findings may indicate that adapting the research content by selecting predetermined topics (Laudel, 2006) may not be a preferred strategy for scientists in the contemporary research context. It may be worth investigating if new researchers that begin their careers and who more frequently come with fresh ideas may adopt this strategy more frequently.

8. Conclusion

The Intergovernmental Panel on Climate Change indicated that:

> "Successfully meeting development and sustainability goals and responding to new priorities and changing circumstances would require a fundamental shift in agricultural knowledge, science and technology." (cited by Vanloqueren & Baret, 2009).

As we need radical changes in culture, lifestyles and social or corporate practices for a sustainable economy and society, ground-breaking research – possibly challenging the present conceptions of desirable future or transition methods to a desirable future – is much desirable. European policy makers should appreciate the already changed research and higher education environment – from an independent university for knowledge exploration, to a university that participates in a competitive funding environment without non-earmarked funds for basic, challenging research – and its implications on research and researchers and their capacity to do radically innovative research. They should also understand the influence of policy priorities on research, and carefully ponder on the type of funding needed for environmental research that can lead to new and truly sustainable ways of being. Funding instruments (with a different evaluation process, simpler in their administration, allowing "academic freedom", etc.) for radical innovations rather than "incremental novelties" to support such innovation should be designed and promoted. Maybe a certain level of recurrent funding should be reintroduced.

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