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HYPE CYCLE DETECTION FOR CERTAIN WASTE MANAGEMENT TECHNOLOGIES

Master of Science Thesis

Examiner: Professor Saku Mäkinen
The examiner and research topic have been accepted at the Faculty council meeting of Business and Built Environment on May 6th 2015.

ABSTRACT

Otto Rantanen: Hype cycle detection for certain waste management technologies
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New and emerging technologies can have a significant impact on individual companies and industries, as they can bring new entrants to existing markets, or create whole new markets, both of which require changes in existing value networks. Recognizing these technologies and tracking their progress from basic or applied research to market introduction and their subsequent adoption is therefore extremely important. This study of technologies is called technological forecasting. Bibliometrics is the study of written works, such as patents, peer-reviewed research or newspaper articles. These works can function as indirect indicators for tracking technological change.

Emerging and untested technologies generally need positive expectations about their performance in both technical and market aspects before they are introduced to the market in order to gain enough resources and support for development. Sometimes these possibly unsubstantiated expectations far exceed the actual performance of the technology, which results in negative expectations and backlash. This phenomenon was named the hype cycle by the consulting group Gartner.

Previous studies have either concentrated on a small number of technologies, geographical areas, or short time scales. In this study 16 different technologies or related concepts were studied in the United States, Germany, and Brazil from the time of the first published article available up until March 31st 2015. These articles were gathered from LexisNexis. The purpose of this study is to find signs of an existing, previous, or upcoming hype cycles using article metadata as secondary indicators.

Generally, there seems to have been an increase in media interest for most of the technologies in the United States and Germany after year 2000. A lack of articles in Brazil may be due to LexisNexis' source selection, but still prevents any trend analysis. Only one technology was found to have gained no media interest. A strong resemblance to the hype cycle curve was found for two technologies in the United States and for two other technologies in Germany. Three other technologies were found to be possibly reaching a peak phase in the hype cycle.

TIIVISTELMÄ

Otto Rantanen: Hypesyklin tunnistaminen tietyistä jätteenkäsittelyteknologioista
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Uusilla ja ensimmäistä kertaa ilmestyvillä teknologioilla voi olla suuri vaikutus yksittäisiin yrityksiin ja toimialoihin, sillä ne voivat tuoda nykyisille markkinoille uusia yrityksiä tai luoda kokonaan uusia markkinoita. Molemmat vaativat muutoksia yritysten välisiin arvoketjuihin. Näiden teknologioiden tunnistaminen ja niiden edistyksen tarkkaileminen perus- ja soveltavasta tutkimuksesta markkinoille tuloon ja sen jälkeiseen käyttöönottoon on siksi erittäin tärkeää. Tätä kutsutaan teknologiseksi ennustamiseksi. Bibliometriikka on kirjoitettujen teosten tutkimusta, kuten esimerkiksi patentit, vertaisarvioidut tiedejulkaisut tai uutiset. Näitä lähteitä voidaan käyttää epäsuorina mittareina teknologisen muutoksen seurannassa.

Uudet ja kokeilemattomat teknologiat yleensä vaativat myönteisiä odotuksia joko niiden teknisestä suorituskyvystä tai suoriutumisesta markkinoilla saadakseen tarpeeksi resursseja ja muuta tukea kehitykseen. Joskus nämä mahdollisesti katteettomat odotukset ylittävät todellisen suorituskyvyn, jonka seurauksena on voimakas vastareaktio ja kielteisiä odotuksia. Tätä ilmiötä kutsutaan hypesykliksi konsulttiyhtiö Gartnerin mukaan.

Aiemmat tutkimukset ovat joko keskittyneet vain muutamaan teknologiaan, maantieteelliseen alueeseen tai vain lyhyelle ajanjaksolle. Tässä tutkimuksessa tutkitaan 16 teknologiaa tai läheistä konseptia Yhdysvalloissa, Saksassa, ja Brasiliassa ensimmäisestä saatavilla olleesta uutisartikkelista marraskuun 31. päivään vuonna 2015. Artikkelit kerättiin LexisNexis-palvelusta. Tutkimuksen tarkoituksena on selvittää mahdollisten hypesyklien esiintyminen artikkelien metadatan perusteella bibliometrisin metodein.

Yleisesti median kiinnostus tutkittuihin teknologioihin lisääntyi huomattavasti vuoden 2000 jälkeen useimpien teknologioiden tapauksessa Yhdysvalloissa ja Saksassa. Artikkelien vähäinen määrä Brasiliassa esti tarkemman analyysin, ja vain yhdestä teknologiasta ei löytynyt yhtään artikkelia. Vahva yhdennäköisyys hypesykliin löytyi kahdesta teknologiasta Yhdysvalloista ja kahdesta toisesta teknologiasta Saksasta. Kolme muuta teknologiaa saattaa olla nousemassa mediahuomion huipulle.

PREFACE

First, I would like to thank my examiner, Professor Saku Mäkinen, for his advice and patience during the writing of this thesis.

Second, I would like to thank my family and friends for having endured endless overtly positive estimates regarding the completion of this thesis, and the occasional vent.

Tampere, 14th of September 2016

Otto Rantanen

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ABBREVIATIONS

RIS file format	A tagged file format used for storing publication metadata for use in citations. The acronym comes from its developer, Research Information Systems.
VBA	Visual Basic for Applications.

1. INTRODUCTION

1.1 Importance

Emerging technologies can have a huge impact on individual businesses, industries, and society alike (Christensen & Rosenbloom, 1995; Kash & Rycroft, 2002). Being the first company to develop and successfully commercialize a certain technology can bring significant competitive advantages. This can lead to a further entrenchment of a market position for established companies, whereas a new entrant might disturb or even create a whole new industry, depending on the technology. Significant changes in technology can also cause major changes in how societies work and provide services to their citizens (Cagnin et al, 2013). Just like the invention of the automobile created a new industry and transformed modern society, so can new and emerging technologies do the same. Even changes at a much smaller level need to be taken into account.

For businesses, there are a few major questions regarding technologies that are extremely important. What are the technologies that we need to have access to in order to remain competitive in the market? Is access enough, or should we keep it to only ourselves? Should we develop the technology ourselves, or can we acquire the technology, patents, and other related things by acquiring other companies? Are there any other alternative emerging technologies that can threaten our business? What is the time frame, or how long do we have to monitor these technologies, decide, and act before it is too late?

1.2 Technological forecasting and bibliometrics

The study of the development of a technology has been called technology forecasting, technological forecasting, and technology foresight among other titles. The first official technological forecasting study was performed by the National Resources Committee in the United States in 1937 (Coates et al, 2001). Technological forecasting aims to provide answers to how technology develops, how it is developed, how products or services are adapted and diffused into the market, how the performance of a technology develops, and what kind of impact the technology might have on the industry and society, in addition to the questions mentioned previously, and not to mention other questions related to technologies and innovations.

An idealized model of the development of a technology is considered to consist of many overlapping stages. First there is the stage of basic or fundamental research, which tries to increase theoretical knowledge about a topic without any practical considerations. It is followed by applied research, which tries to solve practical problems using knowledge gained from basic research. This leads to the development of products, which is followed by production. Lastly, the said products are brought to the market, where adoption and diffusion begins.

This development of a technology can be approximated and tracked with indirect indicators (Watts and Porter, 1997). For example, basic research activity can be measured through the number of scientific articles appearing on journals, whereas applied research can be measured through new patent counts. Many indicators have been proposed for tracking the later stages of development (Watts and Porter, 1997; Jun, 2012a and 2012b; Bakker, 2010a), most of which involve mass media.

The Cambridge University Press dictionary (2015) describes hype as “a situation in which something is advertised and discussed in newspapers, on television, etc. a lot in order to attract everyone's interest”. The hype cycle model, developed by Jackie Fenn for the technology consulting company Gartner, tries to provide answers to companies about the maturity of certain technologies. The hype cycle model is focused on the later stages of development, when companies should be making decisions about which technologies to develop or acquire. This can be difficult, as some emerging technologies have been observed to produce unsubstantiated positive expectations, i.e. hype. These expectations can for example be about technical performance, the scope of problems that the technology will be able to solve, or how a large a market the companies can serve. The hype cycle model tries to approximate the stage of development by taking into account both the technical maturity and the level of hype in the mass media. The mechanics of hype have also been studied extensively without any relation to Gartner (i.a. Bakker, 2010a; Borup et al, 2006; Konrad, 2012; van Lente et al, 2013). Some amount of hype is seen to be necessary in order to attract the first investors and customers of new technologies.

Bibliometrics is the study of written works using statistical means (Pritchard, 1969). It has been used to identify the most important articles and authors in scientific fields, and the most important patents for certain technologies, for example. Combined with the concept of technology life-cycle indicators, bibliometrics provides a quantitative way to measure the development of a technology using indirect means. The underlying assumption is that as a technology matures and is being introduced into the market, mass media will produce more articles about the technology in question, which in turn can be tracked and used for estimations.

1.3 Research questions and structure

This study aims to provide information regarding the life- and hype cycles of certain waste management technologies and concepts. Identifying maturing technologies might provide competitive advantages to companies by new venues of research and development, or even identify new emerging markets. Identifying rising media interest might help other researchers to justify their research projects when applying for grants.

Previous studies have focused on only a few technologies at most and mainly for periods less than 10 years. In addition, the studies have for the most part included only one geographical region. This study includes 16 technologies or concepts starting from the first publication available up until March 2015 and from three countries, which should allow for more comparisons than before.

The purpose of this study is firstly to determine if any signs of a possible hype cycle can be found for the specific waste management concepts or technologies with a bibliometric method. Secondly, are there signs of any other trends and are there major differences between the countries?

This study is limited only to sources in the mass media and therefore to the later stages of development of a technology. All the data is collected from LexisNexis, a database which collects and provides access to articles from newspapers and trade magazines among other types of sources. The data is collected from the United States, Germany, and Brazil to see if any geographical or national differences exist. This data consists of article metadata, which will be harvested, analyzed, and plotted in order to search for any trends, major differences between countries or technologies, and other changes in publishing activity.

The theories and prior research concerning this study are explained in Section 2. The research method and its limitations are discussed in Section 3 and the results are shown in Section 4. Conclusions, reliability of this study, and suggestions for future research are discussed in Section 5.

2. THEORY

2.1 Technological forecasting

The aim of technological forecasting is to provide information and insights about technological change in advance of its actualization (Watts & Porter 1997, p. 25). Such information can be useful, for example, in deciding if a company should adopt certain technologies or when it should acquire the companies developing those technologies. Identifying the most important upcoming technologies in the value network is crucial for established companies and new entrants alike (Christensen & Rosenbloom 1995). Cozzens et al (2010, p. 361) agree that emerging technologies can be both great opportunities and threats. Goldenberg and Efroni (2001, p. 295) emphasize the need to understand market dynamics for companies whose strategy is to be “first and alone” in new markets with new products. Sood and Tellis (2005, p. 161) suggest an increasing pace of technological change, which could necessitate the development of effective monitoring tools for new technologies.

According to Coates et al (2001, p. 2) and Miles (2010, p. 1449) the first official technological forecasting study was published in 1937 by the National Resources committee in the United States. Its purpose was to predict the economic and societal impacts of 13 major innovations.

Further, Kash and Rycroft (2002) argue that transformational and transitive technologies and innovation activities can cause or require significant changes in networks between organizations. They define a transformation pattern as one that can result in a fundamentally different technology, and transitive pattern as a technology that can radically improve the underlying technology, but is not fundamentally different (ibid, p. 586). For example, the invention of the airplane would be a transformational technology, but moving from propeller-driven airplanes to jet planes would be a transitive technology. New transformative technologies and innovations will most likely require the creation of new networks between organizations as all the other related innovations and required knowledge might not be found in the existing network (ibid, pp. 588-590). Transitional innovations might also cause a need for existing networks to integrate new organizations and even for previously competing networks to start co-operating in order to reduce uncertainties related to the new technologies (ibid, pp. 596-597. In order to identify possible needs in the network, companies need to also identify essential new innovations and technologies well in advance. A similar find was made by Tushman and Anderson (1986, p. 444), who suggest that competence-enhancing innovations benefit the established companies the most, while competence-destroying innovations benefit new entrants. A more market-driven classification is made by Chris-Christensen (1997) who divides innovations into sustaining and disruptive innovations. Sustaining innovations improve the performance of existing technologies either incrementally or radically, but do not create new markets. A disruptive innovation, on the other hand, might have worse performance, but can create a whole new market for new products and services.

Taylor and Taylor (2012, p. 541) claim that there is confusion in terms of terminology between technology life cycles, product life cycles and industry life cycles and the actual targets of studies. Over 95% of the studies concentrate on the product life cycle alone (ibid. p. 542). They propose an integrated three tier approach to technology life cycles as presented in figure 1.

Increasing granularity	**Application**	Technology for recording and storing music						
↓	**Paradigm**	Analog - phonographic		Analog – magnetic			Digital	
	Generation	Cylinder	Record	Reel-to-reel	8-track cartridge	Compact cassette	Compact disc	MP3
	Increasing time →							

Figure 1. *A three-tier approach to analyzing technology life cycles, adapted from Taylor and Taylor (2012, p. 548)*

These three levels are: application, paradigm, and generation (ibid, pp. 547-548). Application considers what purpose a technology is meant to do, such as record music. A paradigm refers to a particular and defining way of providing that capability, such analog or digital ways of storing recorded music. A generation is one form or stage of a technical solution, but which still uses the same underlying principles as the previous or other ones of the same paradigm. Sood and Tellis (2005, p. 153) suggest a somewhat similar approach with platform innovations, component innovations and design innovations.

Mishra et al. (2002, pp. 3-4) have identified 31 different methods that have been or can be used in technological forecasting, which are represented in table 1. A good overview on the limitations of different forecasting techniques can be found in Mishra et al (2002, p. 6).

Table 1. *Technological forecasting techniques, adapted from Mishra et al. (2002, p. 4)*

Subjective assessment methods	**Exploratory methods**	**Normative methods**
Jury of executive opinion	Scenario developments	Operations research (OR) models and simulations
Sales force composite methods	Delphi approach	Network techniques
Formal surveys and market research-based assessments	Cross-impact matrices	System of Opportunities and Negatives (SOON) charts
Individual subjective probability assessments	Curve fitting and envelopes	Relevance trees, Planning Assistance Through Technical Evaluation of Relevance Numbers (PATTERN)
	Analogy methods	System dynamics
	Morphological research	Dynamic modeling
	Catastrophe theory	Phenomenological modeling
	Trend extrapolation	
	Simple analytical models	
	Multivariate analysis	
	Game theory	
	Growth models	
	Input–output models	
	Contextual mapping	
	Monitoring	
	System for Event Evaluation and Review (SEER)	
	Brain storming	
	Substitution analysis	
	Analytic Hierarchy Process (AHP)	
	Nominal Group Technique (NGT)	

Meade and Islam (1998, pp. 1127-1128) found 29 models for modeling technological diffusion, of which the logistics or s-curve is the most widely used. They suggest that more than one model should be used to enhance the accuracy of the forecast (ibid. p. 1115). Cagnin et al (2013, p. 381) also recommend combining models and tools and not to rely on a single solution for all cases. Eerola and Miles (2011, p. 267) also emphasize that researchers should familiarize themselves with multiple models or tools and use them as the need arises, rather than just use the tools one is already familiar with. Similarly Cazzens et al (2010, p. 375) recommend combining qualitative and quantitative techniques. Popper (2008, p. 66; 70) has identified 24 methods used in forecasting studies. Most widely used methods were qualitative in nature and five to six different methods were used on average in a forecasting study.

Daim et al (2006) provide classifications on the types of forecasting methods, which are collected in table 2. They also suggest different methods for different tasks and phases of technology forecasting, which are gathered in table 3.

Table 2. *Technological forecasting methods, adapted from Daim et al (2006, p. 983)*

Category	**Definition**	**Forecasting Methods**
Direct	Direct forecast of parameter(s) that measure an aspect of this technology	Expert Opinion (Delphi, Surveys, NG), time series, analysis, trend extrapolation (growth curves, substitution, life cycle)
Correlative	Correlative parameter(s) that measure the technology with parameters or other technologies	Scenarios, lead – lag indicators, cross impact, technology progress function, analogy
Structural	Explicit consideration of cause-and-effect relationships that effect growth	Causal models, regression analysis, simulation models (deterministic, stochastic, gaming), relevance trees, morphology

As can be seen in tables 1 and 2, many of the same methods appear in both tables. The differences lie in how the methods are categorized. Table 1 is categorized by what the methods are trying to measure, from current opinions and suspected trends (subjective assessment) to what these measured changes might cause in the future (exploratory), and what kind of changes are needed to cause a desired state in the future (normative). Table 2 is categorized by what kinds of parameters are being used.

Table 3. *Technology forecasting method selection table, adapted from Daim et al (2006 p. 1009)*

Data collection	Patent Analysis, Bibliometrics, Analogies, Delphi
Relationship building	Delphi, System Dynamics
Diffusion/forecasting	System Dynamics, Scenarios, Growth curves

Haegeman et al (2013, pp. 386-387) distinguish between quantitative, qualitative, and participatory methods and data. Quantitative data is expressed as numerical data, and quantitative methods rely on mathematical tools, whereas qualitative data is anything else other than numerical - such as text and images – and qualitative methods do not rely on mathematical tools. Participatory data can be both quantitative and qualitative, but the participatory method requires active participation from stakeholders.

The concept of technological forecasting relies on the assumption that innovation happens in a certain order, which can be observed, and the data gathered can be used to analyze and predict the state or rate of technological change. However, as Basberg (1987, p. 131) notes, "*most available methods of measuring technological change are indirect measures of the process. By this we mean that any indicators we might use will be able only to shed light on certain aspects or parts of the process*". Comparatively, Porter et al (1991, p. 114) suggest that technological change can be heralded by changes in other technologies and the socioeconomic environment, and that these changes can be monitored.

One model that has been used for modeling innovation is the linear model of innovation. It proposes that innovation happens in a specific order (Godin 2006, p. 639):

Basic research → Applied research → Development → Production → Diffusion

The model has been used widely previously (ibid, p. 640), although nowadays the model has fallen out of favor as new, more complex models have been developed. It is claimed to misrepresent the process of innovation as either too linear or that it ignores too much of the dynamic aspects of innovation. However, Balconi et al (2010) argue that much of the critique aimed at the linear model is misdirected or that the model is misunderstood.

Even if the linear model of innovation might be considered too simplistic, it can still be of use. As Lüdeke (2002) says, the value of models is not in their ability to certainly predict results, but rather in their ability to structure thinking. Haegeman et al (2013) also claim that for future-oriented technology analysis, models can be more useful as analytical tools than predictive tools. Additionally, as said by Tuomi (2012, p. 27) "*...the focus of future-oriented analysis should be learning, problem redefinition and innovative construction of new empirically relevant categories, not predictive modelling*". Regarding the linear model of innovation, Balconi et al (2010) argue that although reality is far more complex than the model might suggest, it is still a useful tool for innovation research.

2.2 Adoption and diffusion models

The diffusion rate of a technology – i.e. the proportion of people or organizations that have adopted a technology out of all possible adopters – as a function of time can be represented as a logistic curve also known as an s-curve, which was first used to model population growth. As can be seen from figure 2, generally the growth begins slowly, but soon turns into exponential growth which tapers off in the end as the marketplace is saturated.

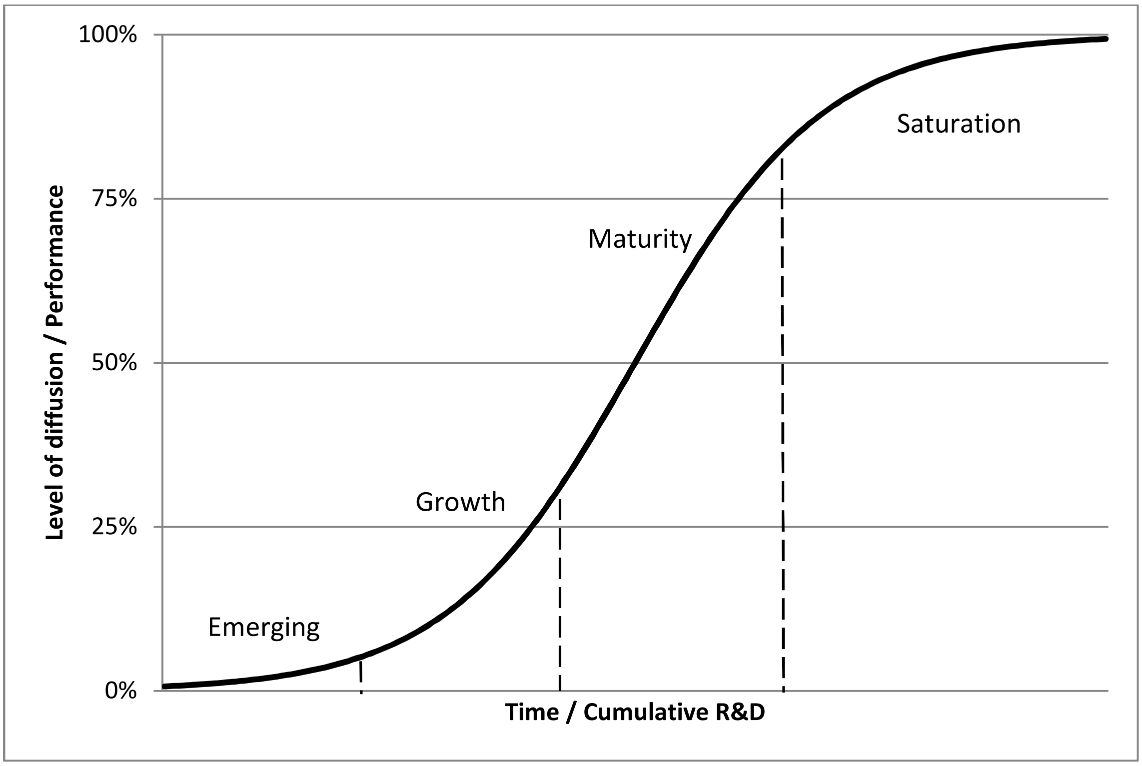

Figure 2. *Technology diffusion represented as a logistics or s-curve*

The product growth model by Bass (1969) and the substitution model for technological change by Fisher and Pry (1971) have both been used to model technological diffusion. The two models portray diffusion similarly as an s-curve, although they have different underlying assumptions. According to Meade and Islam (2006, p. 521), modeling the diffusion of a technology should fit the following criteria:

- Model validity: The product should be adoptable rather than consumable
- Statistical validity: Use of significance tests
- Demonstrable forecasting ability and validity: The forecast should be credible and the uncertainty should be measured

Islam and Meade (1997, p. 60) suggest that the actual diffusion patterns of successive generations of the same technology can be very different. For example, later generations of mobile phones in the late 1980s and early 1990s were found to spread much faster than their early counterparts.

Rogers (2003) suggests dividing potential adopters into five categories based on the time of the adoption and their general innovativeness. These categories are the innovators, early adopters, early majority, late majority, and laggards, innovators being the first to adopt an innovation and laggards being the last. The categories, as seen in figure 3, are assigned based on the mean time of adoption and its standard deviation, measuring 2.5%, 13.5%, 34.0%, 34.0%, and 16%.

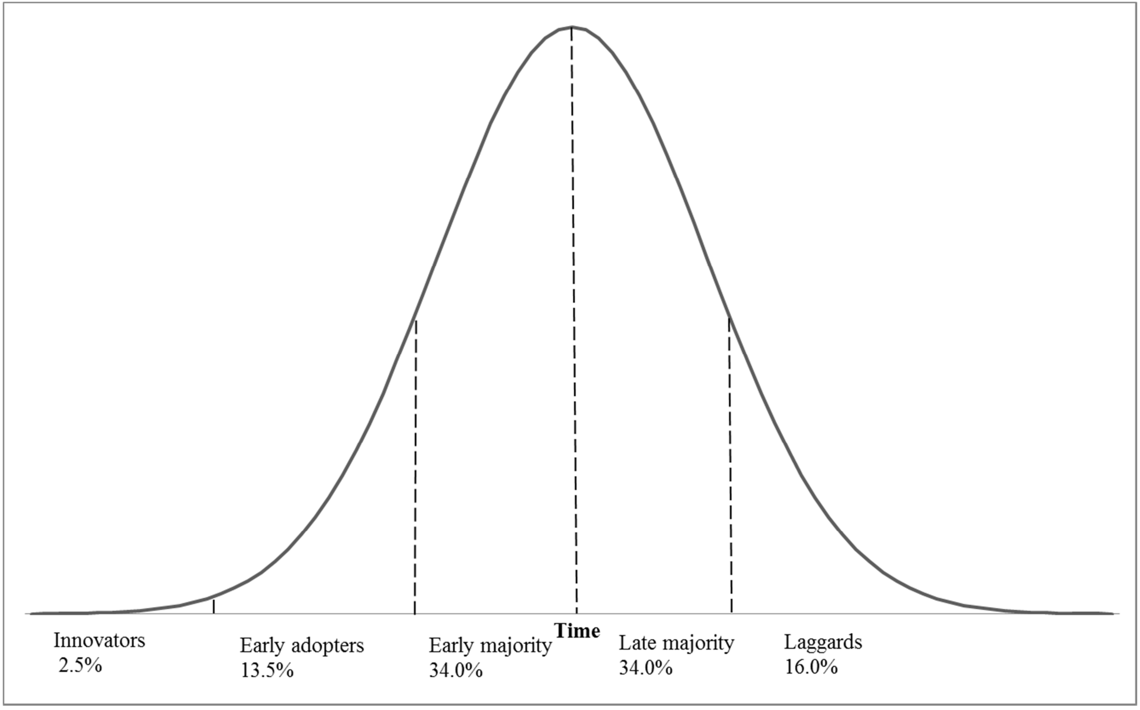

Figure 3. *Innovation adopter categories based on innovativeness, adapted from Rogers (2003, p. 281)*

The differences in innovativeness are thought to be due to the characteristics of the individuals (Rogers 2003). Innovators, for example, have more tolerance and appetite for risks, whereas the late majority is influenced more by peer pressure. The most important factors are socioeconomic status, personality values, and communication behaviour. According to Moore (1995), the differences between innovators and their needs and the early adopters and their needs are diverse enough that a lot marketing effort has to be made in order to get the innovations to "cross the chasm" i.e. for the adoption of the innovation to take off.

2.3 Bibliometrics

The statistical analysis of written publications was first labeled bibliometrics by Alan Pritchard (1969). It was at first used to determine the impact of certain authors or scientific articles in their respective fields. However, as computational power, algorithms, and databases have developed, more uses for the bibliometric methods have been found. Even though bibliometric methods are mostly quantitative, they are usually used to make qualitative assessments (Wallin 2005, p. 261).

Van Raan (2004, p. 4) explains the difference between data and bibliometric indicators as such: "*An indicator is the result of a specific mathematical operation (often simple* *arithmetic) with data. The mere number of citations of one publication in a certain time period is data. The measure in which such citation counts of all publications of a research group in a particular field are normalized to citation counts of all publications worldwide in the same field, is an indicator.* ***An indicator is a measure that explicitly addresses some assumption***" [emphasis added].

Abrahamson and Fairchild (1999, p. 717), for example, assumed that an increase in the number of all articles published during a certain year would also lead to an increase in articles concerning quality circles, regardless of any actual increase in interest about quality circles. In other words, a larger set of articles about anything would also contain a larger subset of articles about any particular topic. To adjust their data, they multiplied the number of quality circle articles during a certain year by the total number of all articles published during that year divided by the total number of articles published during a year in the middle of the data set.

In the case of technological forecasting, it could be assumed that the number of scientific articles or patent applications pertains to the level or rate of development in the innovation process, for example. However, as Basberg (1987, pp. 133-134) notes, not all innovations are represented by patenting activities, as shown in figure 4.

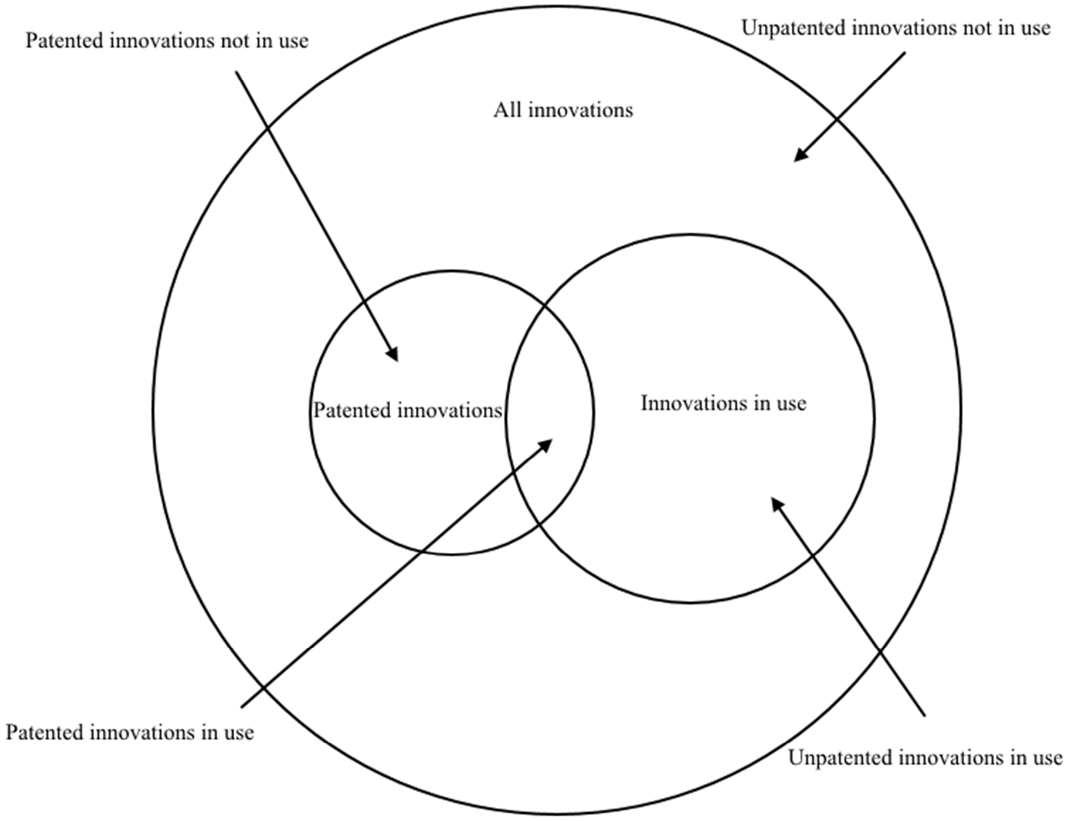

Figure 4. *Relationship between patenting, innovations, and inventions. Adapted from Basberg (1987, p. 133)*

If a company considers an innovation to have economic value, it will probably choose to protect it somehow. To do so, it will either have to try to patent the invention or hide its existence, depending on circumstances (Basberg 1987, p. 133). For example, some inventions are simply non-patentable under current laws, such as computer programs or algorithms in the European Union (European Patent Office 2013). The inventor might not be able to pay the costs of a patent application, or choose not to patent if the costs are higher than the expected income from the patent. Patenting might also be disadvantageous if it is easy for any other companies to simply circumvent the patent, or if the invention’s expected life span is either very short or very long compared to the life span of the patent (Basberg 1987, p. 134).

One of the limitations of bibliometrics is that it does not differentiate between the qualities of publications from their number (Watts & Porter 1997, p. 27). In other words, expert judgement is needed to assess any qualitative properties (Wallin 2005, p. 271). Also, it is possible that some institutions or companies might not even try to publish or patent their findings, which is not reflected in bibliometrics studies. Despite this, bibliometrics was found to be most widely used for identifying key technologies (Popper 2008, p. 80).

Regarding this limitation, Watts and Porter (1997, p. 44) found it very strange that General Motors and Chrysler – two large car manufacturers in the US – seemed to ignore certain important engine technologies, as they did not find any relevant patents or research publications in their name. Nelson (2009, p. 996) suggests that technology licenses provide a better view on what patents and technology are actually being utilized and therefore being adopted and diffused. Firstly, the licensee must value the patent enough to consider paying for the license. Secondly, the potential licensor must value the patent enough to monitor and enforce proper use of their patent. As both parties require a sufficient financial interest in order to sign a technology license, only the most important patents will be licensed.

Watts and Porter (1997, p. 27) also argue that the data used in forecasting is usually lacking, as the timescale for emerging technologies might be very short, public institutions might not have begun to collect relevant data, and the companies involved try to withhold information to suit their interests. Likewise, data sources that are closest to the markets have an inherent lag, which can prevent a timely strategic response according to Cozzens et al (2010, pp. 368-369). Mogoutov and Kahane (2007, p. 894) also warn against the possibility of having many false positives and false negatives – irrelevant articles and missing articles - when basing research on a newly appearing and poorly defined technological field. According to Popper (2008, p. 76) there is a clear absence of bibliometric studies concentrating on the far future.

Bengisu and Nekhili (2006, p. 840-842) studied the correlations between publication activity and patenting activity for certain technologies with regards to their perceived importance by a Delphi panel of experts. Some technologies, such as micro electro mechanical systems, were found to have high correlations in publishing and patenting activity and expert judgement, whereas over a quarter of technologies that had been decided to be important did not see much growth in either. They also found evidence suggesting that companies developing technologies related to hydrogen storage might be trying to hide their research and development activities, as the number of patents was increasing while the number of publications stayed nearly the same (ibid, p. 843).

Nelson et al (2014, pp. 928-929) identified four different mechanisms that can distort the apparent state of diffusion derived from analyzing keywords and index terms from the actual patterns of diffusion. These mechanisms are presented in table 4.

Table 4. *Diffusion pattern distortion mechanisms, adapted from Nelson et al (2014, p. 929)*

	Pre-labeled emergence	**Strategic avoidance**	**Symbolic adoption**	**Obliteration by incorporation**
Description	A common label does not yet exist	Practitioners avoid association with the label, possibly due to fears of bad hype	Organizations adopt in name only, no actual activity	Labeling is not explicit, as it is taken for granted
Measurement problem for researchers	False negatives (especially early on)	False negatives	False positives	False negatives (especially later on)

Identifying the correct search terms and databases is extremely important in bibliometrics in order to both find the most find relevant results and leave out the irrelevant ones. As said by Porter et al (2008, p. 715) regarding the bibliometric research of nanotechnology: "*A fundamental building block of this work involves development of an operational definition of nanotechnology in specific bibliometric terms.*" They found that although two different search algorithms can produce a similar number of search results, the results themselves can be considerably different or unique (ibid, p. 717). They also recommend that expert judgement can be helpful to both broaden the search and filter irrelevancies, although it will take more time and be harder to replicate in other studies (ibid, p. 717). Nelson et al (2014, p. 935) claim that basing research on keywords, index terms, or expert judgement will produce very different results especially in the first decade of a new technology.

2.4 Technology life-cycle indicators

Watts and Porter (1997, p. 29) propose certain indicators for measuring the development stage and rate for a certain technology, which are presented in table 5. The different subdivisions under the R&D profile reflect the stage of development of the technology in question. The databases are chosen based on relevant topics, i.e. technologies related to computer science should be searched in databases specializing in computer science. Using consumer search activity to monitor hype has been suggested by Jun (2012a).

Table 5. *Technology life-cycle indicators. Adapted from Watts and Porter (1997) and Jun (2012a).*

Stage	**Indicator**

Basic research	Number of items in databases such as Science Citation Index
Applied research	Number of items in databases such as Engineering Index
Development	Number of items in databases such as U.S. Patents
Application	Number of items in databases such as Newspaper Abstracts Daily
Social impacts	Issues raised in the Business and Popular Press abstracts
Growth rate	Trends over time in number of items
User hype	Search traffic in Google Trends

The rate of technological change or maturity can be estimated by searching for trends in the R&D profile data. In theory and as proposed by the linear model of innovation, the trends should follow each other as time passes. For example, a rise in the number of articles in scientific journals should be followed by a rise in the number of patents, which in turn should be followed by a rise in the number of newspaper articles. This was found to be the case by Daim and Suntharasaj (2009, pp. 50-51) with RFID technology. Likewise, as new scientific articles on a topic peter out, it should be followed by a decline in the number new patents. However, as Järvenpää et al (2011) have shown, this might not be the case with every technology. Paananen and Mäkinen (2013, p. 374) found a high correlation between media attention overall and the adoption of some renewable energy sources in the United Kingdom and Germany.

An idealized view on how the frequency of indicators should develop in relation to the development of technology is shown in figure 5. In reality - unlike in figure 5 - the levels of activity might not be of similar strength and the rates of ascend and descend will not be the same as well.

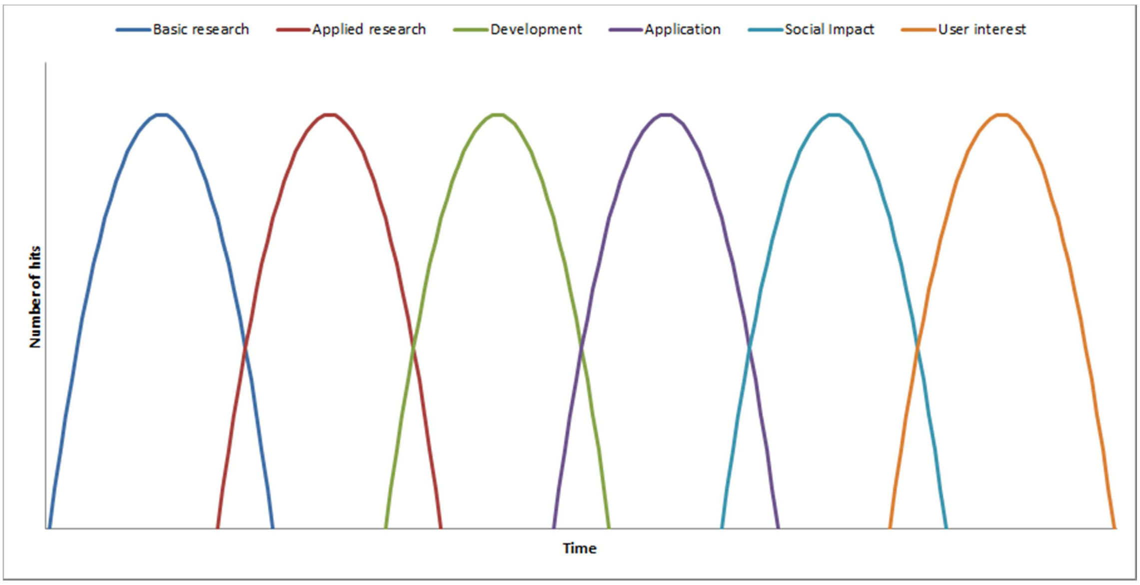

Figure 5. *Bibliometric estimate of stage of innovation. Adapted from Martino (2003, p. 721 and Jun (2012a, pp. 89-90)*

According to Nelson (2009, p. 1000) patent counts or even direct patent citations can mislead in relation to the diffusion and development of technologies. For example, it was discovered that in the case of technologies related to recombinant DNA counting only direct patent citations left out almost 90% of organizations that were developing or utilizing those technologies.

In addition, with a sufficient data set a logistics curve (s-curve) can be fitted, which can provide a rough estimate of the technology life-cycle. However, the s-curve demands certain assumptions to be made, such as the maximum value of the curve and the estimation of where the adoption of the technology is right now, which can be problematic if no suitable data exist.

Tushman and Anderson (1986, p. 443) propose that technological incontinuities and dominant designs are only apparent in retrospect and therefore hard to predict. Similarly, Tuomi (2012, p. 23) poses that detection and interpretation of progress and important changes can only happen when the future has already happened and the framing has been altered.

2.5 Hype and the hype cycle model

The hype cycle model was first published and used by the technology research and consulting firm Gartner in 1995. It is used to represent the conceived maturity of a technology based on its visibility and expectations in the mass media. (Fenn & Raskino 2011, p. 3)

Hype can be defined as “extravagant or intensive publicity or promotion” (Oxford University Press 2015) or “a situation in which something is advertised and discussed in newspapers, on television, etc. a lot in order to attract everyone's interest” (Cambridge University Press 2015).

Some amount of hype is seen to be necessary for new innovations that are being developed and introduced to the market. In addition to the technology developers’ point of view, the new innovations might need input from other parties as well, such as the developers of other related technologies, policy makers, investors, and research institutions, which together form an innovation network. However, at the same time, the actual competitive advantages, business models, future regulations, societal impacts, and other related factors are very uncertain. This leads to the fact that the companies involved have to rely on expectations about the technology rather than actual knowledge (Konrad et al 2012, p. 1084; van Lente et al 2013, p. 1616). Bakker (2010a, p. 6540) agrees that technologies may need positive expectations, but that they do not necessarily need to be realistic, just powerful enough and shared by many organizations to commit resources toward development. Strategic hype building can begin 5-10 years before market entry (Konrad et al 2012, p. 1091).

In some cases hype building can begin in earlier stages as well. Caulfield (2004, p. 338) thinks that as universities, other research institutions, and also individual researchers face increasing pressure to justify their research by potential short-term financial results, they can be compelled to exaggerate their findings. This in turn can be picked up and reported by the media, which will add to the hype. In this way early basic research can also influence the hype cycle. Brown (2003, p. 14) and Borup (2006, p. 292) note that the language used by research communities in press releases differs greatly from the language used in peer-reviewed journals, and is likely meant to persuade other actors to invest in their research.

Hekkert et al (2007, pp. 421-425) propose that these innovation systems or networks have the following functions:

1. Entrepreneurial activities
2. Knowledge development
3. Knowledge diffusion through networks
4. Guidance of the search
5. Market formation
6. Resources mobilization
7. Creation of legitimacy / Counteract resistance to change

According to Alkemade et al (2007) the activity of these functions can be analyzed separately with different indicators, which are presented in table 6. Negro et al (2008, pp. 61-63) posit a similar approach, although they divide the activity into positive and negative events, rather than simply activity. Their proposed indicators can be seen in Appendix A.

Table 6. *Activity indicators for innovation system functions, adapted from Alkemade et al (2007)*

Function	Indicators
Entrepreneurial activities	New entrants in the market, diversification activities, experiments with the new technology
Knowledge development	R&D projects, patents, investments in R&D
Knowledge diffusion through networks	Workshops, conferences, research collaborations, size and intensity of research network
Guidance of the search	Specific targets set by public or private actors, articles in professional journals about the technology
Market formation	Formation of new niche markets, specific tax regimes, new standards
Resources mobilization	R&D program funding
Creation of legitimacy/counteract resistance to change	Rise and growth of interest groups and lobbying actions

Much of technological forecasting studies concentrate on the producer or supply side of technological diffusion, while the hype cycle model concentrates on consumers and demand (Jun 2012b, p. 1414). Whereas many previous studies have been interested mainly in the earlier R&D parts of the innovation process – e.g. basic & applied research in addition to development – the hype cycle model is concerned with the later parts involving customer or user interaction and visibility, e.g. application and social impacts as presented in table 5.

The hype cycle consists of five parts: the technology trigger, the peak of inflated expectations, the trough of disillusionment, the slope of enlightenment, and the plateau of productivity (Fenn & Raskino 2011, pp. 4-5). These parts are presented in figure 6.

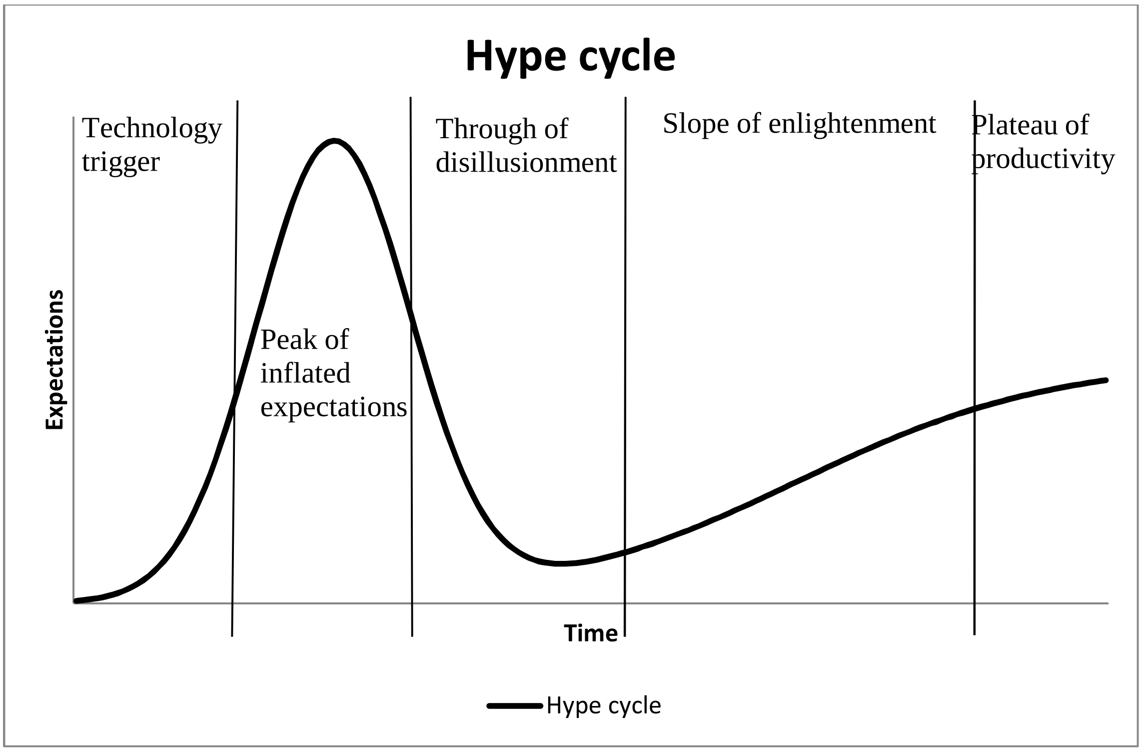

Figure 6. *Gartner hype cycle*

The cycle starts with **the technology trigger**, in which a technological or scientific breakthrough is made and that could provide a basis for new products or services. However, commercial viability is not yet proven and R&D is mostly proof-of-concept work (Fenn & Raskino 2011, pp. 4, 7). Media interest is low due to non-existent products and negligible marketing efforts (Jun 2012b, p. 155).

First products appear on the market at **the peak of inflated expectations**. Hype has reached mass media and is at its peak. The initial successes and failures pave way to next phase (Fenn & Raskino 2011, pp. 8-9). When the level of hype is high enough, some actors may feel the need to have to participate to maintain legitimacy due to collective expectations of the innovation network, even if they do not have any specific expectations i.e. see any other concrete benefits in doing so (Konrad 2006, p. 436; Nelson et al 2014, p. 928). Quet (2015, pp. 215-216) states that even vaguely related events can cause spikes in media interest. For example, a published study about the genetic modification of mice greatly increased worry in the French media about the prevalence of genetic doping by athletes, even though no one was actually caught or even suspected of using said doping method.

When the first generation products fail to reach customer expectations, the cycle shifts to **the trough of disillusionment**. In the absence of good products customer and media interest falls sharply and is mostly focused on the failures. Some companies might go bankrupt. The surviving companies either switch to other technologies or begin improving the current technology for second generation products in order to satisfy early adopters (Fenn & Raskino 2011, pp. 9-10; Jun 2012b, p. 155). The failure of individual projects can lead to decreased expectations, which can lead to the canceling of other projects, causing a cascade of failures and lowered expectations (Konrad 2006, p. 441). Furthermore, the technology itself does not need to fail, but just the expectations of it (Bakker 2010a, p. 6541). Additionally, these expectations can be completely different for different actors (Brown 2003, p. 10). For example, Verbong et al (2008, p. 569) suggest that focusing too much on the technical aspects of renewable energy technologies in Netherlands led to neglecting other important learning processes, such as mapping commercial prospects and communicating with legal and societal shareholders, which in turn led to problems in the implementation phase and resulted in negative hype.

Bakker et al (2012, p. 1070) also note that expectations can also compete with the expectations of other technologies or systems of technologies, and that failures to achieve previously set expectations can hinder that competition greatly in relation. Specifically, some actors are looking to drop losing technologies rather than pick winning ones (ibid, p. 1069). For example, expectations of large main frame computers for use in traffic control shifted to expectations of personal computers in the 1980s (Geels & Smit 2000, p. 877), whereas the development of hydrogen fuel cells for use in cars have suffered in comparison to plug-in hybrids (Bakker et al 2012, pp. 1069).

Konrad et al (2012, pp. 1092, 1095) show that the entry and exit strategies of these organizations can differ remarkably depending on the reasons why they tried to either develop or integrate the technology in question. The reasons for producing hype were found to be essentially attracting either customer or investor interest (ibid, p. 1091). When the technology hype cycle hit the trough of disillusionment, organizations that had participated mostly for image reasons ceased their activities (ibid. p. 1092), whereas organizations that had identified the technology as strategically important continued their involvement (ibid. p. 1095). Abandoning technologies with growing negative hype makes sense for companies that have adopted the technology only symbolically for public image reasons (Konrad, 2006; Nelson 2014). Dependence on public funding and external investors were also found to be important factors in how organizations reacted to negative hype.

As second generation products enter the market and other possible applications are found for the technology, **the slope of enlightenment** begins. As the understanding of the technology grows, companies will begin to adopt best practices and bring third generation products to the market. Customer and mass media interest are on the rise again, and more companies are becoming interested in the market. (Fenn & Raskino 2011, p. 10)

At **the plateau of productivity** the products are complete and final enough to drive mass-market adoption of the technology. However, less than 5% of the market has actually adopted the technology (Fenn & Raskino 2011, pp. 10-11). As can be inferred from figures 2, 3, and 6, a diffusion level of 5% is the result of much activity, even if market adoption is at its early stages.

According to van Lente et al. (2013, p. 1617), Borup et al (2006, pp. 291-292), and Brown and Michael (2003), the actual shape of the hype curve depends on the level and scale of expectations that is transmitted in the mass media. In other words, failures on project- or product-scale should not influence the curve as much as failures in general expectations. However, disappointment in actual products or implementations can result in great troubles for said product categories. In the case of general expectations the companies can reorient their efforts after a public disappointment, whereas it is much harder to do for products that have been evaluated on the market. In addition, each actor experiences the hype differently based on his level of access to the relevant information. I.e. a researcher on a topic will have a different reaction to hype compared to an investor or a politician.

In some cases, actors involved in the development of a technology might try to limit the effects of negative hype through communicated goals. For example, Bakker et al (2011, p. 158) found that some researchers were being vague about the goals of their research regarding hydrogen storage technologies, as they feared that failing to reach specific targets would increase disappointment and therefore reduce their funding. Some actors might strategically refrain from commonly used or hyped terms to distance themselves from the effects of possible negative hype (Nelson et al 2014, p. 928).

Abrahamson & Fairchild (1999, pp. 725-726) analyzed how the content of articles changed through time. They counted words associated with positive and negative evaluations, and words relating to thought and emotion. The discourse was found to be very emotional and positive during the phase of initial interest. Similarly, Konrad et al (2012, p. 1089) analyzed articles based on how optimistic they were about the technology rated from very optimistic to moderately optimistic, optimistic, no appraisal, and skeptical. The amount of optimism of all kinds rose quickly, followed by an increase in skepticism and a large drop in optimism.

The curve of the hype cycle consists of two components: engineering and business maturity and the level of hype in the media. At first some fundamental problems may still linger in the technical parts of the technology, and the actual business logic might not have been developed yet. As the technology develops technical challenges and business logic is solved. The development is presented in figure 7. Campani and Vaglio (2015) suggest measuring the two components separately: mass media for the hype level and patents and journals for technical maturity and normalizing them to produce a hype cycle curve. However, they do not provide much justification for this normalization. Steinert and Leifer (2010) and Dedehayir and Steinert (2016) instead reject Gartner's hype cycle model based on several factors. First, that the hype cycle measures two different phenomena and adding them to measure a third is not possible. Second, that these phenomena lack proper quantification and which again cannot be added together. Third, a single measurement for hype level does not differentiate enough between different types of actors with their own separate levels of hype. Steinert and Leifer (2010) conclude that due to these issues Gartner's hype cycle model is essentially unfalsifiable, and therefore can be rejected as a theory. Although Dedehayir and Steinert (2016) in addition find many inconsistencies in Gartner's own hype cycle reports and also find Gartner's model dubious, they consider the study of hype dynamics as important.

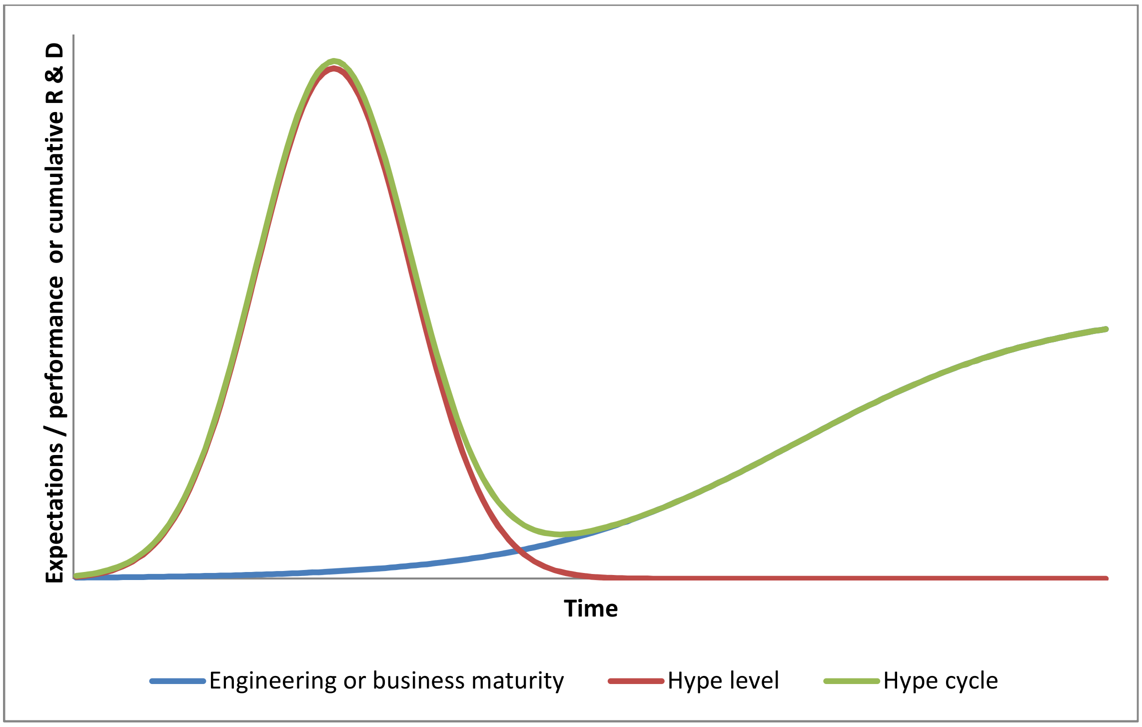

Figure 7. *The composition of the Gartner hype cycle, adapted from Fenn and Raskino (2011)*

Additional indicators for measuring hype activity have been proposed by Jun (2012b, p. 1418) and Bakker (2010a, pp. 6541-6543), which are presented in table 7. Patents, news, and search traffic have also been proposed as technology life cycle indicators.

Table 7. *Hype cycle actors and measurements for hype activity, adapted from Jun (2012b, p. 1418) and Bakker (2010a, pp. 6541-6543)*

Actor	Measurement
Production (researcher)	Patents
Media (network)	News
User (consumer)	Search traffic
Production (company)	Prototypes presented

	to the public
Production (company)	Company statements

Jun (2012a and 2012b) proposes that users might have a different hype stage than other actors and that search engine traffic might function as an indicator. Bakker (2010a, pp. 6541-6543) on the other hand studied the number of prototypes that were shown to the general public. He also studied how the public statements about the stage of the technology from involved companies changed from positive to modest, and finally to explanations why the technology failed to commercialize. More, he studied how the expectations of time frames changed over time, or how long it would take for the technology to be available based on the public hype.

Alkemade and Suurs (2012, p. 451) studied expectations for alternative fuels using event history analysis, which examines series of single events in order to track processes of changes. These events can be anything important to the innovation system, such as public declarations of positive or negative expectations or the setting of specific targets. The events were analyzed for the following content:

1. Positive or negative: Are the expectations positive or negative?
2. General or specific: How specific are the expectations? Does the expectation relate to the technology's performance in some regard or will the technology solve a societal problem?
3. Short or long term: Are the expectations about the near future or far future?
4. Actor type: Entrepreneur, government, knowledge institute, non-governmental organization, other
5. Is the technology first or second generation, if applicable?

All the examined technologies showed some hype cycle characteristics. First positive expectations rose, which was then followed by either decreasing positive expectations and/or increasing negative expectations (ibid pp. 452-454). They claim that increasing specificity and short term expectations for natural gas as a fuel could mean converging expectations, which could signal an approaching dominant design. Similarly, a lack of convergence in expectations for biofuels and hydrogen could indicate that the innovation system has not decided on the best core technologies. Bakker (2010b) and Pilkington (2004) also suggest - although for converging patent portfolios – that the appearance of similar technology choices might signal that companies have found the most promising technologies to commercialize. Bakker (2010b) however recognizes that studying the similarity of patents is somewhat difficult, as they are written in a way to give away as little actual technical information as possible in order to protect the companies.

On a more general level, O'Leary (2008, pp. 248-249) proposes three strategies for studying technology hype cycles, each with their own caveats:

1. Choose a single technology and follow it during its hype cycle from start to finish
2. Choose a single research methodology and study many technologies in similar hype cycle stages
3. Choose a single research methodology and technology and follow its hype cycle from start to finish

3. METHOD

3.1 Method

The research method was partially adapted from the "Steps of an innovation forecasting process" by Watts & Porter (1997, p. 31). The method is as follows:

1. First an initial search was done on certain topics in Web of Science and Google. These topics were provided by Professor Mäkinen.
2. The results were then analyzed for additional related concepts and topics. Suitable topics were in turn analyzed for further related topics.
3. Next, all the appropriate topics were translated from English into German and Portuguese using Google Translate. The resulting translations were used in Google and LexisNexis as search criteria to see if they produced any meaningful results. If not, either the translation was appended with a wildcard operator or another translation was chosen. This process was repeated until the translations were deemed sufficient. The translations are presented in Appendix B.
4. All the resulting topics were then used as search criteria in LexisNexis. The full list of search terms is presented in Appendix C.
5. First, article metadata was downloaded through LexisNexis' export metadata function. Next, the actual articles were downloaded using the export article function.
6. The metadata and articles were sorted into folders, processed and analyzed in Excel, after which the data was plotted into graphs in order to look for any trends and possible signs of hype cycles.

16 topics were chosen. The technologies and concepts that were studied are:

- Fluidized Bed Combustion / Fluidized Bed Boiler
- Landfill Gas
- Mechanical Biological Treatment
- Municipal Solid Waste
- Plasma Gasification
- Recovered Fuel Co-Firing
- Refuse-Derived Fuel
- Reverse Logistics
- Solid Waste Management
- Solid Recovered Fuel / Specified Recovered Fuel
- Sustainable Business
- Thermal Depolymerization
- Waste Gasification
- Waste Incineration
- Waste Pyrolysis
- Waste To Energy

The Portuguese and German translations for these 16 concepts can be found in Appendix B.

The process for exporting the metadata from English language sources is:

1. Use a web browser to access the LexisNexis site at http://www.lexisnexis.com/hottopics/lnacademic/.
2. Perform any search.
3. Log in using the provided username and password.
4. Click "New Search".
5. Click "Search by Subject or Topic", choose "All news".
6. Write the search terms.
7. Click "Advanced options".
8. Set Geographic location as:
9. By region: Country
10. By location: United States
11. Set "Sources" as:
12. Newspapers, Major world publications, Magazines,
13. Wire services, Blogs, Business and Industry news,
14. University newspapers, U.S. newspapers
15. Set the date range as needed.
16. Click "Ok".
17. Click "Search".
18. If only about 1000 documents or an error message are shown, choose "Edit search" and choose a narrower date range.
19. Sort: Oldest to newest.
20. Click the "Export bibliographic references" icon from the upper right corner of the result view.
21. Set "Document range" as:
22. Choose "All documents" if possible, otherwise choose a range of 250 documents
23. Set "Export Type" as
24. "Download Bibliographic Data for other generators, e.g. EndNote".
25. Click "Export".
26. Wait until the export is complete and download the file.
27. Repeat until all the documents are exported and downloaded.
28. Click "Edit Search" and choose another date range with fewer than 3000 documents.
29. Repeat until all the documents up to March 31, 2015 are exported and downloaded.
30. Move all the files into a folder.
31. Rename RIS files as needed to make sure that their chronological and alphabetical order is the same.
32. Open Windows Command Prompt and navigate to the said folder. Make sure no unneeded RIS files are in the folder.
33. Merge/concatenate the RIS files that were downloaded by using the command "copy *.ris Name.ris". This command copies the contents of all the ris files in alphabetical order to a new file.
34. Open the resulting RIS file with Excel and complete the import wizard, the resulting file should have 3 columns with data.

35. Importing RIS files with Portuguese or German text requires choosing "65001 - UTF 8" as "File Origin" in the text import wizard.

The method for German and (Brazilian) Portuguese differs from the aforementioned process in a few places:

5. Click "Search by Subject or Topic", choose "Foreign Language News".
7. Click “Advanced options”.
8. Choose German or Portuguese.
9. Continue as before.

Exporting whole articles is the same up to section 14.

15. In “Duplicate options” in the upper-right corner of the result view, choose “On – High similarity”. The page should reload and an asterisk should appear next to the document counter in the upper middle part of the result view.
16. Click the “Download documents” icon in the upper-right corner of the result view.
17. In “Format”, choose “PDF”.
18. In “Document View”, choose “Full Document”.
19. In “Font Options”, choose “Search Terms in Bold Type”. This makes it easier to locate the search terms in the documents.
20. In “Document Range”, choose “All Documents” if there are less than 1000 documents. Otherwise set a range with less than 1000 documents.
21. Click “Download”.
22. Wait until the export is complete and download the file.
23. Repeat until all the documents are exported and downloaded. The final export and download action might be interrupted with a small red note in the export window, saying that the number of documents is actually smaller than previously reported. This is due to the duplicate filter finding more duplicates. When this happens, adjust the upper limit of the document range as needed.
24. Move all the files into the correct folder.

3.2 Excel Scripts

Several scripts were developed in Excel with Visual Basic for Applications (VBA) to facilitate data filtering and analysis. The purposes of these scripts were threefold:

1. Find and remove duplicate articles in the original downloaded data
   - The script compares article headlines, publishing dates, and sources. If all match, one article is considered as a duplicate and is removed. If publishing dates do not match, the article is considered a republishing or a correction and is not removed. If the sources do not match, the article is considered syndicated content and is not removed.
2. Parse the filtered data to find articles and their dates and sources
3. Do additional processing and analysis of sources

The script that finds and removes duplicates had to be limited to search for duplicates only in the next 500 articles due to performance reasons. This means that it is possible that some duplicates still exist if, for example, the same article appears as a duplicate months or years after the first publication, which depends on the total number of articles. The scripts are available upon request.

3.3 Limitations of LexisNexis and metadata

There are some difficulties and impediments that have to be addressed that are related to how LexisNexis operates. Some are mere annoyances, while others might reduce the validity of the study if no additional precautions or measures are taken.

The first limitation is that only 3000 search results are shown, and if more results are found, then only the 1000 most relevant will be shown. It is not apparent what LexisNexis considers the most relevant. The results cannot be arranged by date before this happens so the user will have no idea when or what is the point where the results exceed 3000. This necessitates many additional searches as the date range is narrowed down. Additionally, bibliographic data can only be exported and downloaded in chunks of 250 documents. Each of these searches and exports need manual work. The concept “waste to energy” ultimately resulted in 43567 articles in the United States. At minimum this would necessitate 15 separate searches and 175 uses of the export function and individual files to download. In practice, metadata for the duplicate articles had to be also downloaded, and since the cut-off point for the 3000 search results could not be predicted the date ranges were conservative, resulting in at least three times as many searches as in the minimum case. The amount and monotony of manual work could easily result in human errors. The truncation of search results also disallows the normalization of search results based on total article counts, as mentioned in section 2.3. LexisNexis also does not publish this information anywhere else on the site.

The service sometimes fails to tell the user about these limitations with an error message, so either the user has to manually verify all the results or end up with incomplete or invalid data. At other times the server script simply crashes.

Some relevant metadata is not exported at all, even if the RIS format would allow it and the LexisNexis service itself uses and shows this metadata. Even the remaining metadata can be exported incorrectly, which necessitates manual correction in Excel.

The searches also produce many duplicate documents, some of which are legitimate syndicated articles, some are due to slightly differing metadata, and it is possible that the server scripts themselves might contain serious bugs. LexisNexis has a built-in duplicate checker and filter, but using it disables the export function of bibliographic metadata completely. For some reason, the duplicate filter can be enabled normally when exporting whole articles and the filter actually works at a higher precision.

Foreign language news can only be searched by language, which is problematic for Portuguese, as it is spoken in many other countries than just Brazil. Over one third of Portuguese sources had to be removed manually, because they included articles published by Portuguese, Senegalese and Mozambican sources among others. LexisNexis also provides a geographical filter, but it does not seem to filter source locations, but rather if a specific place is mentioned in the content. So, for example, an article written in English and published in Indonesia about a landfill gas plant in Iowa would pass the geographic filter for United States and be considered an American source.

The source selection for the US contains 4811 unique sources, of which only 3614 are being kept up-to-date. This could result in a lower number of articles and a milder possible hype cycle trend if the abandoned sources were of relatively high importance for the technology in question. The same numbers for sources are 236 and 211 for Germany, and 20 and 12 in the case of Brazil.

The source selection also contains 3480 duplicate sources, i.e. some sources appear both as "Newspapers" and "Magazines", for example. It is unknown if the duplicate documents result from these duplicate sources, although no duplicate sources could be seen in the left-side menu of the search result box in LexisNexis.

Largest single source category – as in “Newspapers” or “Magazines” - contains only 2249 sources. So, either the source selection has to be severely limited or a risk of downloading many duplicate documents and removing them afterwards has to be taken. It has to be noted that duplicate documents appear even with other types of search.

An example of the severity of duplicate documents can be seen with the search term "Municipal solid waste". The article "Connecticut officials OK mattress recycling plan" appears between January 6th 2015 and January 14th 2015 as 356 separate articles. The built-in duplicate checker finds only 164 duplicate articles on "moderate similarity", and only 149 duplicate articles on "high similarity", so more than half of the duplicates would remain even if exporting was possible. This causes a major distortion in the data, as there are about 750 articles in total between January 1th 2015 and March 31th 2015. However, the duplicate removal script should remove most of these cases.

Due to the number of possible sources and gaps in the LexisNexis’ metadata, any classification of articles by source type – such as newspaper or trade journal – relies on manual work and takes a lot of time. However, it was discovered that there exists a strong pareto distribution between sources and article counts i.e. the top 10% of sources might include over 80% of all the articles written. This was utilized when classifying the American sources into categories. Sources were selected for further analysis depending on the number and distribution of articles of a technology. The technologies that had many articles only the sources that had published over 10 articles were chosen, and for the rest sources were selected until at least 80% coverage was gained. All these sources were then combined and checked for duplicates and used for filtering the articles. The resulting table therefore also contained sources for other technologies that either had not published at least 10 articles or was not included in the 80% coverage selection, resulting in even greater coverage. Ergo, at the very least the coverage for all the technologies is 80%, but likely it is higher. It is however possible that the sources that were left out might distort the data and the resulting charts.

3.4 Limitations of the research method

A serious limitation arises from the fact that most technologies are either too complex or networked to be clearly defined as sets of search terms, as suggested by Haupt et al (2007, p. 388). Landfill gas, for example, is an umbrella concept that is inclusive to many specific technologies related to producing, capturing, transferring, and utilizing said gas. In order to fully estimate the development of those specific technologies, they would have to be identified and tracked separately with sufficient granularity. However, the general concept might be more suitable for research in the non-technical mass media.

Huang et al (2011, pp. 154-155) argue that in the case of patents a search using keywords will be less precise than one using patent classes. Firstly, keywords might not encompass wholly the relevant technology such as with the landfill gas example and according to Haupt et al (2007, p. 338). Secondly, patents, research articles, and stories in the mass media might contain irrelevant buzz words to stoke interest. Using keywords is also prone to biasing search results towards subjects that the researchers are acquainted with (Huang et al 2011, p. 155).

This study is closest to O’Leary’s (2008, pp. 248-249) second strategy i.e. pick a single research method and use it to study many different technologies. This strategy has some disadvantages, however. With 16 technologies or concepts, having extensive or deep knowledge about a single technology becomes very difficult.

3.5 Other limitations

It has to be noted that the author is not proficient in either German or Portuguese, and much trust has been placed in Google Translate. Even though the translations were checked to produce meaningful search results, it is still possible that they could be wrong or at least have wrong forms or syntax. An effort was made to circumvent this problem by leaving out any articles and determiners from the search terms. Additionally, some words were truncated with the exclamation mark (!) operator to account for any possible forms that a word might have. The Portuguese search terms in particular had to be modified this way. The truncation points were decided by searching for other forms of the words in the LexisNexis search results. The truncated search terms were then connected with the “W/n” connector, which allows the search terms to appear within n words of each other in the text. Although this allowed some flexibility with the search terms, it is possible that more irrelevant documents were found as a result.

4. DATA AND RESULTS

4.1 Metrics and data presentation

Four metrics were chosen from the data to be studied. These metrics are **the number of unique articles published per month**, **the cumulative number of unique articles, the cumulative number of unique sources that published those articles**, and **the ratio of published articles per month and their sources**. These metrics were then plotted into four different line charts.

The cumulative number of articles represents the accumulation of articles through time. Another important aspect is that it also shows long-term growth trends. In this study, the number of articles is expected to be an indirect indicator for the level of interest in the media. The y-axis is set to a logarithmic scale to better fit the data for all the countries in one chart. It has to be noted that because of this any seemingly straight lines actually represent exponential growth instead of linear growth. The starting point for data is the first time an article has been published.

The cumulative numbers of articles are represented in two charts, the first with all the articles together by geographical location, and the second with the articles divided into source types in the United States, as it had the most available and diverse set of sources.

The cumulative number of sources indicates how many sources have been interested in publishing articles about the technologies. This is to distinguish between the interests of specialized sources - e.g. trade magazines - and general sources such as newspapers. The y-axis is also set as log10 and the starting point is the same as for the articles. Sources which were discontinued have been removed from the removal date onwards.

The number of articles per month or monthly frequency indicates short-term trends in media interest. The y-axis was set to linear to enhance the visibility of the fluctuations and differences of scale between the countries. The fluctuations can however obscure major trends and therefore a trend line of a 12-month moving average was plotted to filter out any short-term fluctuations. The frequencies are also divided into two charts, first containing all the articles by country and the second containing articles from the United States categorized into two source types. Only newspapers and trade journals and magazines were chosen for the latter, as they resemble previous studies most closely. The countries were divided into two charts if the orders of magnitude were significantly different. The starting point was set to 1st of January 2000 to highlight the latest growth trends.

The article to source ratio is the number of unique articles per month divided by the number of unique sources per month. The purpose of this chart is to highlight potential date ranges of interest. The starting point was set to the first appearance of an article.

The level or width and breadth of media interest should change according to the position of the technology in the hype cycle. The proposed ratio is a tentative guide to pick interesting points in the data. High ratios could result from increased media interest in general or from increased interest focusing on specific sources. Low ratios could result from low interest, but also from a high number of sources publishing only a few articles. However, additional research should be done to distinguish and classify real events or trends from noise.

Charts that had only a few points of data are not included. The ending point for the data was set as 31st March 2015 for all the charts.

4.2 Fluidized bed combustion or boiler

Figure 8 shows the progression of article accumulation and growth rate. There is a clear lag in the interest of Germany and Brazil compared to The United States. Brazil can be found in the lower right corner.

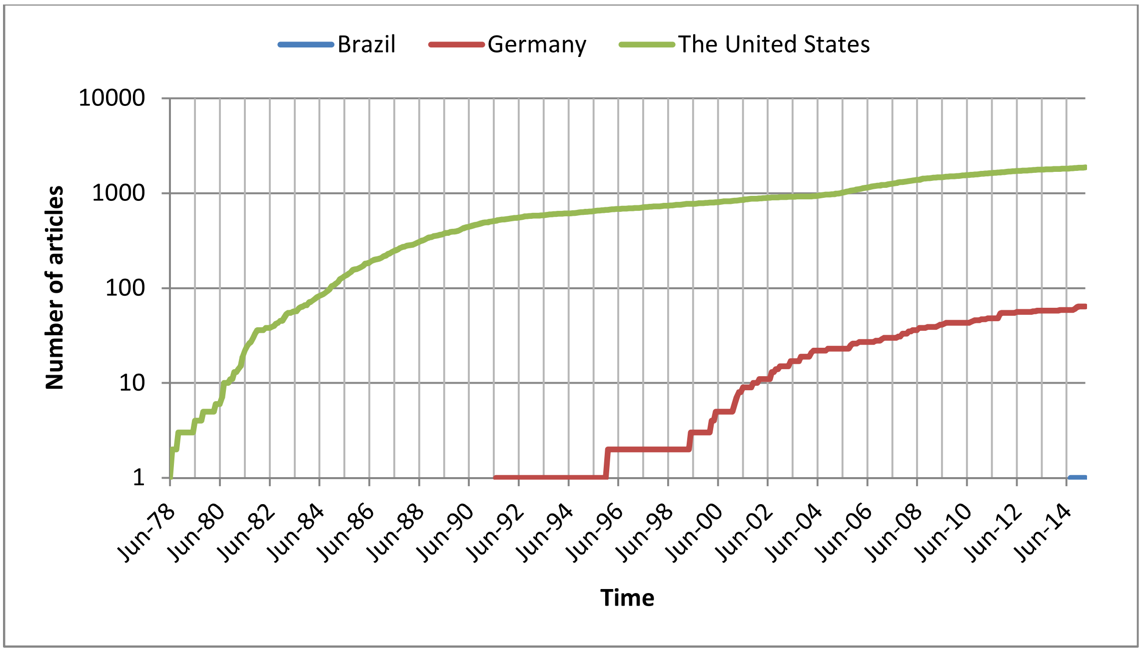

Figure 8. *Cumulative number of articles from the first article to 31st of March 2015 for fluidized bed combustion or boiler.*

A likewise progression can be seen in figure 9 with regards to the number of sources that have published articles about the technology in question. Both Germany and the United States exhibit a period of growing interest starting in May 2007 and November 2003, but that growth seems to be slowing down.

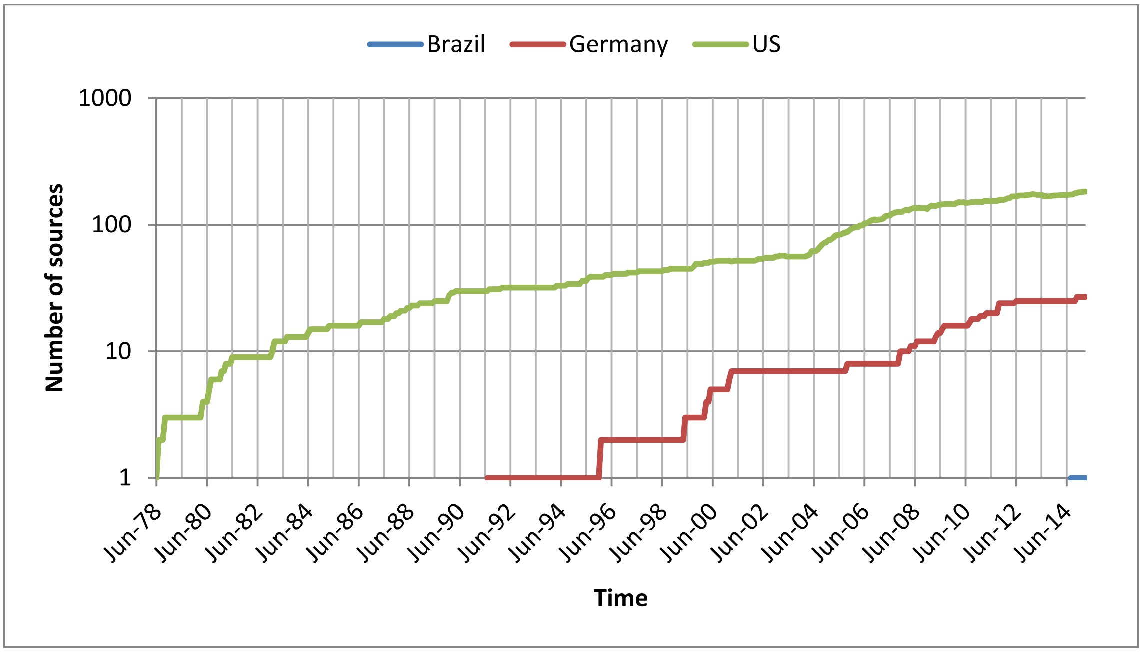

Figure 9. *Cumulative number of sources from the first article to 31st of March 2015 for fluidized bed combustion or boiler.*

The United States clearly has a higher frequency of new articles per month, as can be seen in figure 10. The number of new articles is very modest in comparison in Germany and barely noticeable in Brazil in August 2014. The trend line for the US shows a slight peak in mid-2006 and a decreasing interest after that.

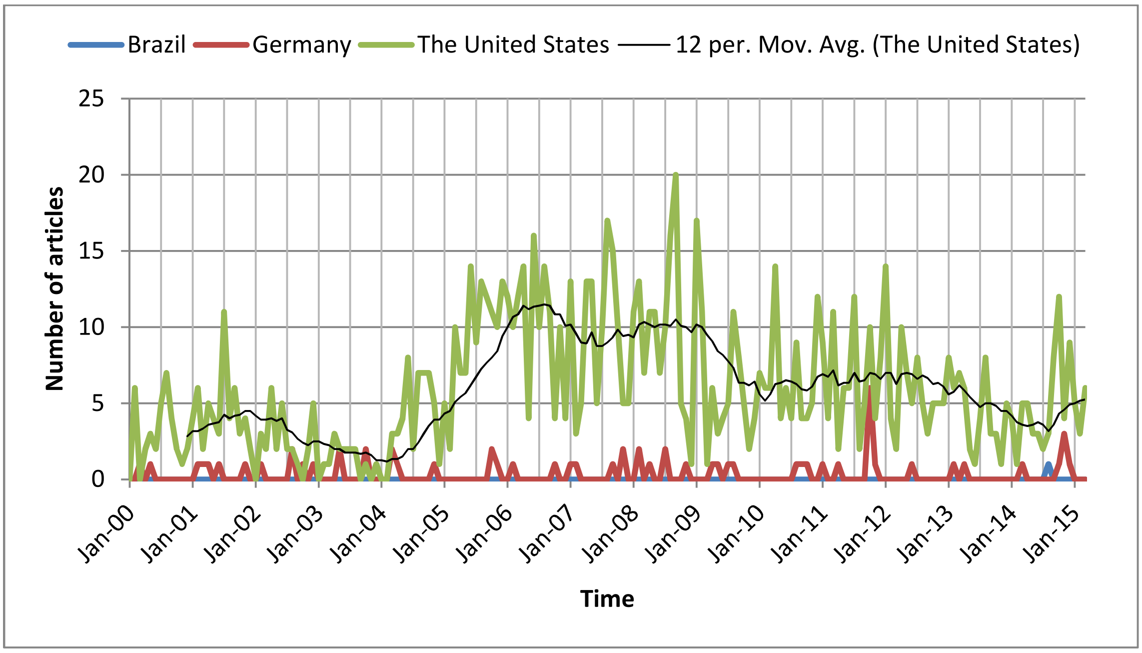

Figure 10. *Frequency of published articles per month from 1st of January 2000 to 31st of March 2015 for fluidized bed combustion or boiler.*

In figure 11 the sources are divided into different categories based on their type. As can be seen, trade journals and magazines outnumber every other category and exhibit greater growth after year 2005. None of the other technologies studied have trade jour-journals as the highest article type. Article counts seem to have increasing since the mid-80s.

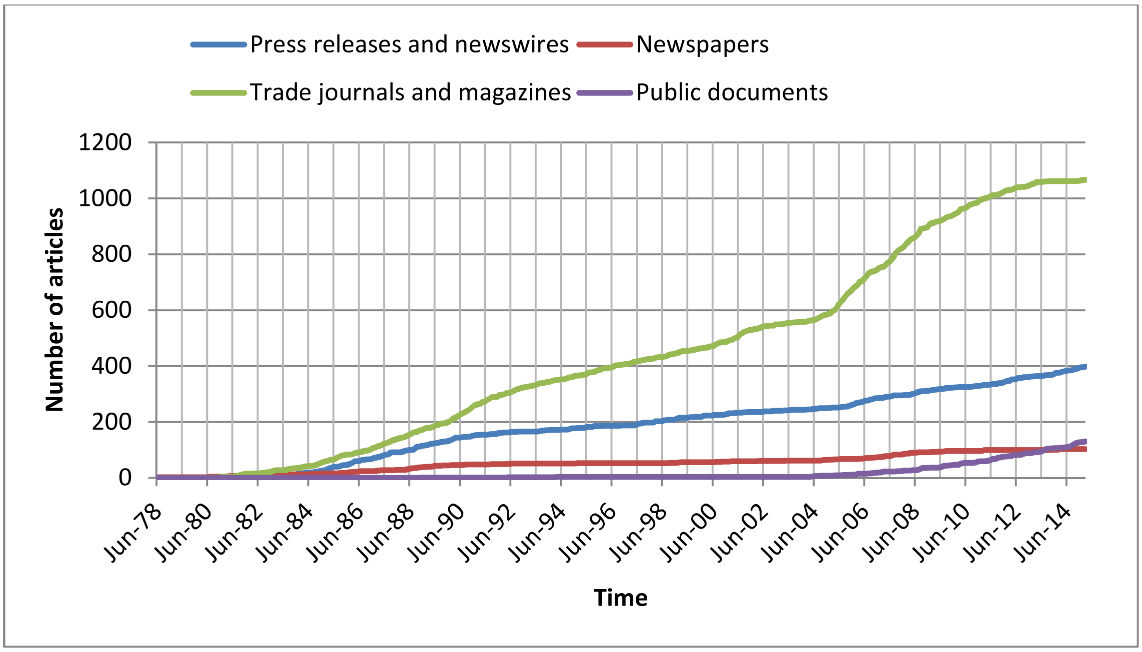

Figure 11. *Cumulative number of articles by source type in the United States from the first article to 31st of March 2015 for fluidized bed combustion or boiler.*

Figure 12 shows monthly trends for newspapers and trade journals. There is very little activity for newspapers, whereas trade journals seem to have experienced growth between 2005 and 2006, but interest seems to have waned since then.

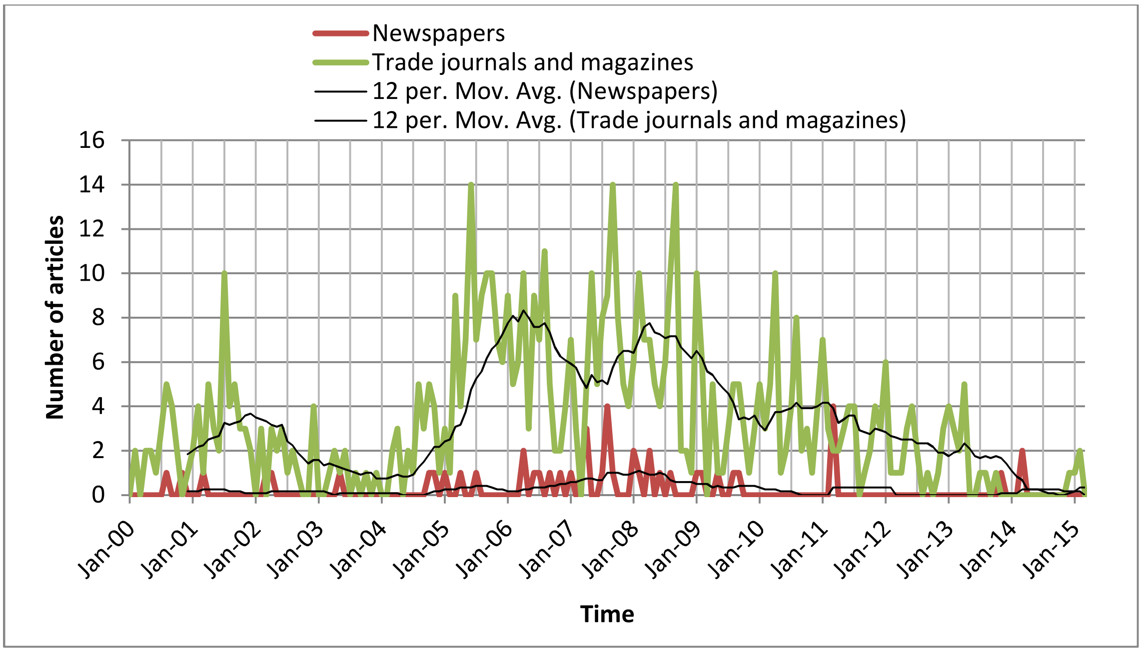

Figure 12. *Number of articles per month by source type in the United States from 1st of January 2000 to 31st of March 2015 for fluidized bed combustion or boiler.*

Although activity for newspapers is very low, the highest activity seems to have coincided with trade journal activity. Activity became almost non-existent for both in 2014.

4.3 Landfill gas

A similar lag in the date of the first article and their numbers between different countries can be seen in figure 13. In the United States, there appears to have been two periods of high growth: the 1980s and after late 2004. In Germany, growth has been relatively high since 2000.

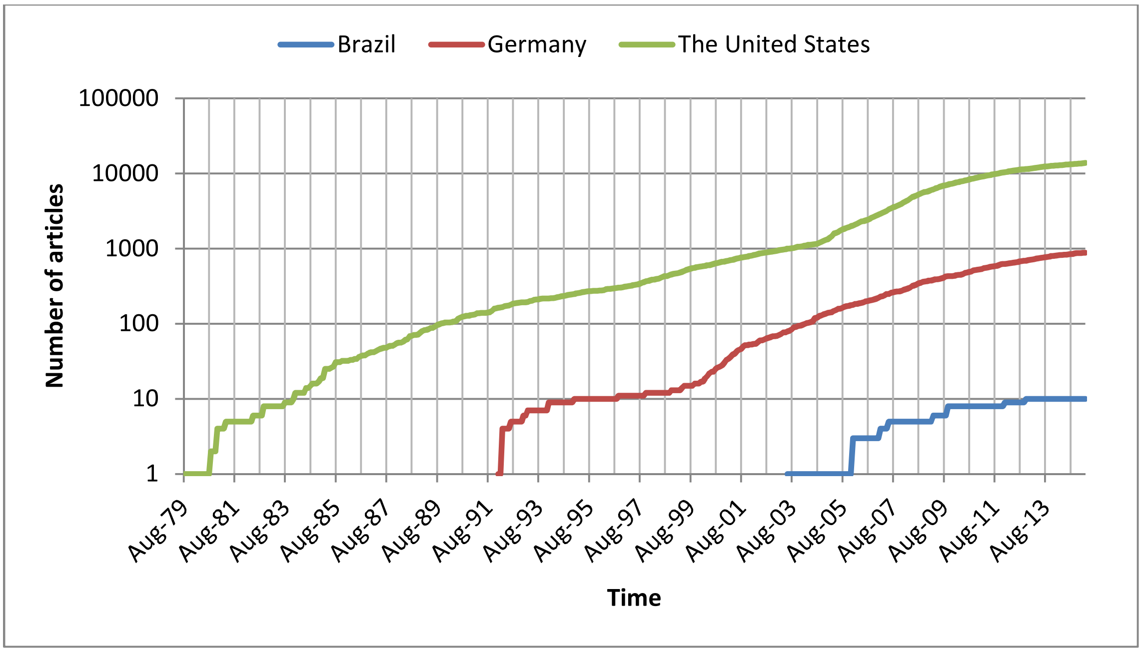

Figure 13. *Cumulative number of articles from the first article to 31st of March 2015 for landfill gas.*

Similar growth with sources can be seen in figure 14. In the United States, interest seems to increase at a fairly steady rate until 2004, after which the growth rate increases. In Germany, the number of sources decreased between late 2001 and mid-2004, even though the number of articles continued to grow.

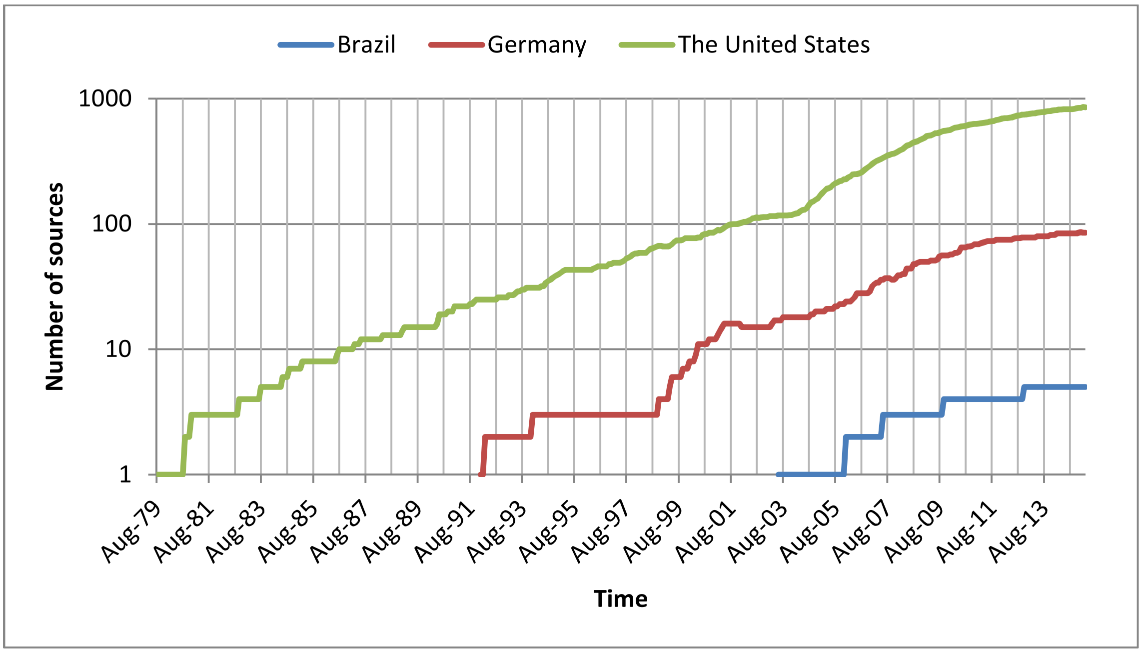

Figure 14. *Cumulative number of sources from the first article to 31st of March 2015 for landfill gas.*

As can be seen in figures 15 and 16, the scale is roughly tenfold between the US and Germany, and Germany and Brazil. The increase in monthly frequency in the US is quite clear. The trends for the US and Germany show that media interest has increased after 2004, producing a peak for the US but not for Germany.

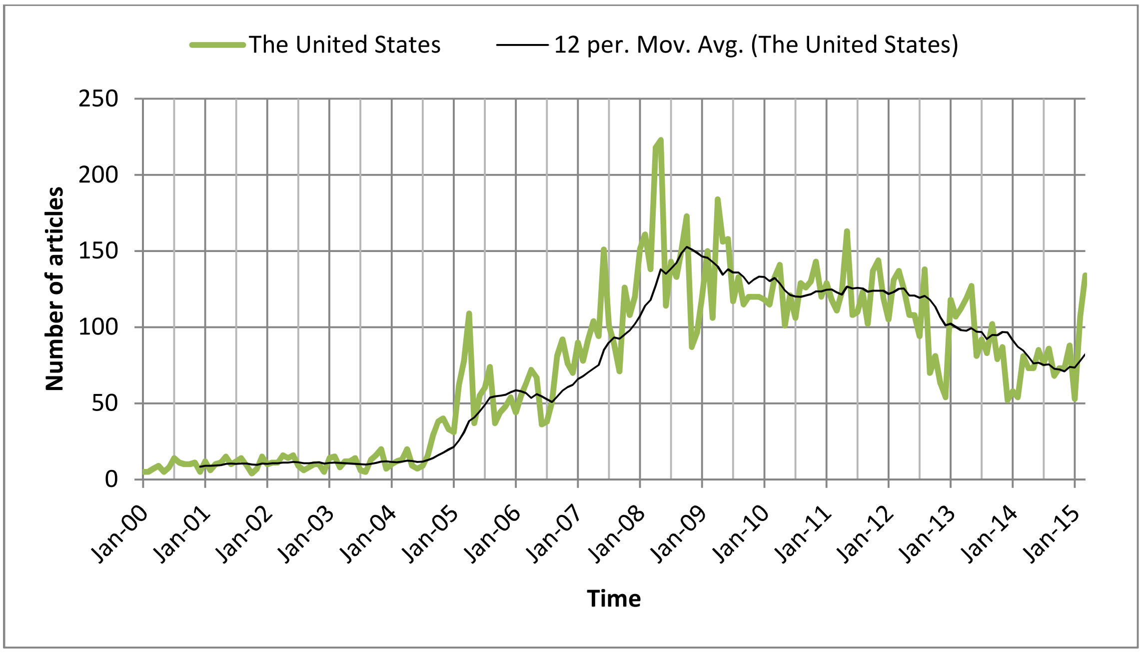

Figure 15. *Frequency of published articles per month from 1st of January 2000 to 31st of March 2015 for landfill gas.*

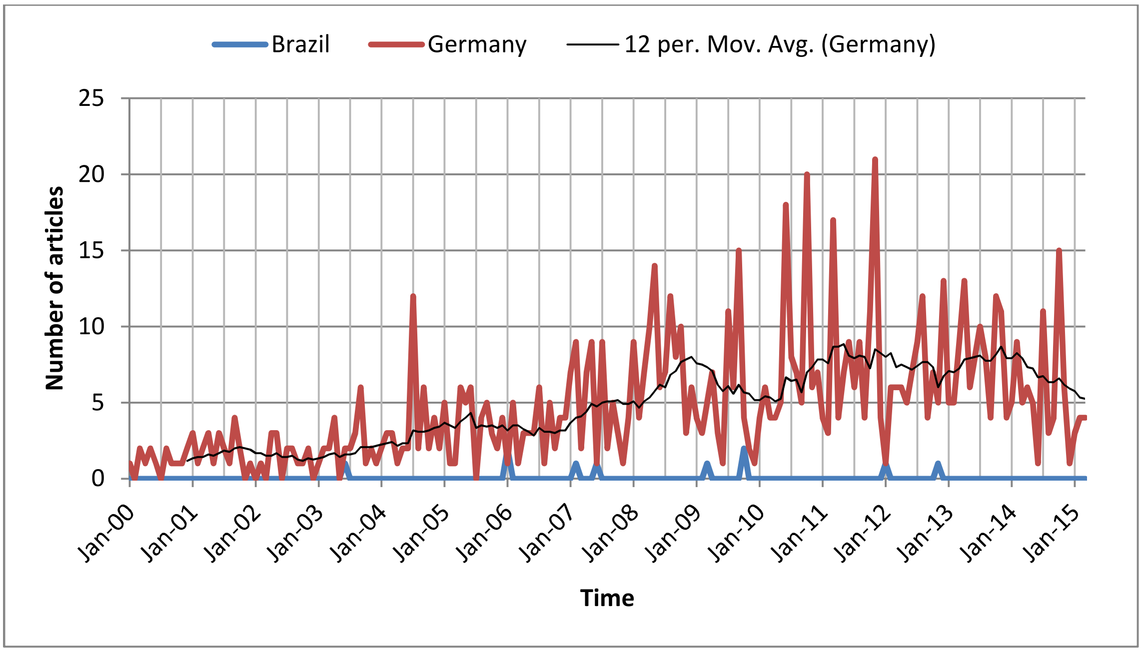

Figure 16. *Frequency of published articles per month from 1st of January 2000 to 31st of March 2015 for landfill gas.*

In figure 17 only few peaks stand out, the largest being December 2012 for Germany. There is also one peak for Germany in November 2011, and April 1997 and March 1999 for the US.

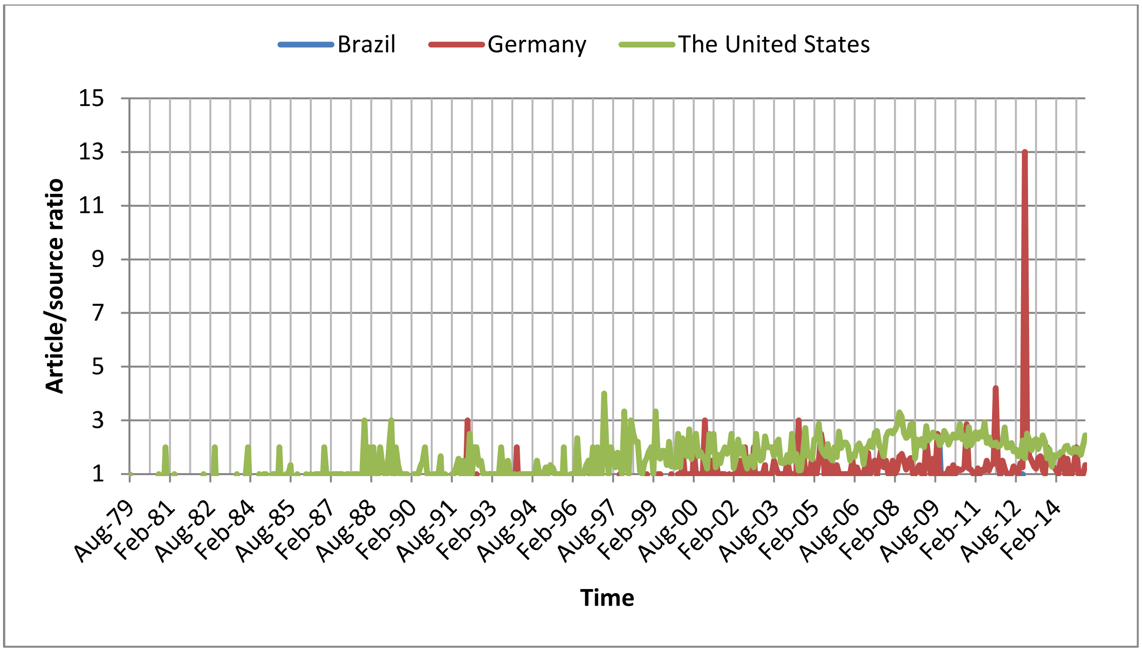

Figure 17. *The ratio of articles to sources per month from the first article to 31st of March 2015 for landfill gas.*

A long lag between the first article and growth is exhibited in figure 18. Press releases are the most numerous articles, which could indicate business opportunities or at least keeping up appearances by companies. There are clear take-off points for all article types after 2004.

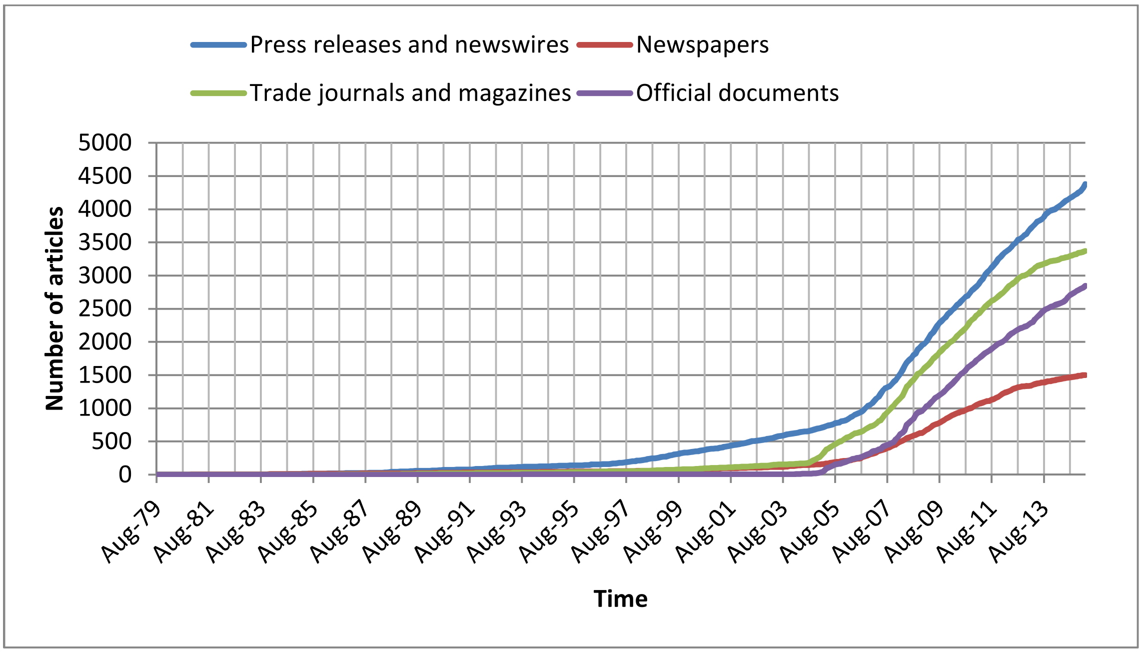

Figure 18. *Cumulative number of articles by source type in the United States from the first article to 31st of March 2015 for landfill gas.*

The starting points for growth can be seen in figure 19. However, it seems that interest has started to decline after 2008 for trade journals and 2009 for newspapers.

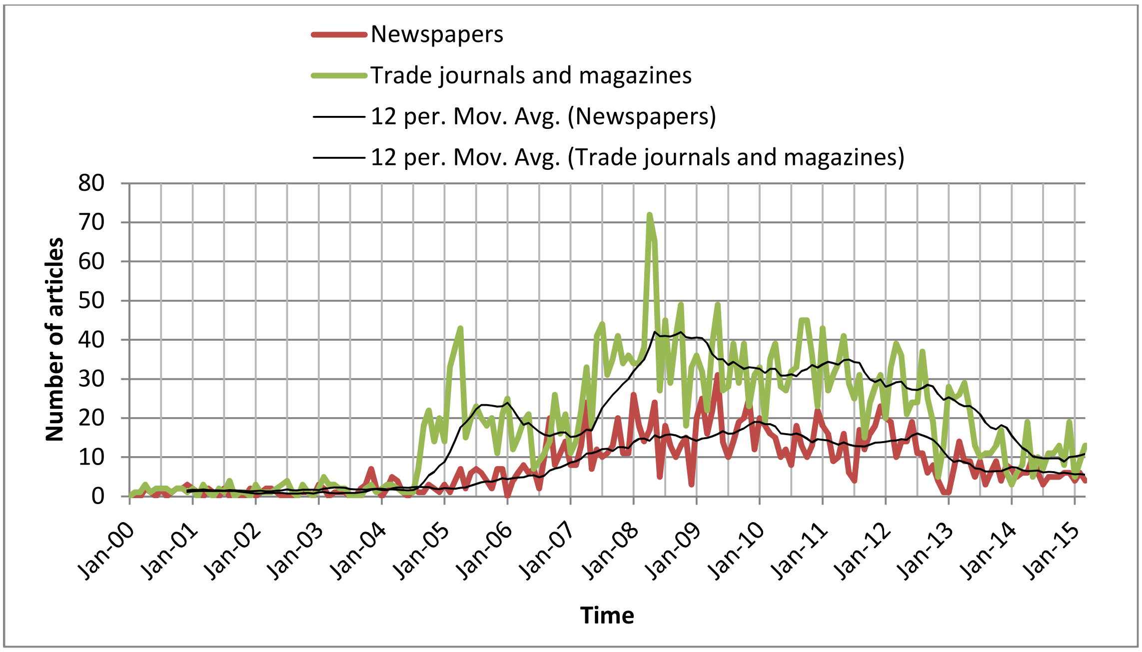

Figure 19. *Number of articles per month by source type in the United States from 1st of January 2000 to 31st of March 2015 for landfill gas.*

Two periods pop up in activity in trade journals: April 2005 and April 2008. For some reason, about 2-3 times as many articles were written during those months than in the preceding months.

4.4 Mechanical biological treatment

For mechanical biological treatment media interest in Germany predates that of the US, although the latter has been closing the gap, which is presented in figure 20. No articles were found for Brazil.

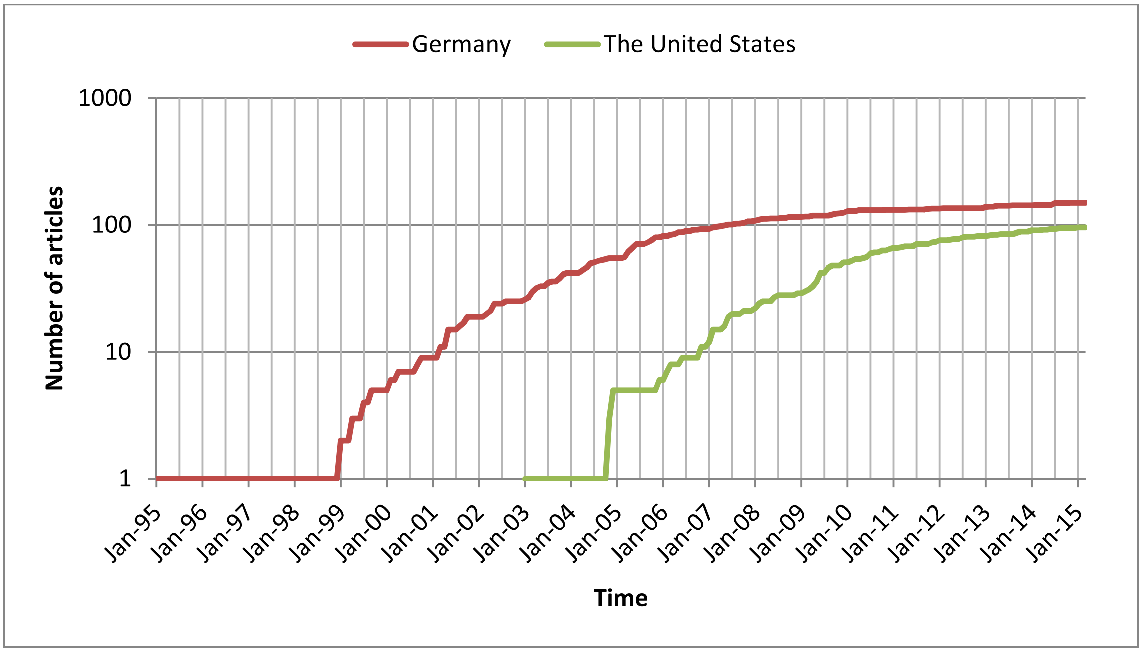

Figure 20. *Cumulative number of articles from the first article to 31st of March 2015 for mechanical biological treatment.*

As for the number of sources, the US passed Germany in 2009. So, although more sources have written about the technology in the US than in Germany, the German sources have written more articles. This is demonstrated in figure 21.

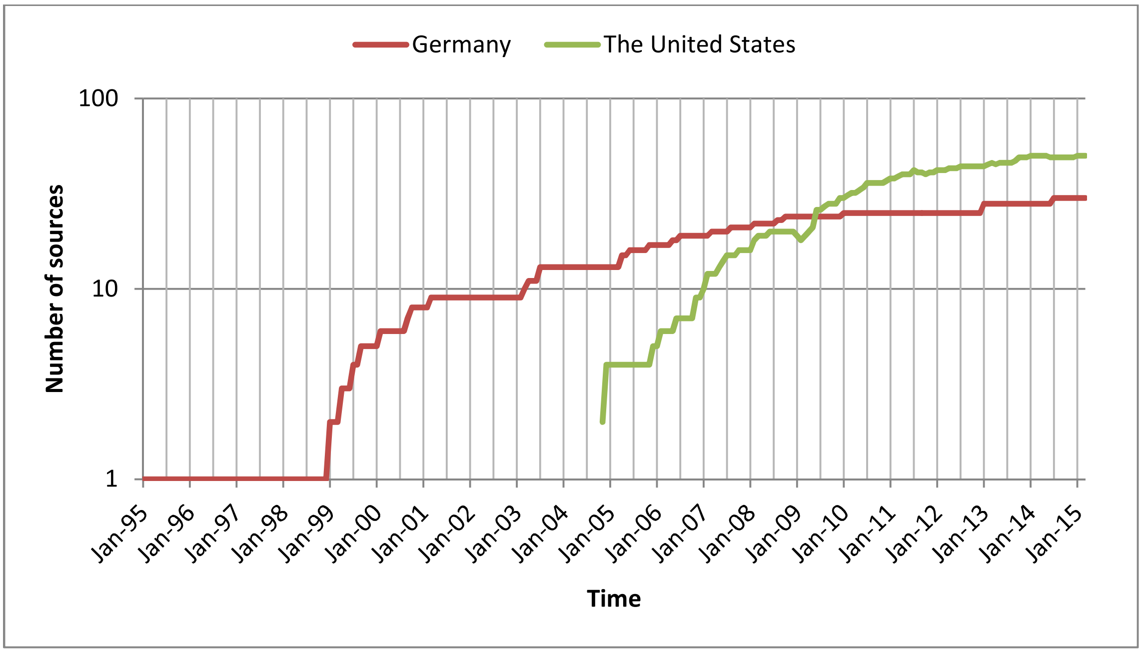

Figure 21. *Cumulative number of sources from the first article to 31st of March 2015 for mechanical biological treatment.*

Figure 22 shows that German interest has waned compared to the US after 2007. Large spikes can be observed in April 2005, June 2009, and July 2014. Both countries' media interest seems to have been waning, but the low number of articles might distort inter-interpretation.

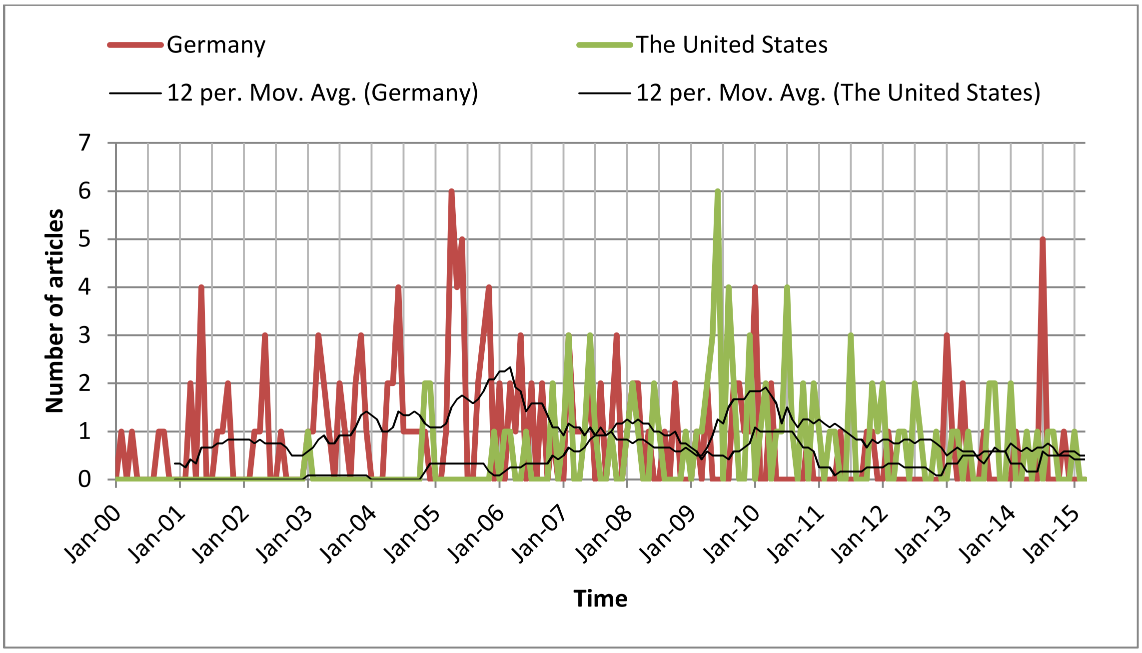

Figure 22. *Frequency of published articles per month from 1st of January 2000 to 31st of March 2015 for mechanical biological treatment.*

Figure 23 shows the development of mechanical biological treatment. Newspapers were the first type of source to report, which was followed by trade journals leading by terms of number.

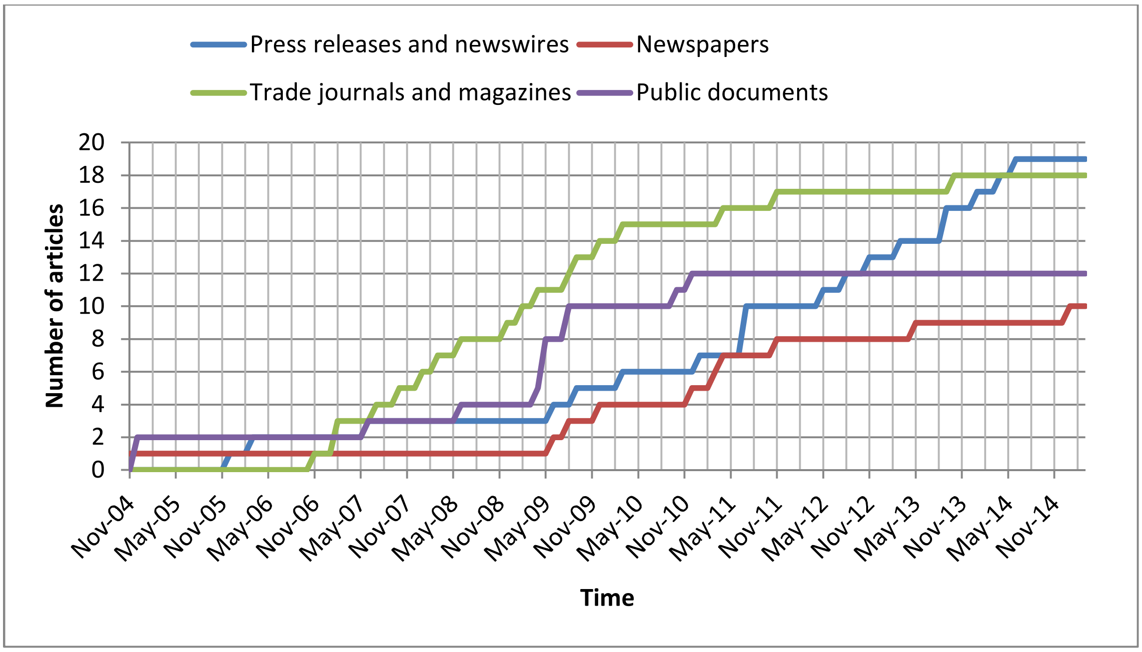

Figure 23. *Cumulative number of articles by source type in the United States from the first article to 31st of March 2015 for mechanical biological treatment.*

Growth has been relatively slow for all source types. For some reason, the topic has not been mentioned once in public documents since 2010.

4.5 Municipal solid waste

Again, there is a clear time gap between the countries. The growth rate for the United States appears to have slowed down between mid-1990s and mid-2000s and resuming high growth thereinafter. The findings are presented in figure 24. Germany has also had a period of relatively high growth between 2001 and 2005.

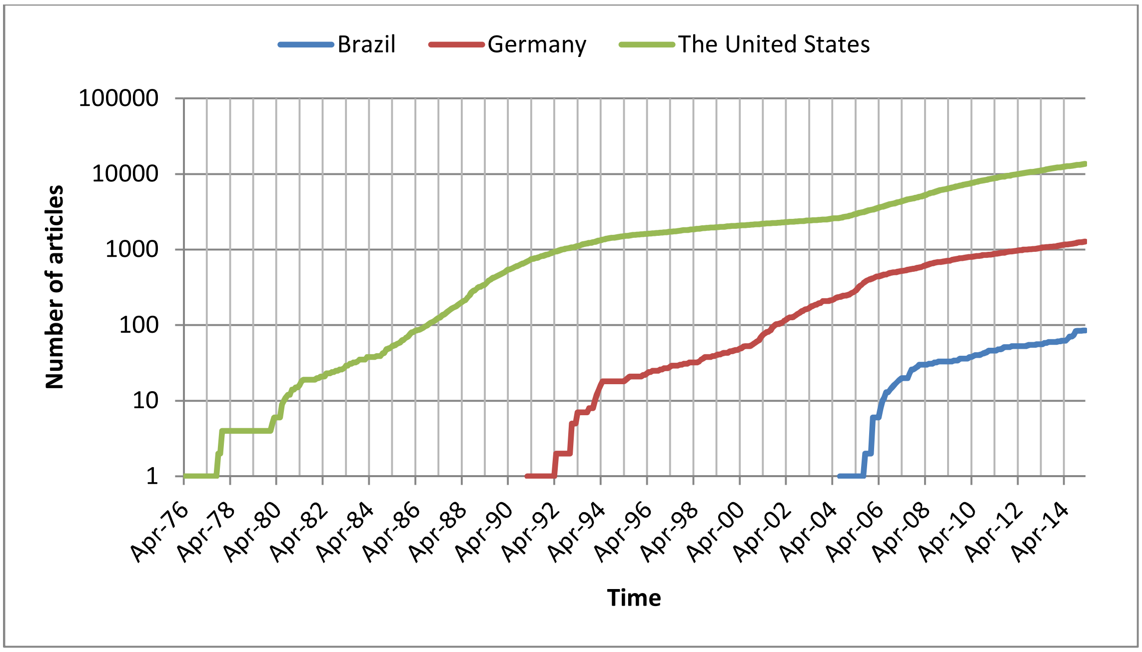

Figure 24. *Cumulative number of articles from the first article to 31st of March 2015 for municipal solid waste.*

In figure 25 it can be seen that the number of sources has continued to grow roughly at a steady rate until mid-2004 in the United States and Germany, when a boost can be perceived.

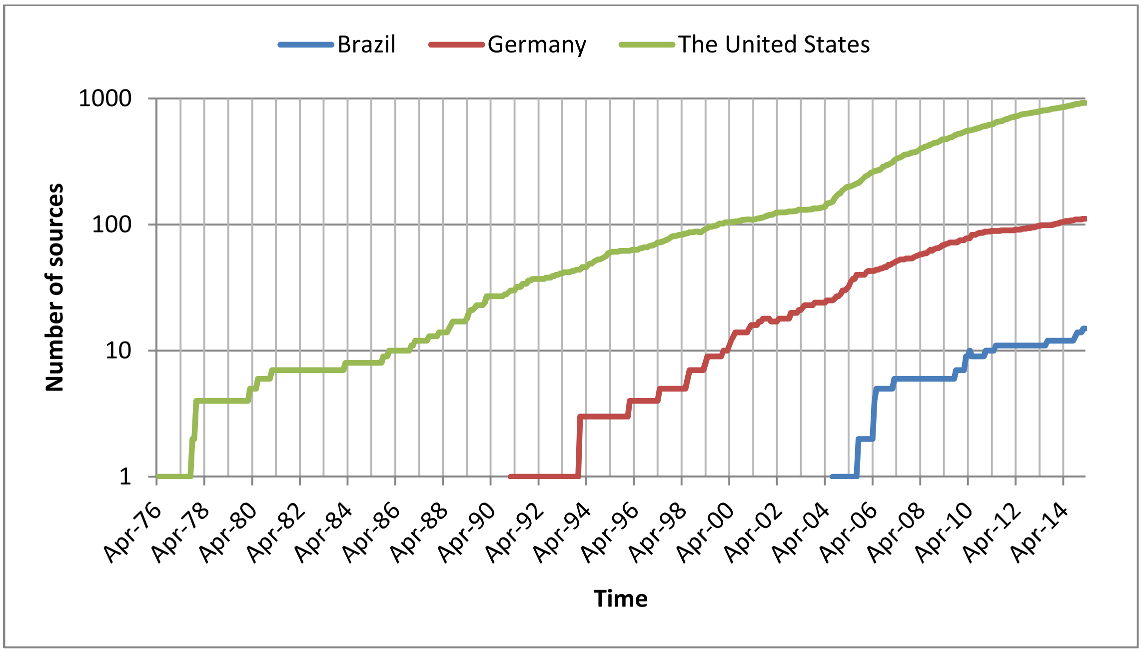

Figure 25. *Cumulative number of sources from the first article to 31st of March 2015 for municipal solid waste..*

This boost can also be observed in figures 26 and 27. There is a distinct change with both the United States and Germany after August 2004. The change is much larger in the US but noticeable in Germany as well. The trend for the US could be leading to hype cycle peak.

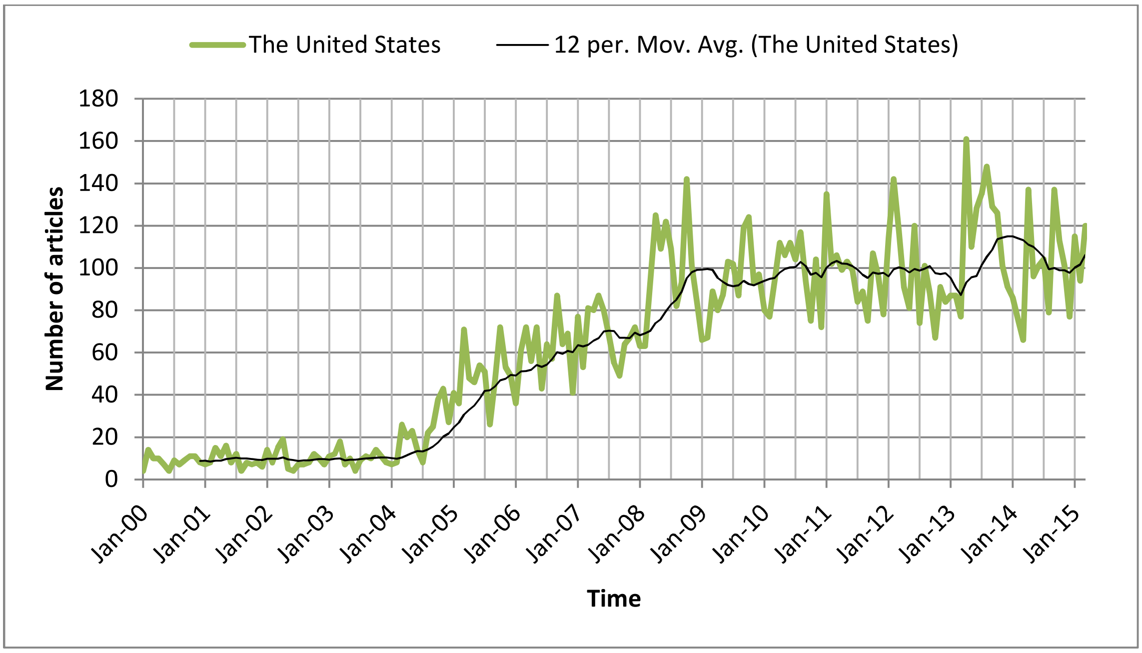

Figure 26. *Frequency of published articles per month from 1st of January 2000 to 31st of March 2015 for municipal solid waste.*

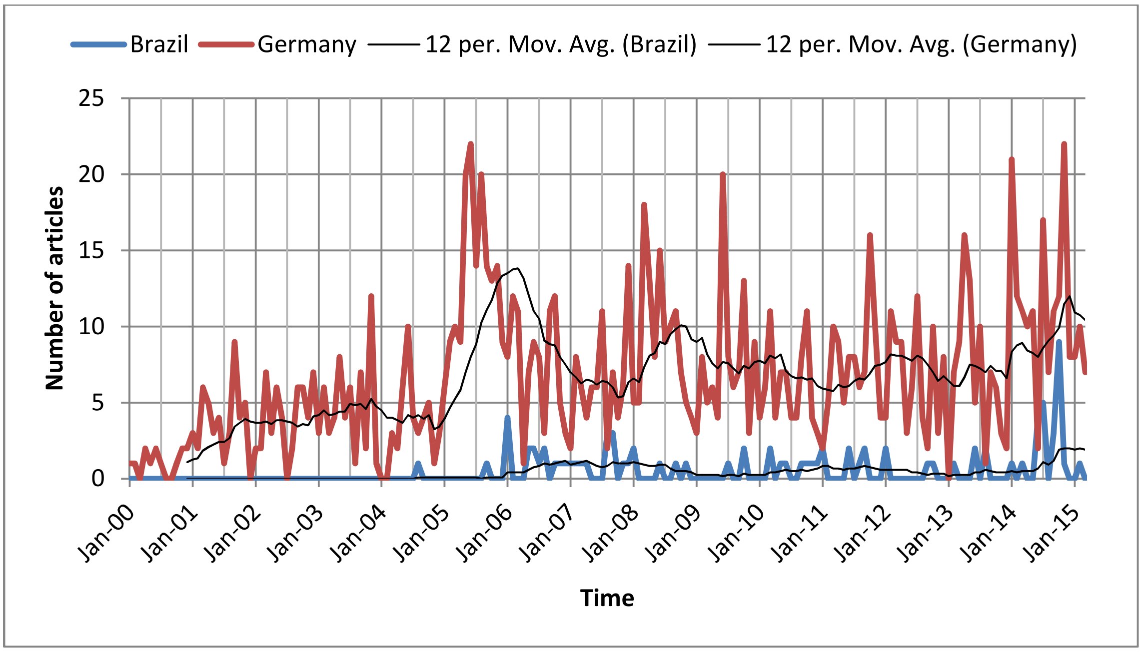

Figure 27. *Frequency of published articles per month from 1st of January 2000 to 31st of March 2015 for municipal solid waste.*

The article to source ratio exhibits much fluctuation in figure 28. However, the ratio seems to stay relatively high - at least in the United States - meaning that the reporting sources publish weekly or biweekly articles on average. This could be due to the concept in question being somewhat broad and general and it staying relevant because of societal needs. Two peaks can be seen for Brazil in January 2006 and October 2014.

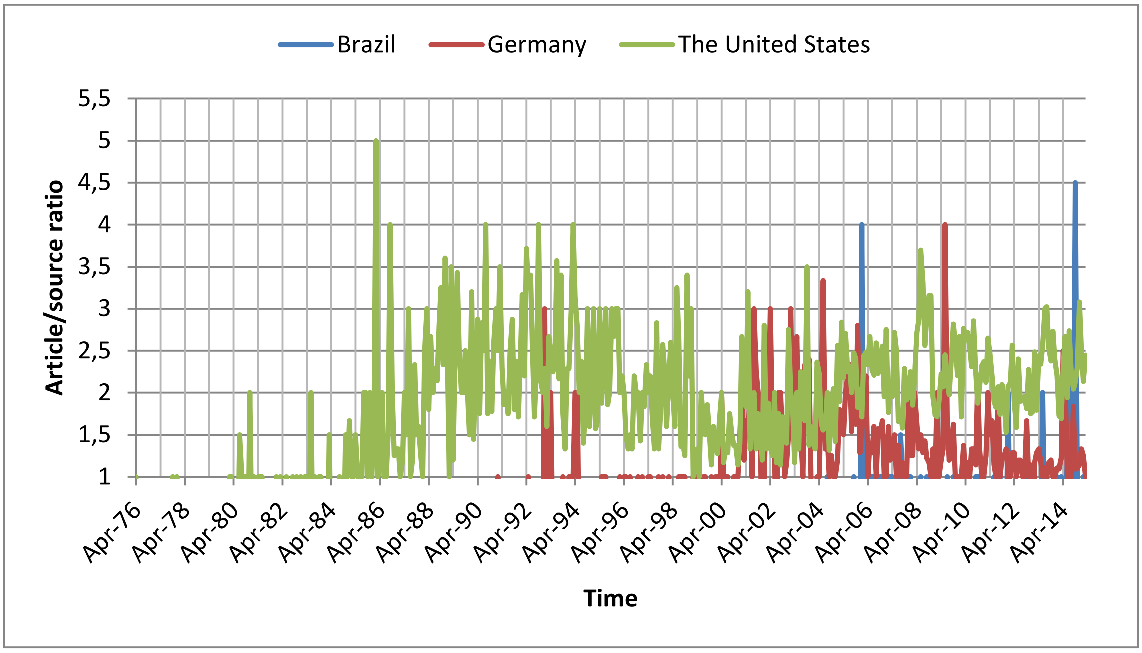

Figure 28. *The ratio of articles to sources per month from the first article to 31st of March 2015 for municipal solid waste.*

In figure 29 a clear lead for press releases and public documents can be seen. Whereas press releases have had growth almost from the beginning, for public documents it has been almost non-existent until late 2004, from where its growth has been faster than anything else’s.

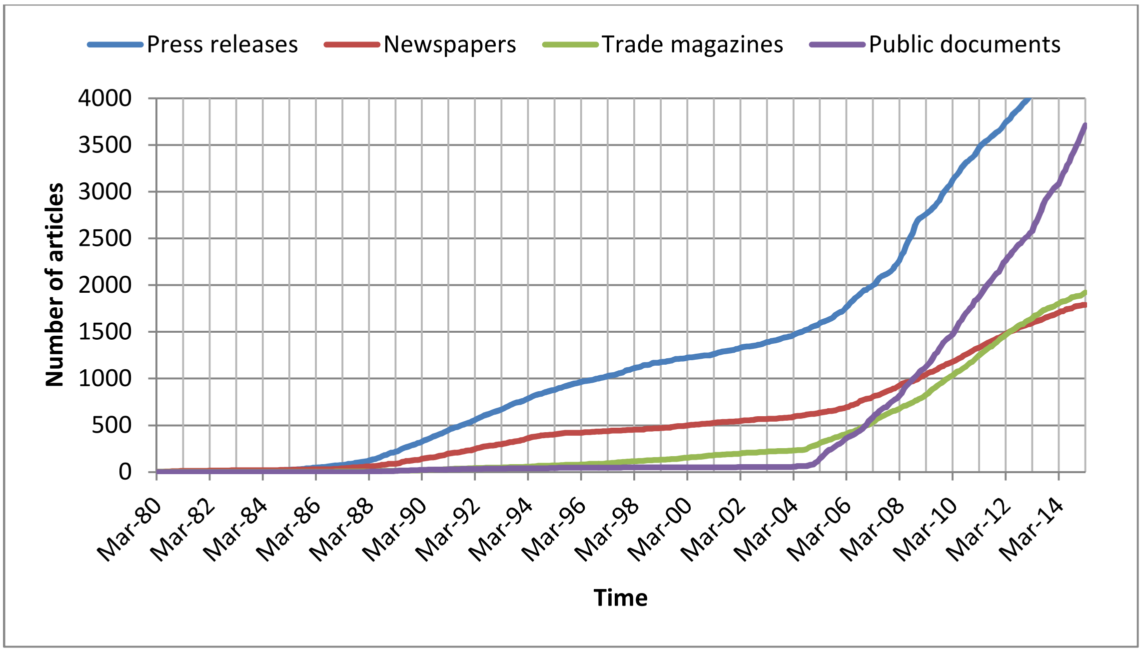

Figure 29. *Cumulative number of articles by source type in the United States from the first article to 31st of March 2015 for municipal solid waste.*

Resurging interest shows for both newspapers and trade journals in figure 30. This interest seems to have been low until late 2004, when a period of high growth started. However, interest has been diminishing again after 2011.

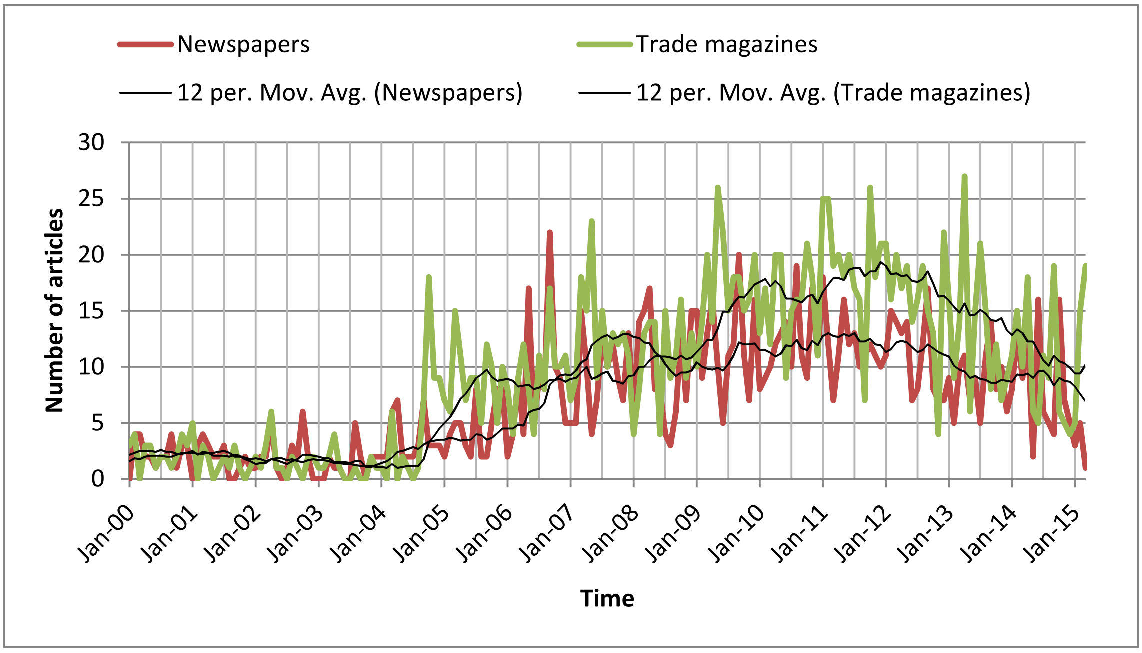

Figure 30. *Number of articles per month by source type in the United States from 1st of January 2000 to 31st of March 2015 for municipal solid waste.*

Although interest has been declining, it is still at the same level as it was in 2007.

4.6 Plasma gasification

Figure 31 shows the development in the number of articles for plasma gasification. The United States exhibits a period of high growth starting in 2006 and ending in 2008. No articles for Brazil were found. A noteworthy observation is that took over 8 years for a second article to appear in the United States after the first.

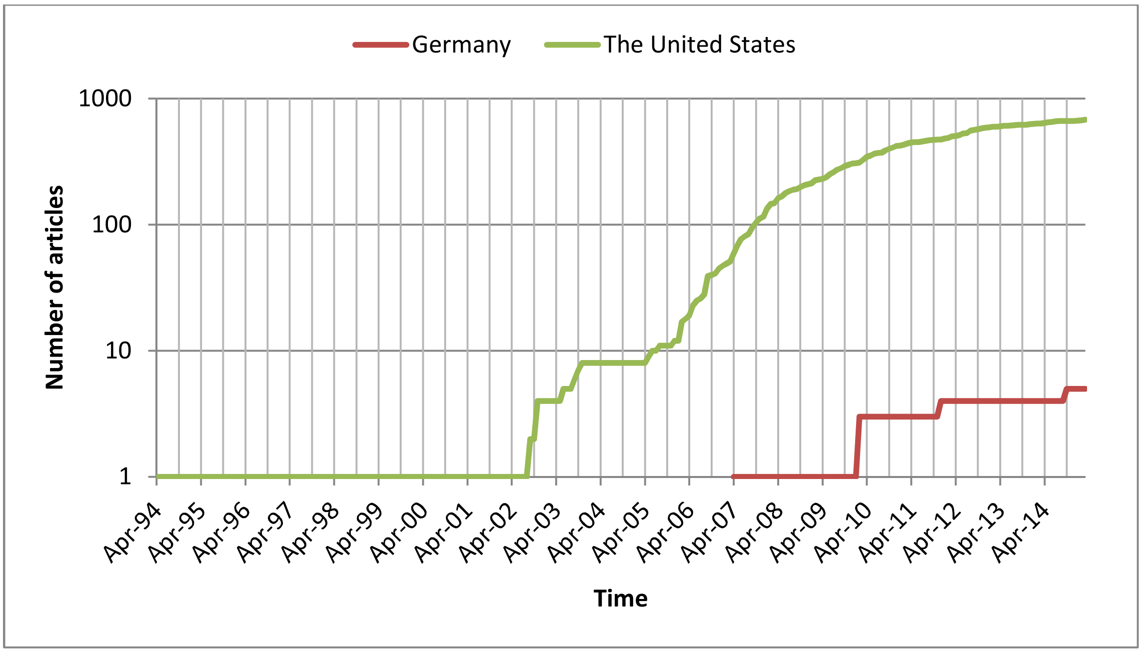

Figure 31. *Cumulative number of articles from the first article to 31st of March 2015 for plasma gasification.*

The same growth can be observed with the number of sources in figure 32. Growth has been quick in the US but slow in Germany, as demonstrated by the fact that it took four and a half years to publish the fourth article after the third.

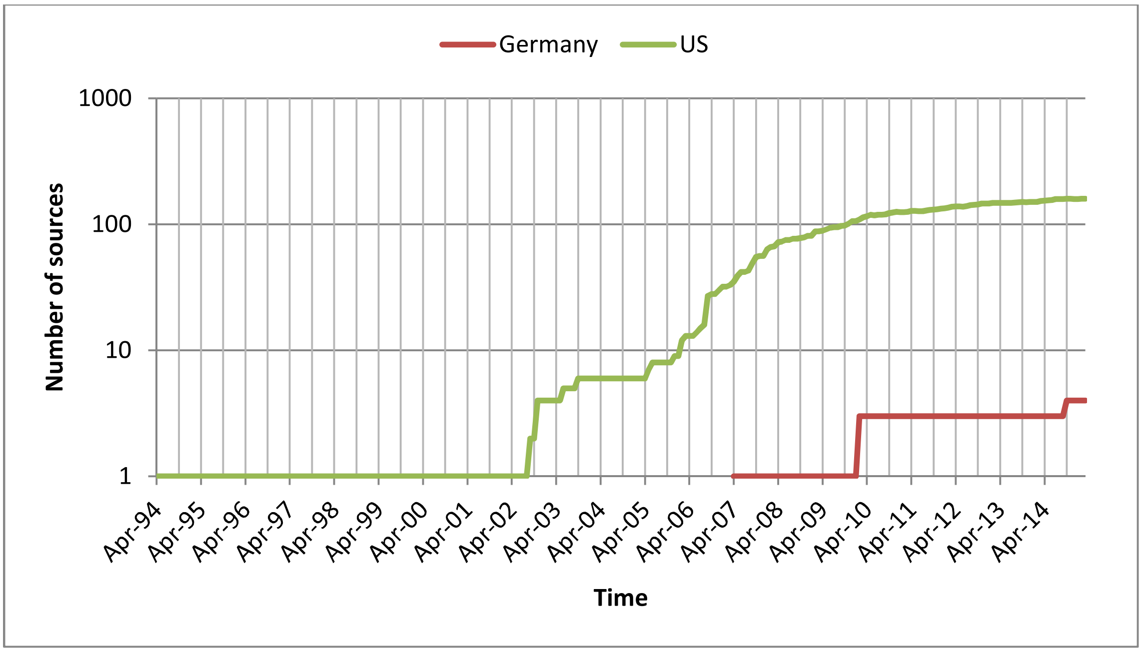

Figure 32. *Cumulative number of sources from the first article to 31st of March 2015 for plasma gasification.*

The growth also shows in figure 33, starting after mid-2006. It cannot be ascertained whether the dip in interest after mid-2013 is short or long term or just random fluctuation due to the end of the time scale.

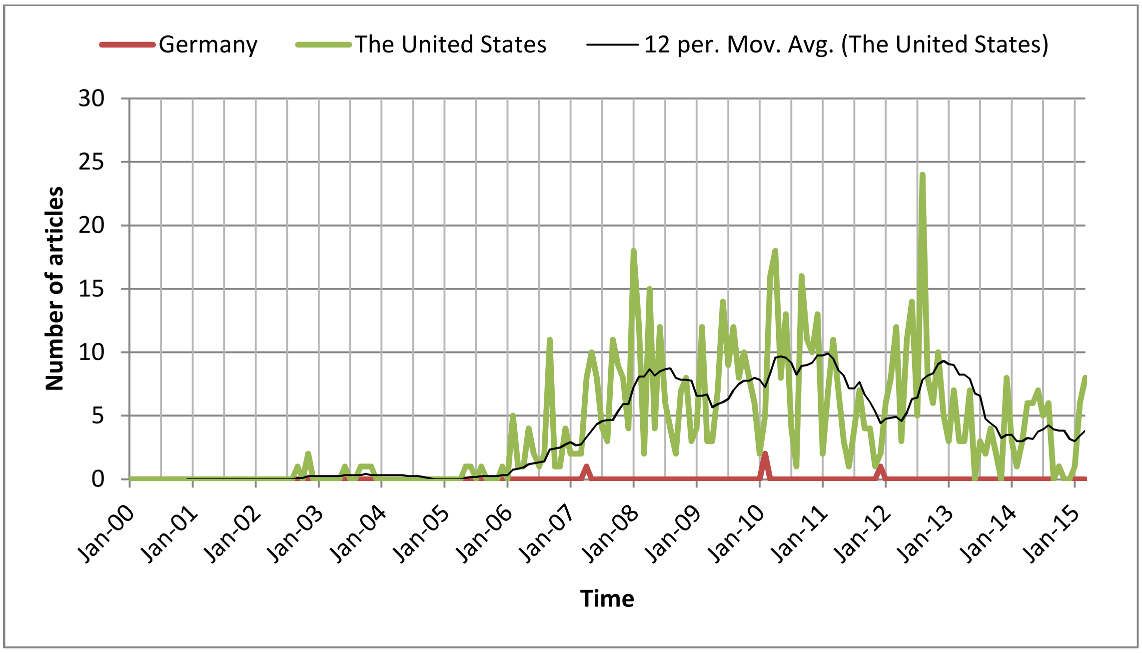

Figure 33. *Frequency of published articles per month from 1st of January 2000 to 31st of March 2015 for plasma gasification.*

Figure 34 shows the progression of article counts by source types. Again, a period of growth can be seen beginning in 2007.

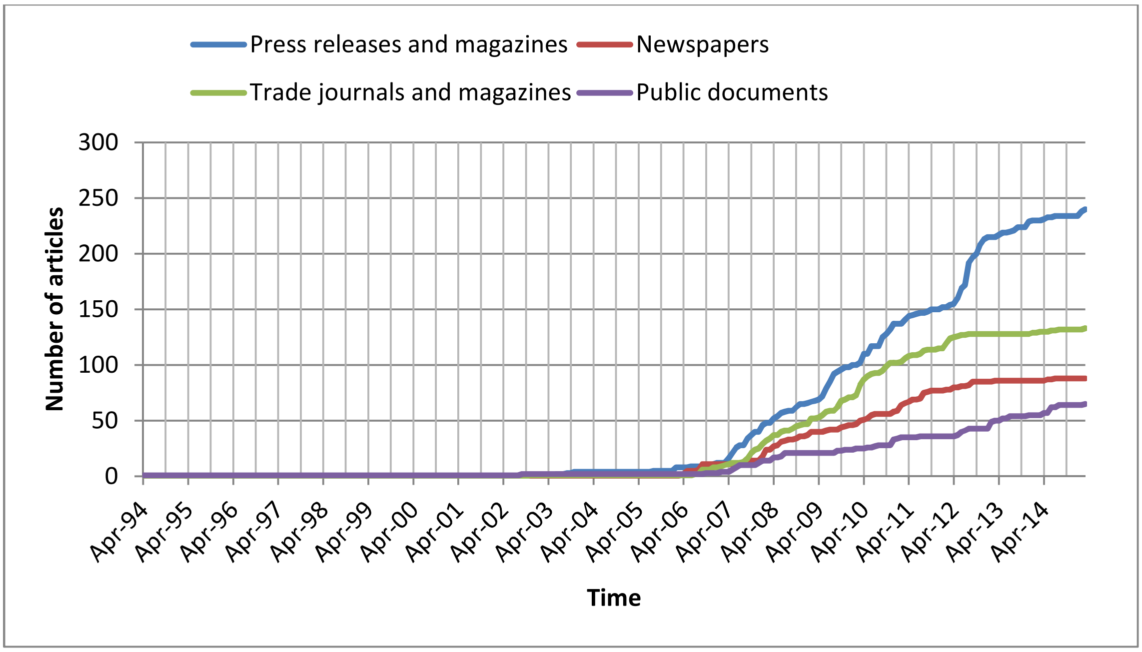

Figure 34. *Cumulative number of articles by source type in the United States from the first article to 31st of March 2015 for plasma gasification.*

Peculiarly, the first article was a public document in 1994 and first articles in newspapers and trade journals appeared in 2002.

4.7 Recovered fuel co-firing (REF)

No articles were found at all for any of the three countries. This could be due to either a lack of interest or more probably the search terms being technical and specific, limiting their use in mass media. Results were found for similar technologies or concepts.

4.8 Refuse-derived fuel (RDF)

Refuse-derived fuel appears to be a relatively old concept according to figure 35. The United States has a 15-year lead over Germany, but a surge in interest beginning in 2000 has made Germany surpass the United States in the number of articles in 2006.

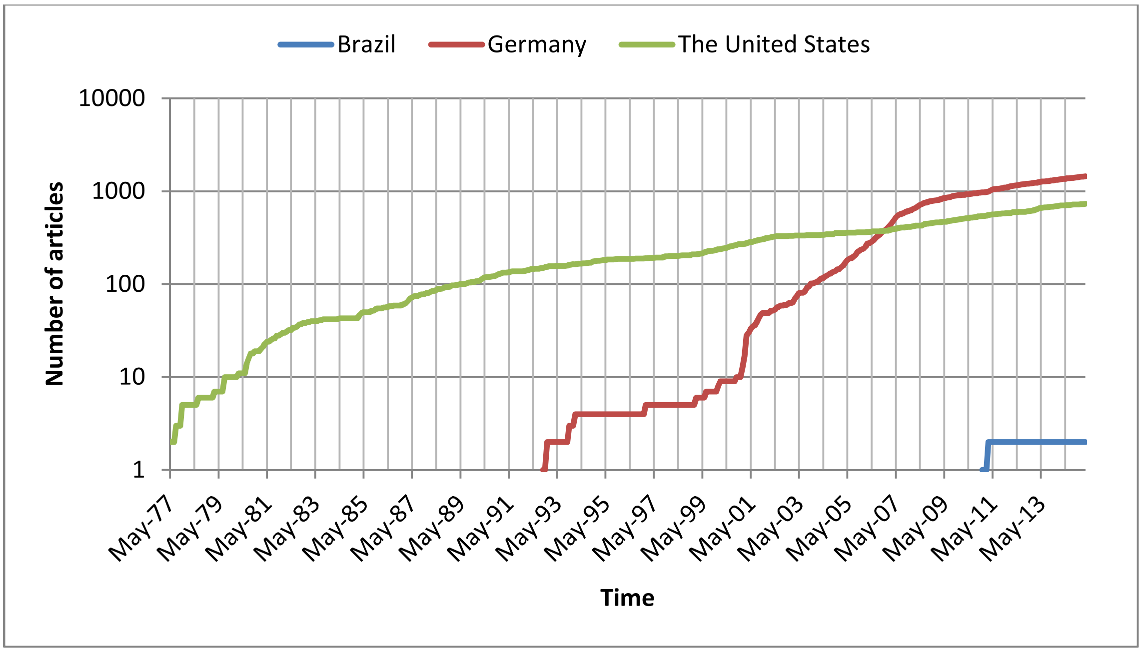

Figure 35. *Cumulative number of articles from the first article to 31st of March 2015 for refuse-derived fuel.*

Despite producing more articles overall, Germany has yet to reach the United States in the number of sources, which can be seen in figure 36. Interest seems to have waned in Brazil, as only two articles and two sources were found and no change has happened after mid-2011.

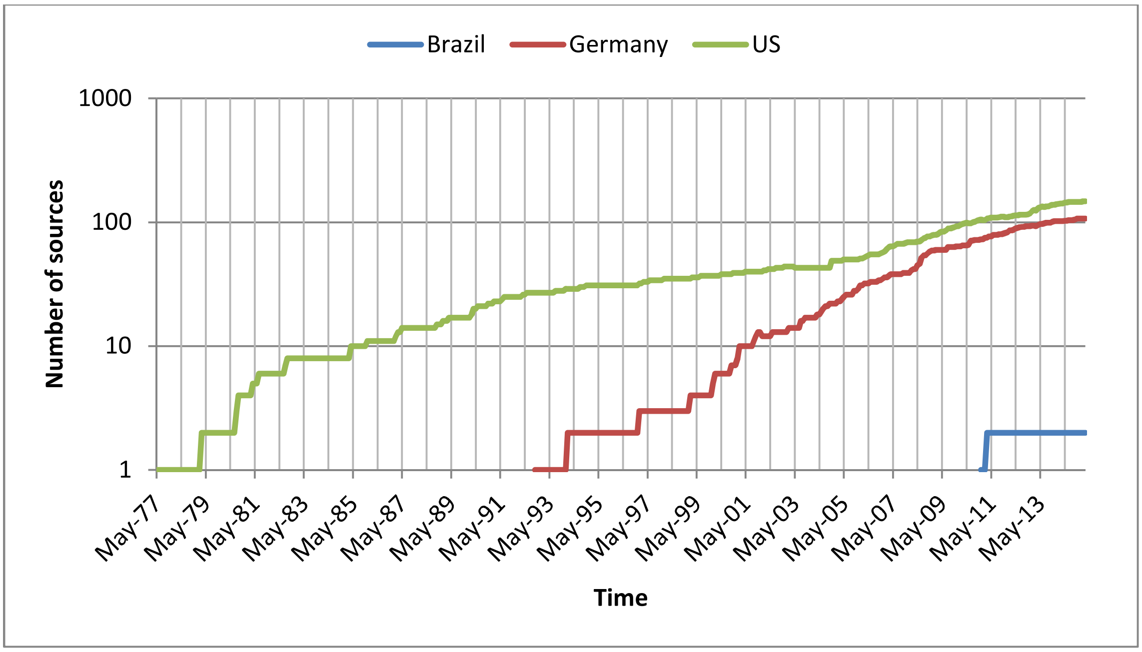

Figure 36. *Cumulative number of sources from the first article to 31st of March 2015 for refuse-derived fuel.*

The increase and subsequent decrease in Germany's interest is easily recognized in figures 37 and 38. The largest spikes appear to be in May 2007 with 38 articles and April 2011 with 28 articles.

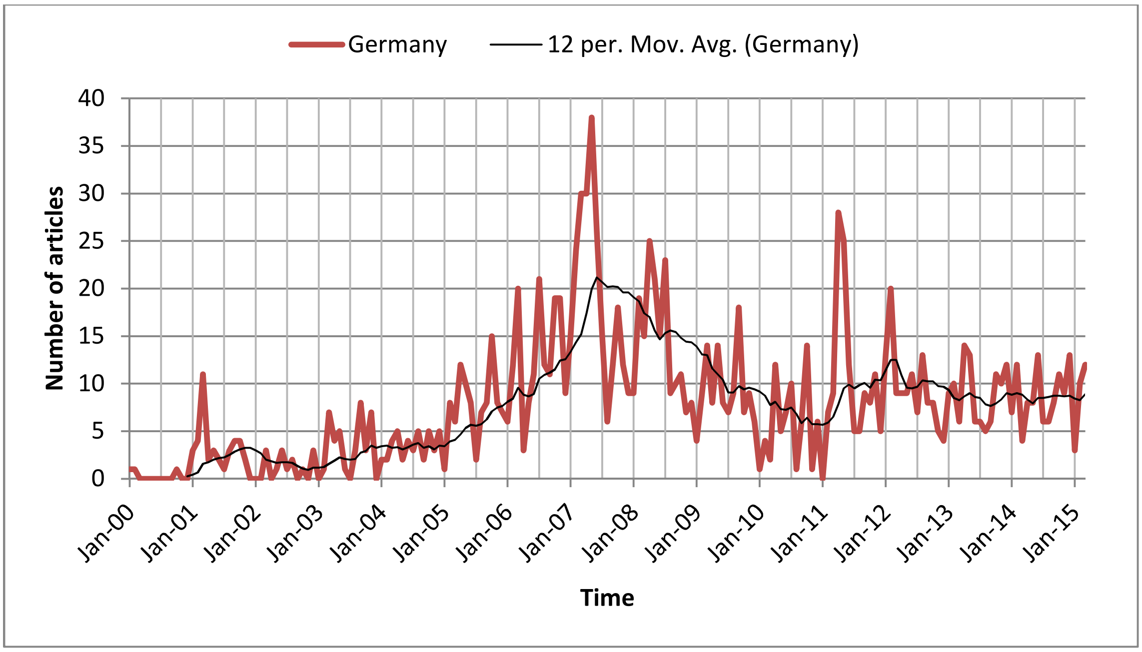

Figure 37. *Frequency of published articles per month from 1st of January 2000 to 31st of March 2015 for refuse-derived fuel.*

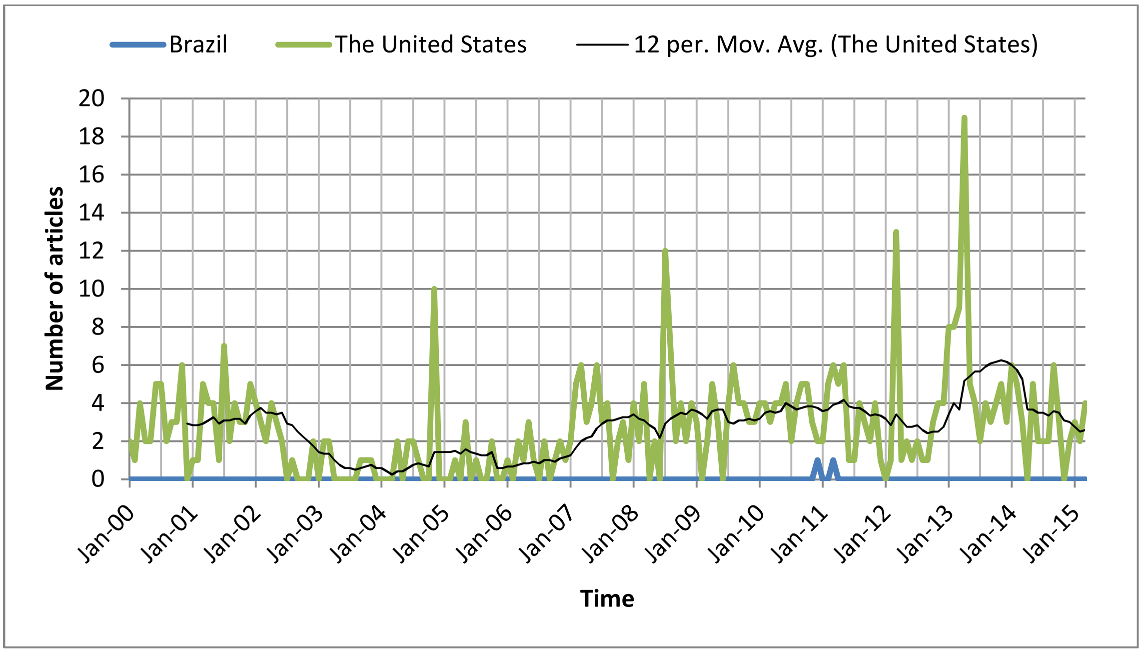

Figure 38. *Frequency of published articles per month from 1st of January 2000 to 31st of March 2015.*

The largest ratios for the United States and Germany are in July 2001 and November 2003, respectively, which is shown in figure 39.

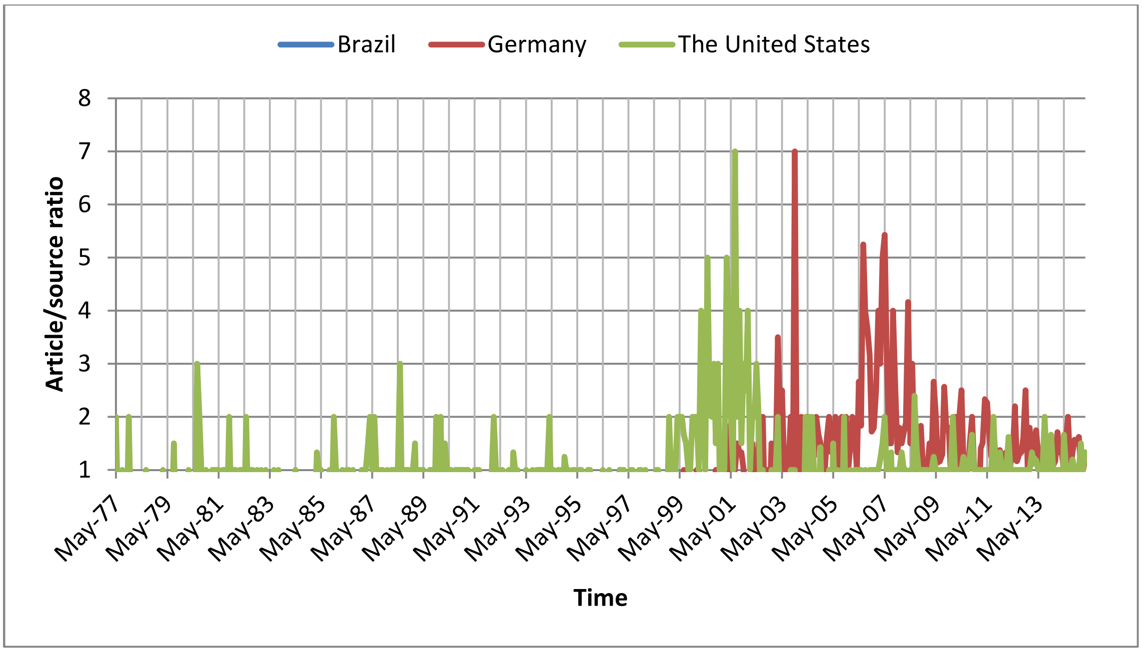

Figure 39. *The ratio of articles to sources per month from the first article to 31st of March 2015 for refuse-derived fuel.*

The first source was a newspaper and more newspapers articles were written than anything else until 1989, when press releases took over. Figure 40 also shows a surge for press releases beginning in late 1999.

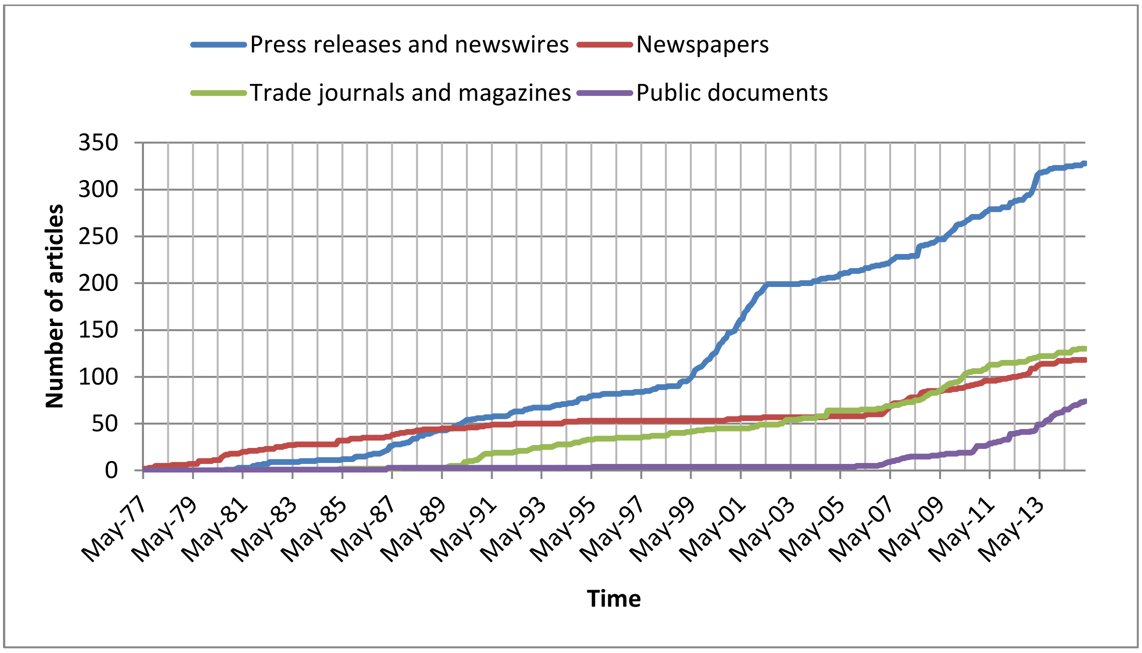

Figure 40. *Cumulative number of articles by source type in the United States from the first article to 31st of March 2015 for refuse-derived fuel.*

The surge could be the result of companies signaling the beginning of R&D programs for new fuels. No other sources have similar surges.

4.9 Reverse logistics

Despite Brazil reporting about reverse logistics for the first time over three years later than Germany, it has quickly surpassed Germany in the number of total articles. In fact, Brazil has widened the gap over the last five years. The data can be seen in figure 41. Growth in the US has been steady.

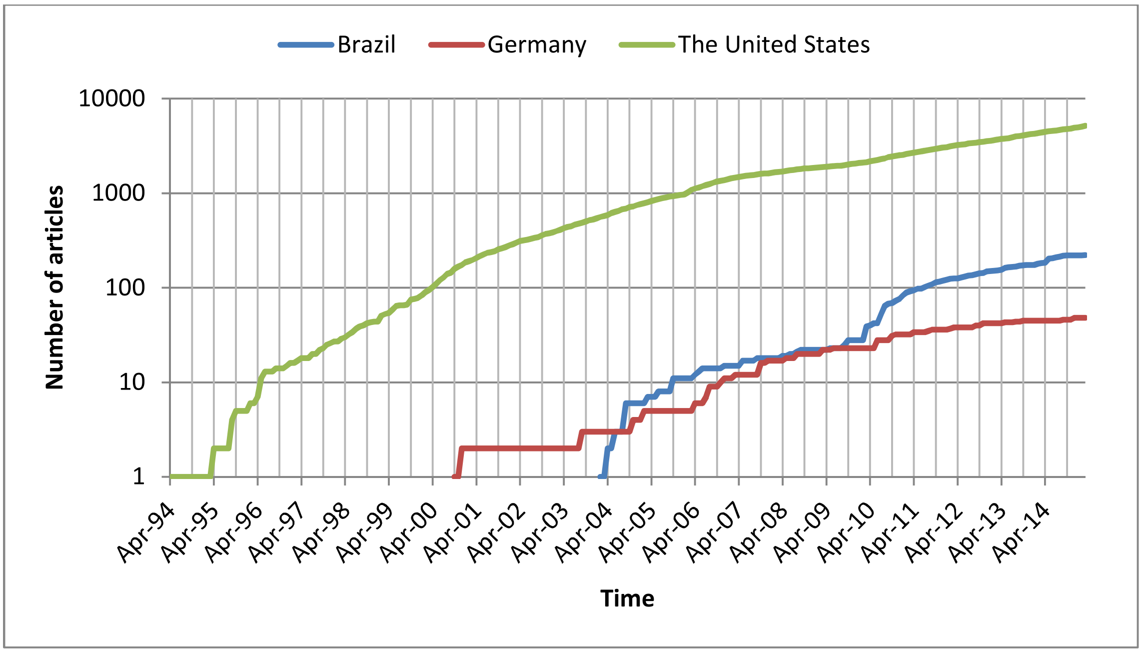

Figure 41. *Cumulative number of articles from the first article to 31st of March 2015 for reverse logistics.*

However, this has not happened with the number of sources, as Germany's count remains higher than Brazil's. This is shown in figure 42. Interestingly, the quick growth in the US between mid-2004 and mid-2005 with the sources has not resulted in a similar growth in the number of articles.

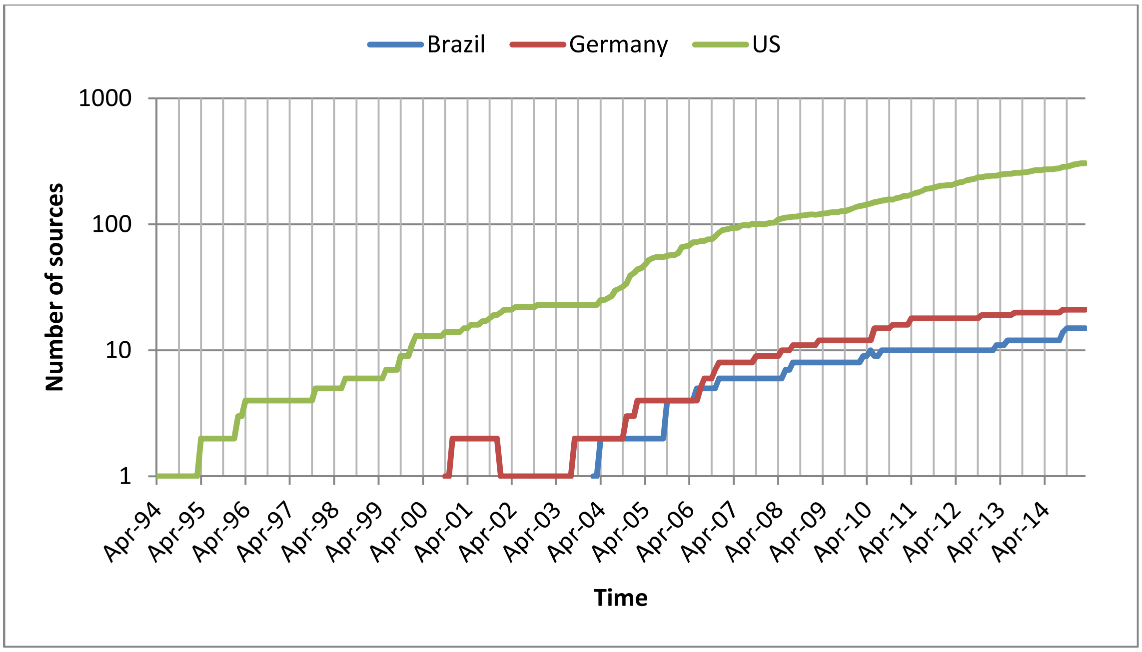

Figure 42. *Cumulative number of sources from the first article to 31st of March 2015 for reverse logistics.*

Interest seems to have risen in the United States after 2000 and in Brazil after 2010, which can be noticed in figures 43 and 44. After a small dip after 2007 the interest seems to have been increasing again in the US.

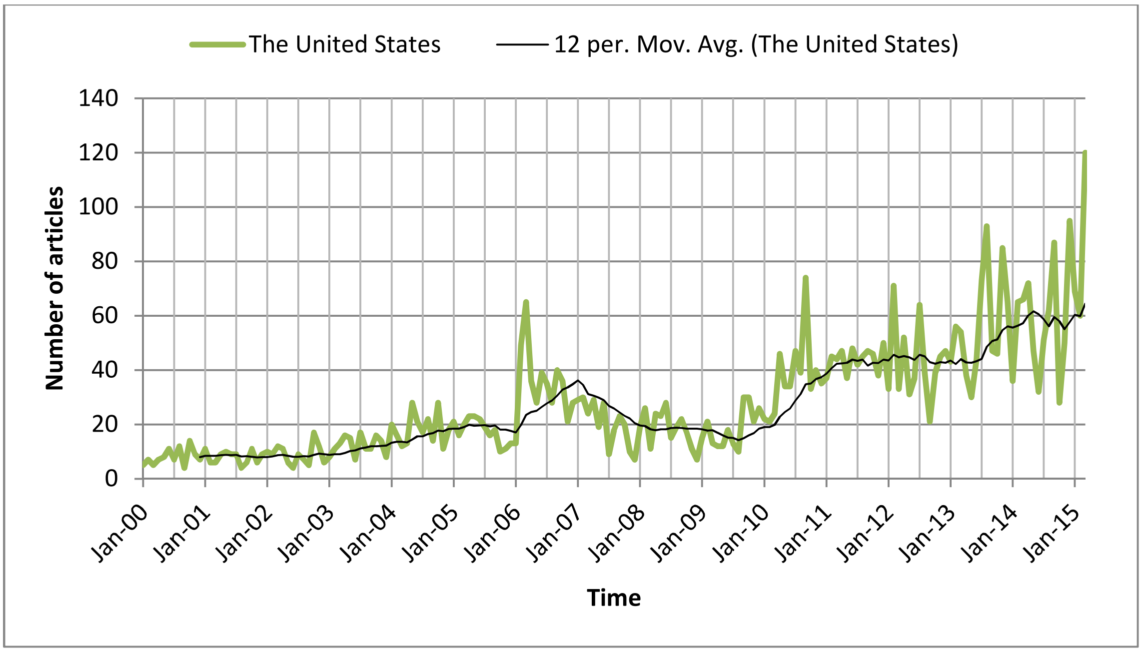

Figure 43. *Frequency of published articles per month from 1st of January 2000 to 31st of March 2015.*

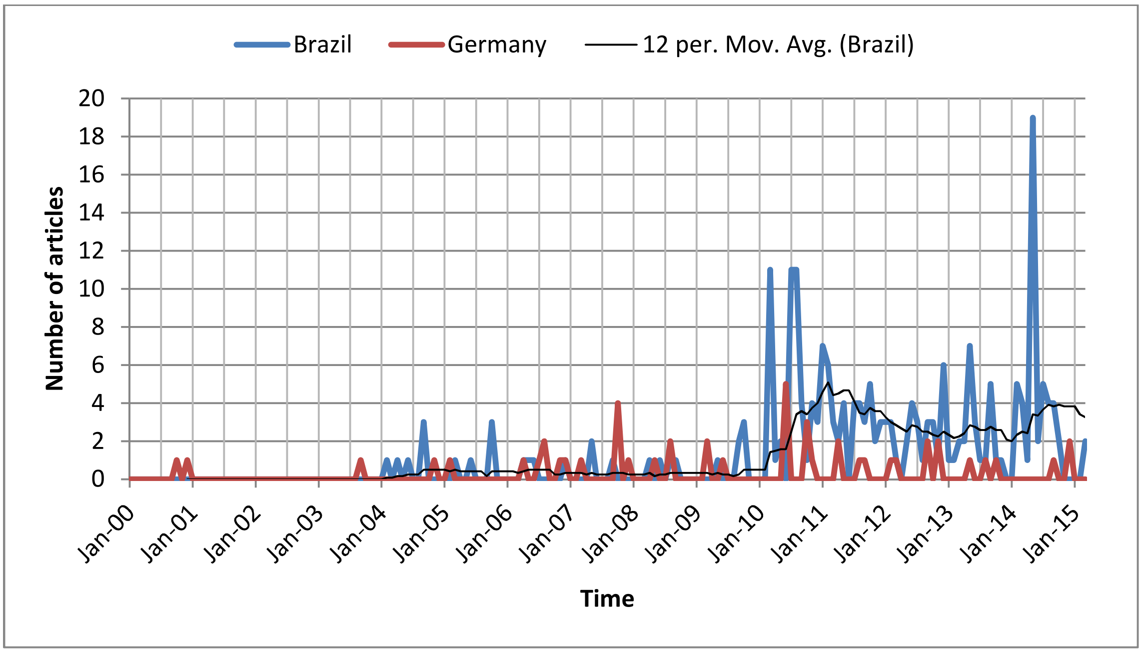

Figure 44. *Frequency of published articles per month from 1st of January 2000 to 31st of March 2015 for reverse logistics.*

Major spikes in interest by sources seem to have happened between 2000 and 2006 in the United States and after 2010 in Brazil and Germany, which can be seen in figure 45.

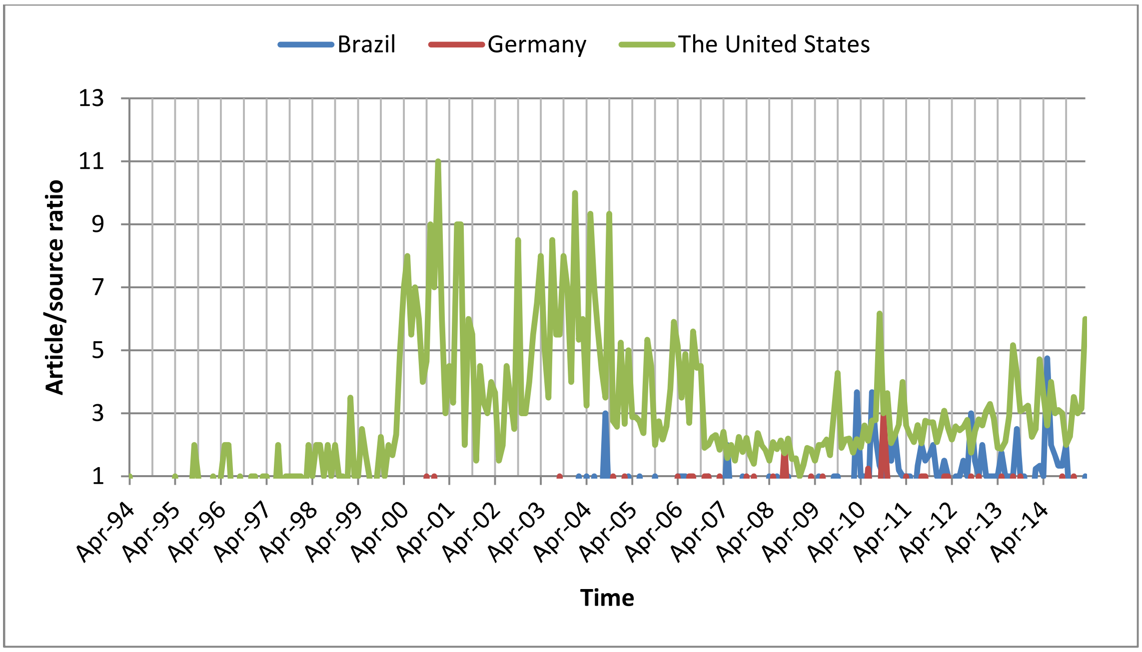

Figure 45. *The ratio of articles to sources per month from the first article to 31st of March 2015 for reverse logistics.*

According to figure 46, reverse logistics is the first concept to have a press release published before anything else. Another thing to note is the number of public documents exceeding those of newspapers and trade journals.

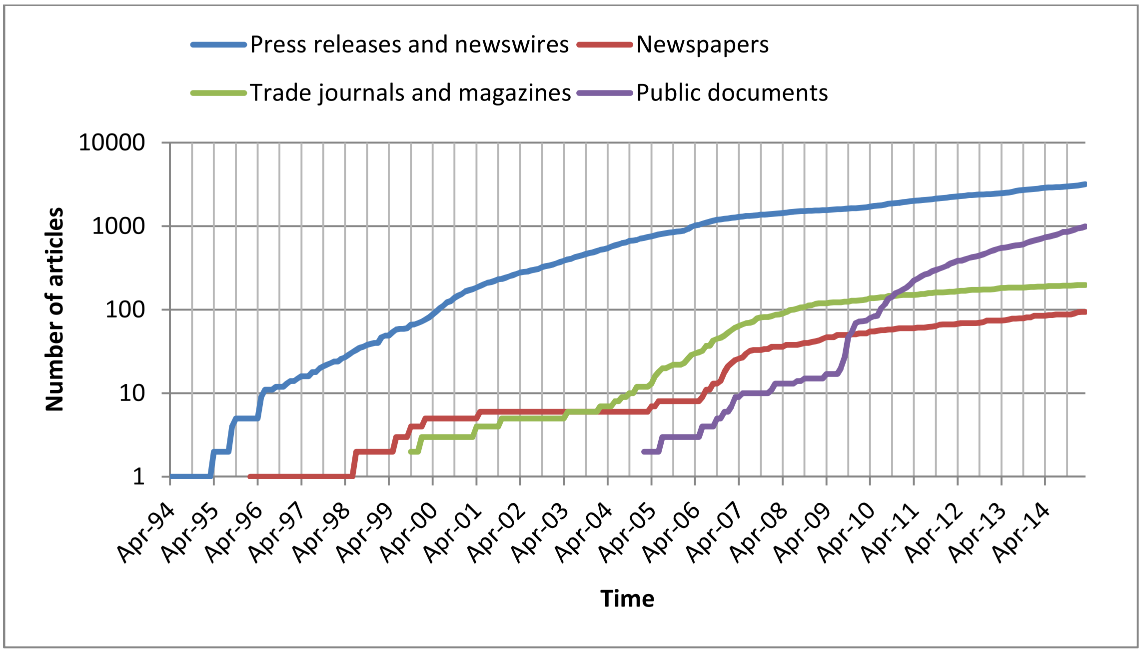

Figure 46. *Cumulative number of articles by source type in the United States from the first article to 31st of March 2015 for reverse logistics.*

Even though the first mention in public documents happened over 6 years after the first appearance in trade journals and 9 years after in newspapers, it took only 6 years to overtake them both. It is possible that reverse logistics was found to be important in public matters to warrant such interest.

4.10 Solid waste management

As figure 47 shows, there is again a clear difference in the time of first appearance between the countries. However, the number of articles in Germany has grown at a much faster rate compared to the United States.

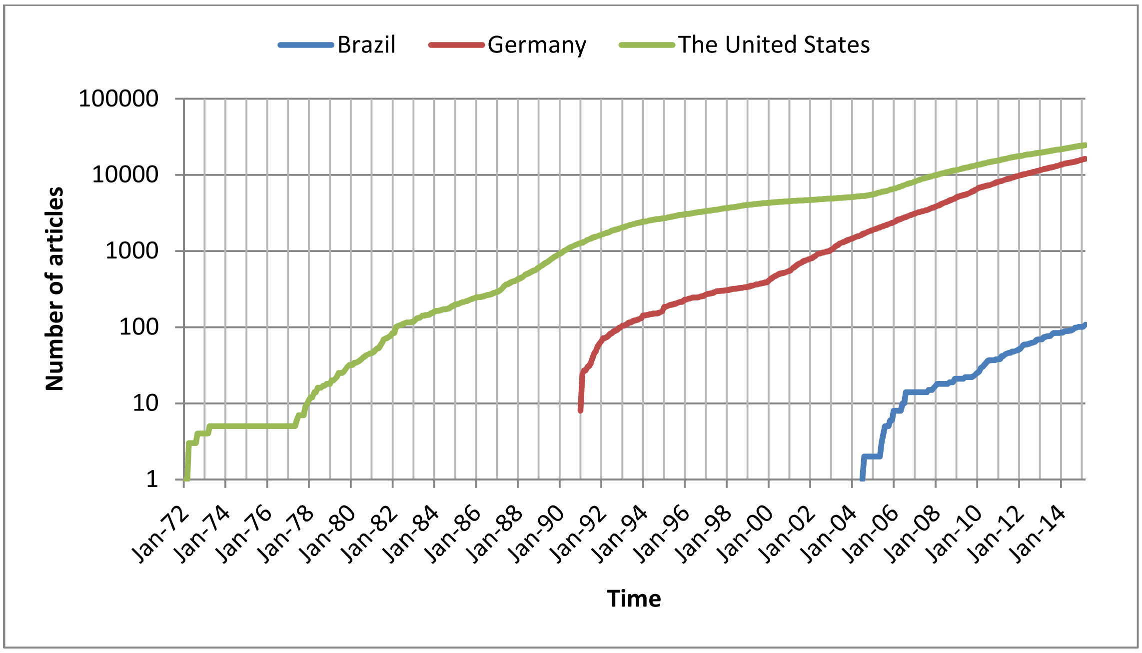

Figure 47. *Cumulative number of articles from the first article to 31st of March 2015 for solid waste management.*

The trends are similar with the number of sources in figure 48. Something seems to have caused the amount of sources to almost double in the United States between August 2004 and August 2006. Overall, growth seems to have been somewhat steady.

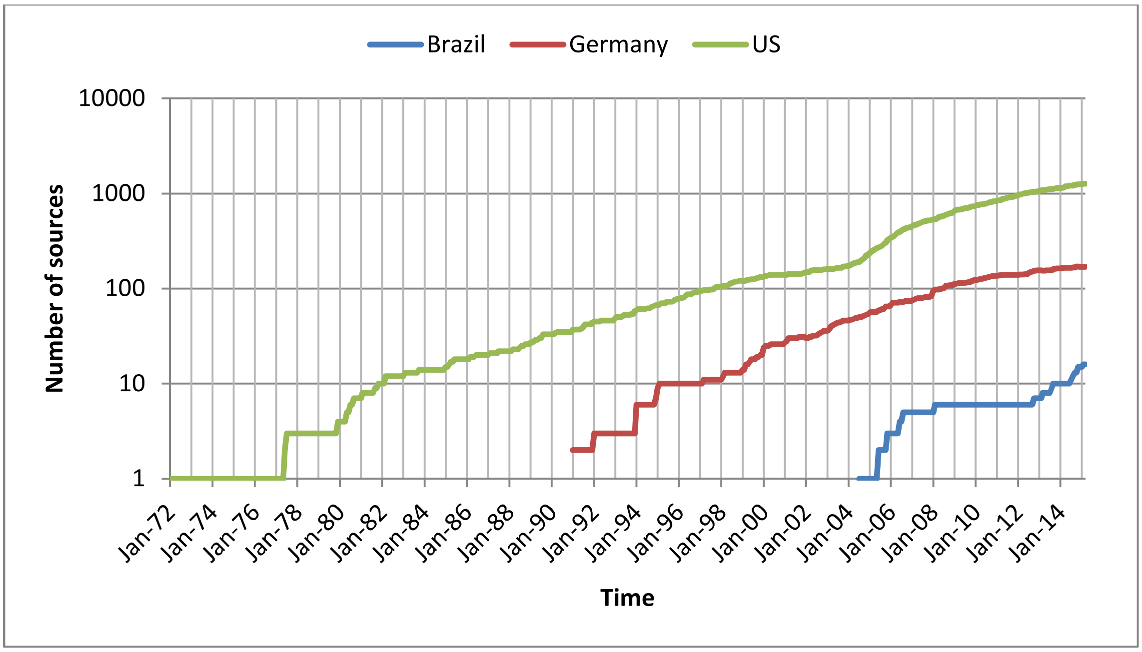

Figure 48. *Cumulative number of sources from the first article to 31st of March 2015 for solid waste management.*

The publishing activity has continued to grow relatively steadily in both the United States and Germany after 2004. The initial growth was faster in the United States but Germany has attained similar rates, as can be seen in figures 49 and 50.

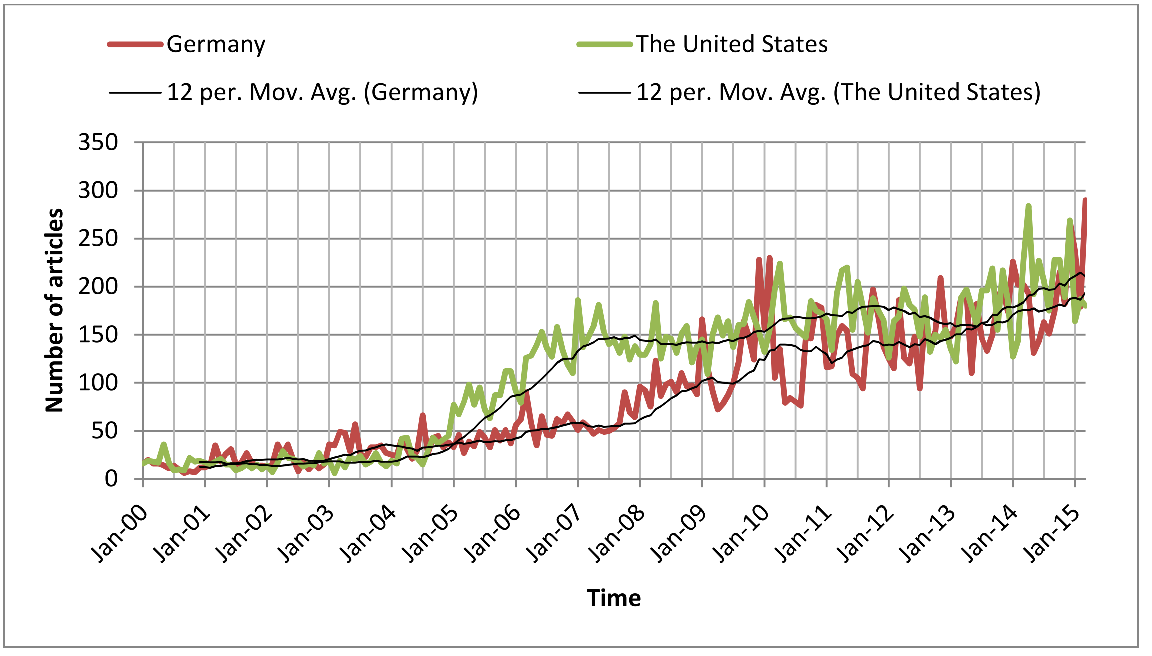

Figure 49. *Frequency of published articles per month from 1st of January 2000 to 31st of March 2015 for solid waste management.*

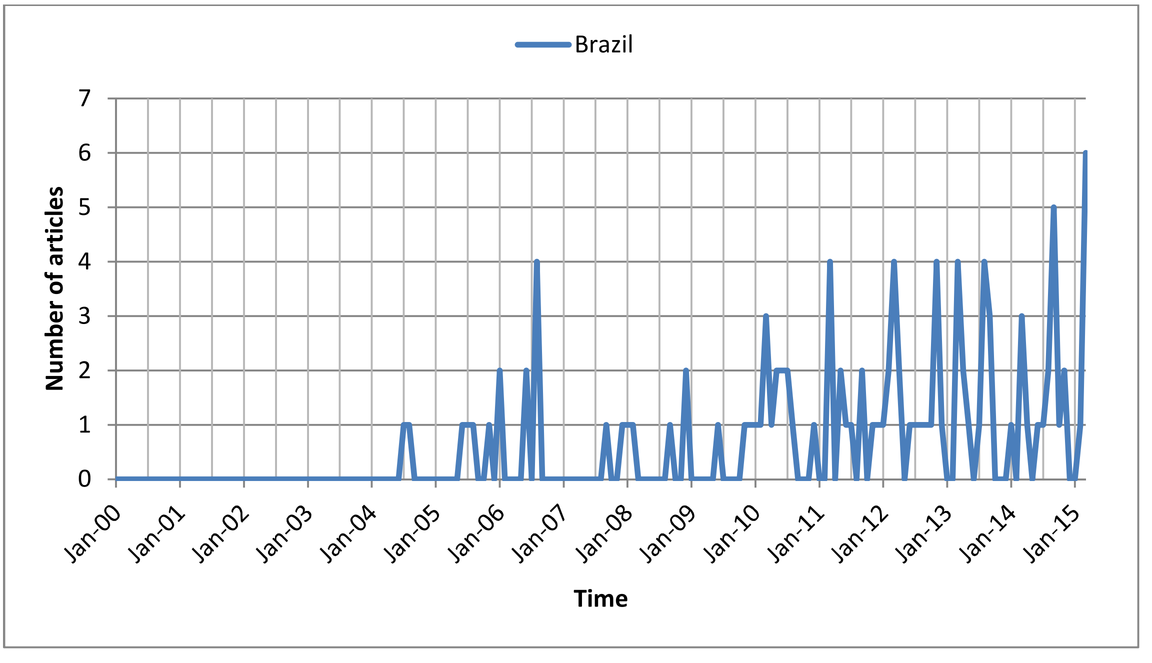

Figure 50. *Frequency of published articles per month from 1st of January 2000 to 31st of March 2015 for solid waste management.*

In figure 51, the first article was published in a trade journal in 1972, which was followed by low interest until late 1980s. Something might have happened in 2005 as both newspapers and public documents have experienced major growth, public documents exceeding newspapers in early 2015.

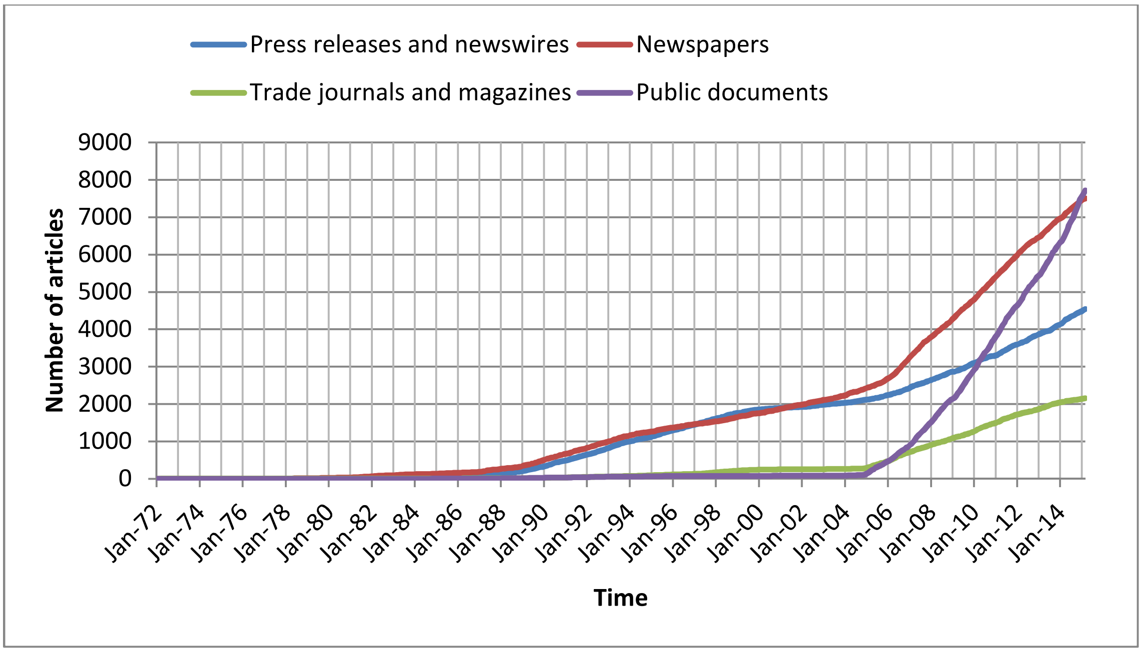

Figure 51. *Cumulative number of articles by source type in the United States from the first article to 31st of March 2015 for solid waste management.*

This growth can also be seen in figure 52. Interest has also increased in trade journals, but the scale is much smaller compared to newspapers.

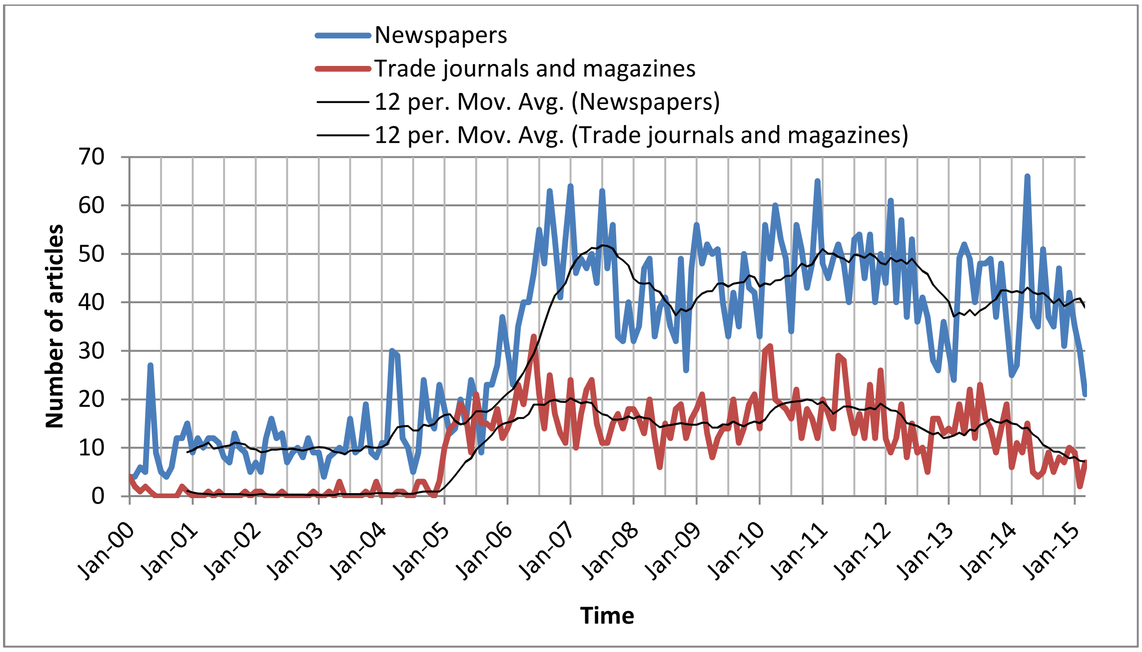

Figure 52. *Number of articles per month by source type in the United States from 1st of January 2000 to 31st of March 2015 for solid waste management.*

Societal importance could explain why newspapers have more interest in the topic than trade journals do.

4.11 Solid/specified recovered fuel

The technology seems to be either relatively new or the terminology is not sufficiently different from other similar technologies or concepts. There has also been a lack in new articles for the United States between late 2008 and 2011, and especially for Brazil after 2008, as can be seen figure 53. No articles for Germany were found.

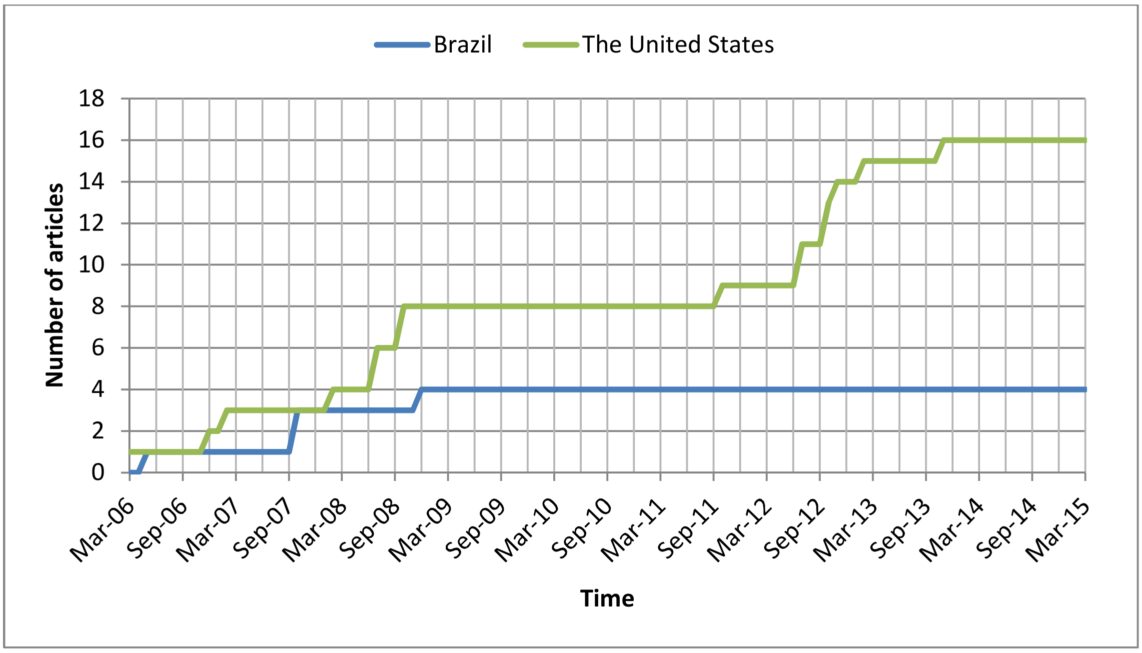

Figure 53. *Cumulative number of articles from the first article to 31st of March 2015 for solid/specified recovered fuel.*

The sources have also stayed at the same level for Brazil, whereas there has been some growth in the United States. Nevertheless, the interest does not seem to have picked up as figure 54 shows.

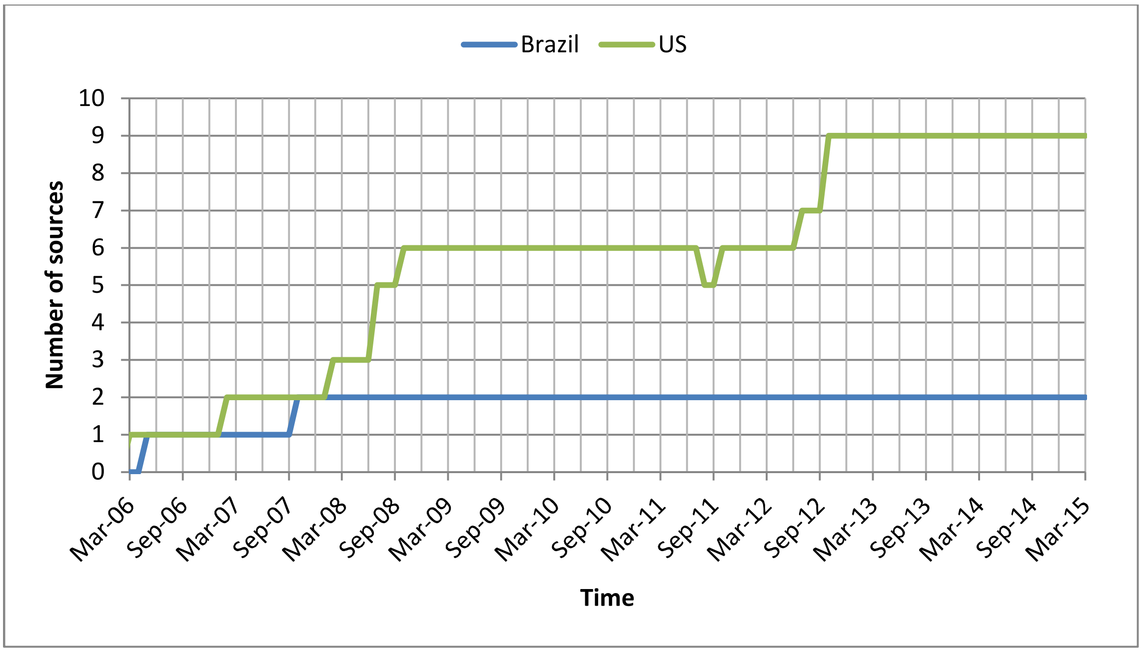

Figure 54. *Cumulative number of sources from the first article to 31st of March 2015 for solid/specified recovered fuel.*

There seems to be no interest at all in newspapers as shown in figure 55. Again, the first article is a press release, followed by those in trade journals.

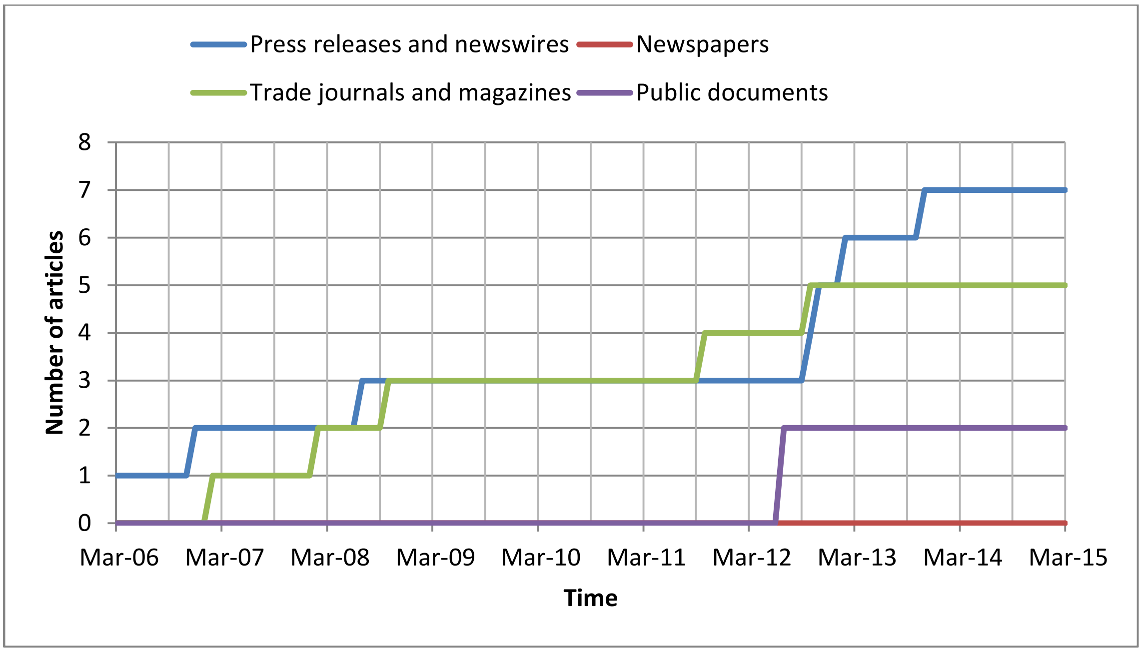

Figure 55. *Cumulative number of articles by source type in the United States from the first article to 31st of March 2015 for solid/specified recovered fuel.*

The overall lack of interest could be due to the concept being relatively new or the terms being too technical.

4.12 Sustainable business

There is clearly much more interest in the United States than in Germany or Brazil, which are very even and have similar growth as well. For the United States, growth has accelerated after mid-1992 and early 1997, which can be seen in figure 56.

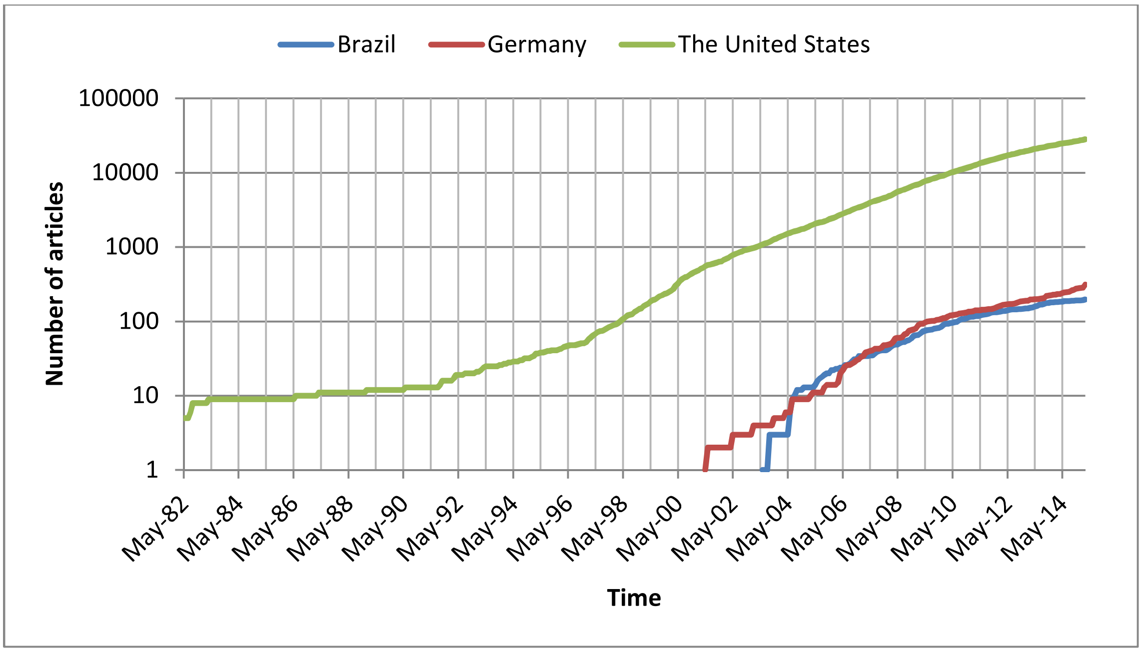

Figure 56. *Cumulative number of articles from the first article to 31st of March 2015 for sustainable business.*

Curiously, even though Brazil and Germany have nearly the same amount of articles published, the number of sources for Brazil is about one fifth of Germany's, which is shown in figure 57.

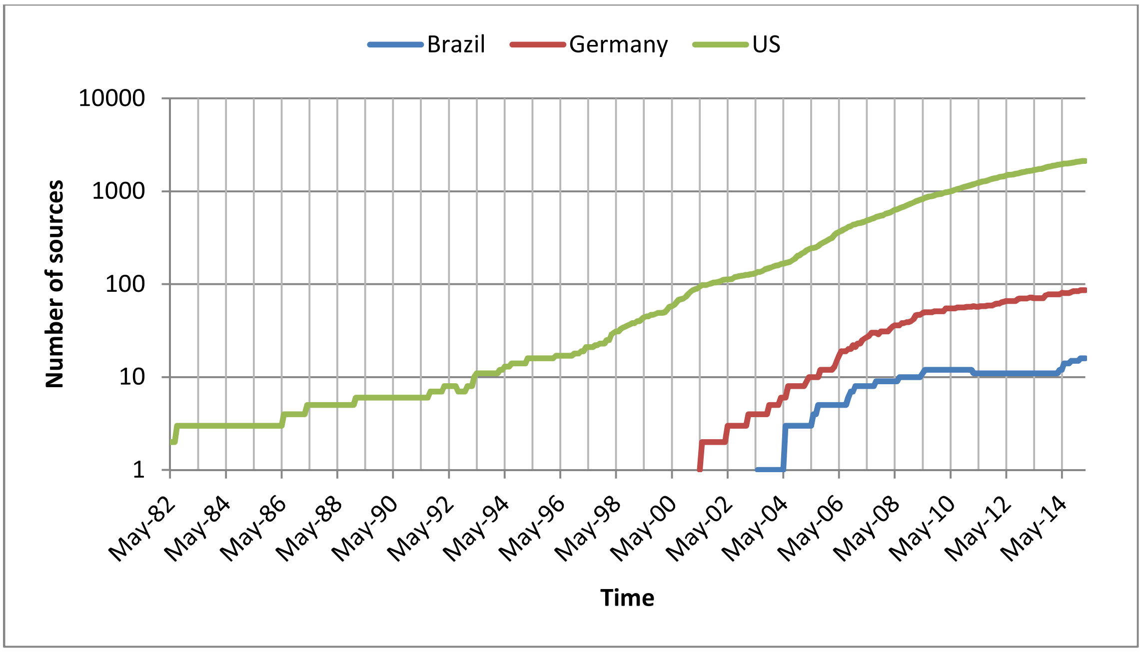

Figure 57. *Cumulative number of sources from the first article to 31st of March 2015 for sustainable business.*

As can be seen in figures 58 and 59, the monthly publishing rates are clearly larger in the United States. In the case of Brazil and Germany it can be seen that interest is not completely continuous.

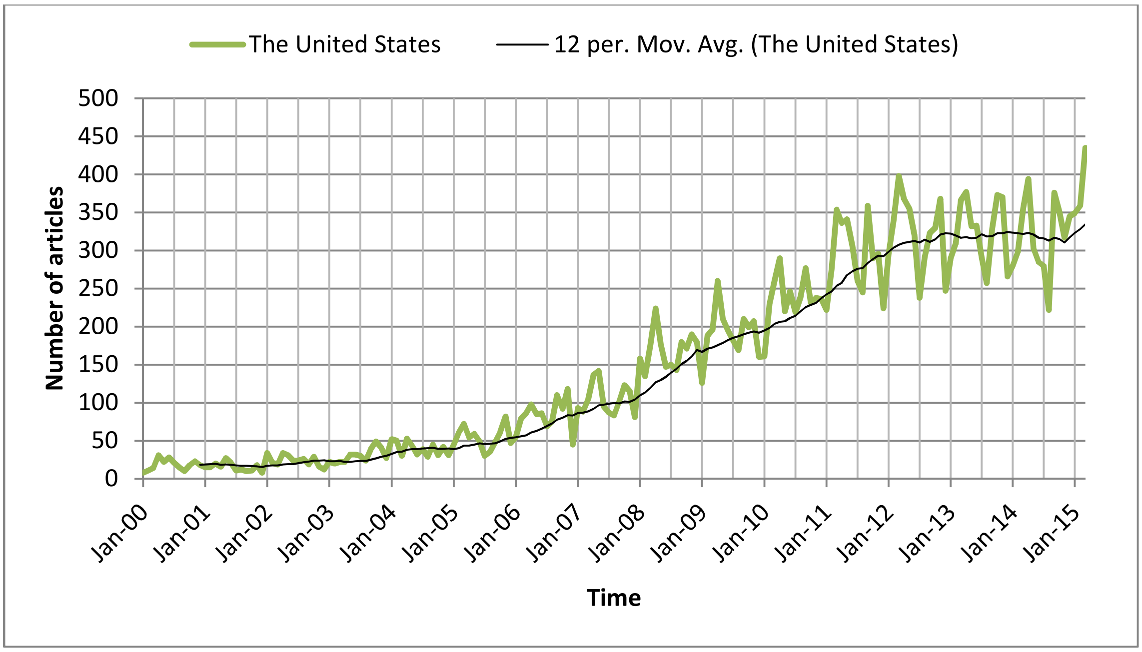

Figure 58. *Frequency of published articles per month from 1st of January 2000 to 31st of March 2015 for sustainable business.*

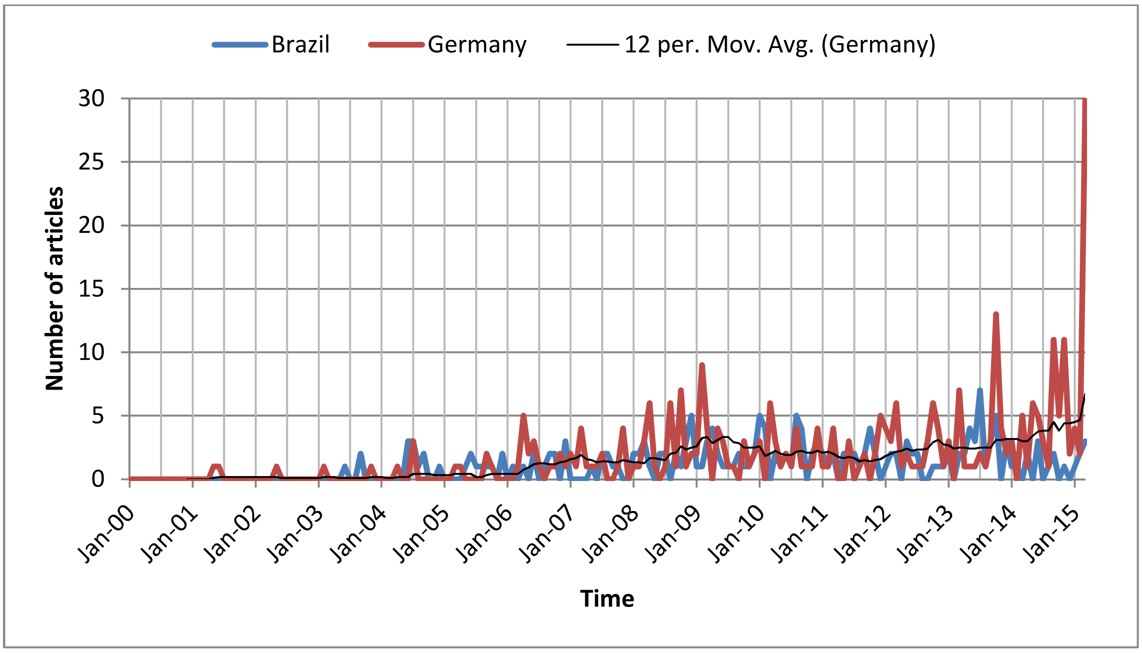

Figure 59. *Frequency of published articles per month from 1st of January 2000 to 31st of March 2015 for sustainable business.*

The United States seems to have larger ratios as well, as shown in figure 60. Since late 1990s the sources have published multiple articles per month as well.

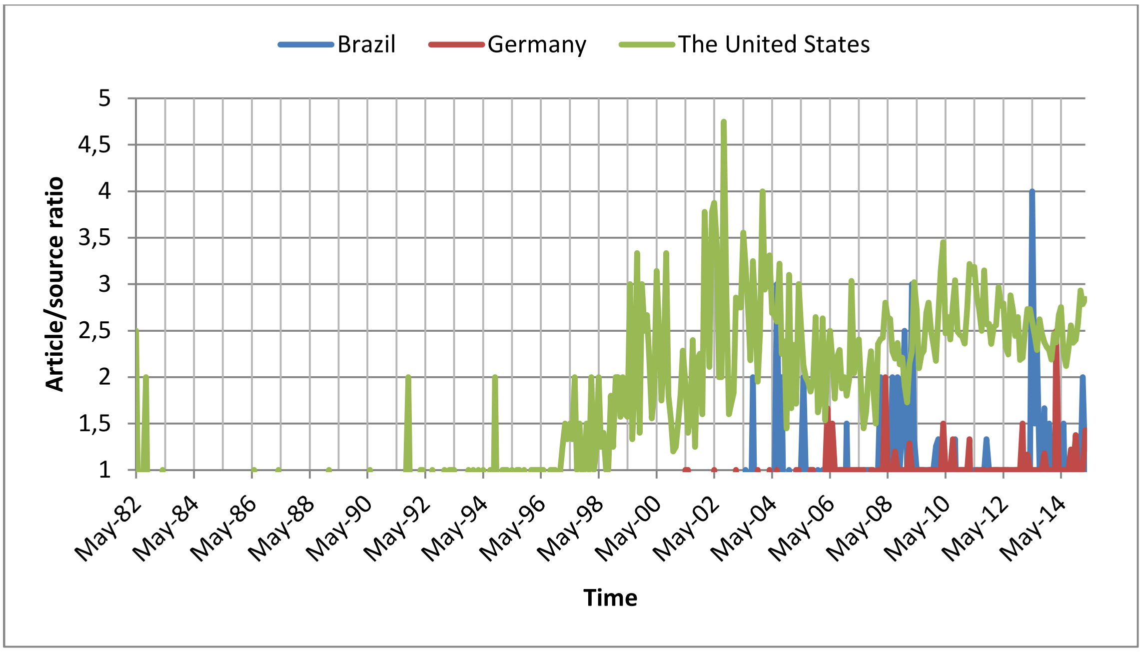

Figure 60. *The ratio of articles to sources per month from the first article to 31st of March 2015 for sustainable business.*

Increasing growth can also be seen for all source types in figure 61. The first article was published in a newspaper in 1982, but there seems to have been a lag of almost 20 years before growth began in press releases and later on for everything else.

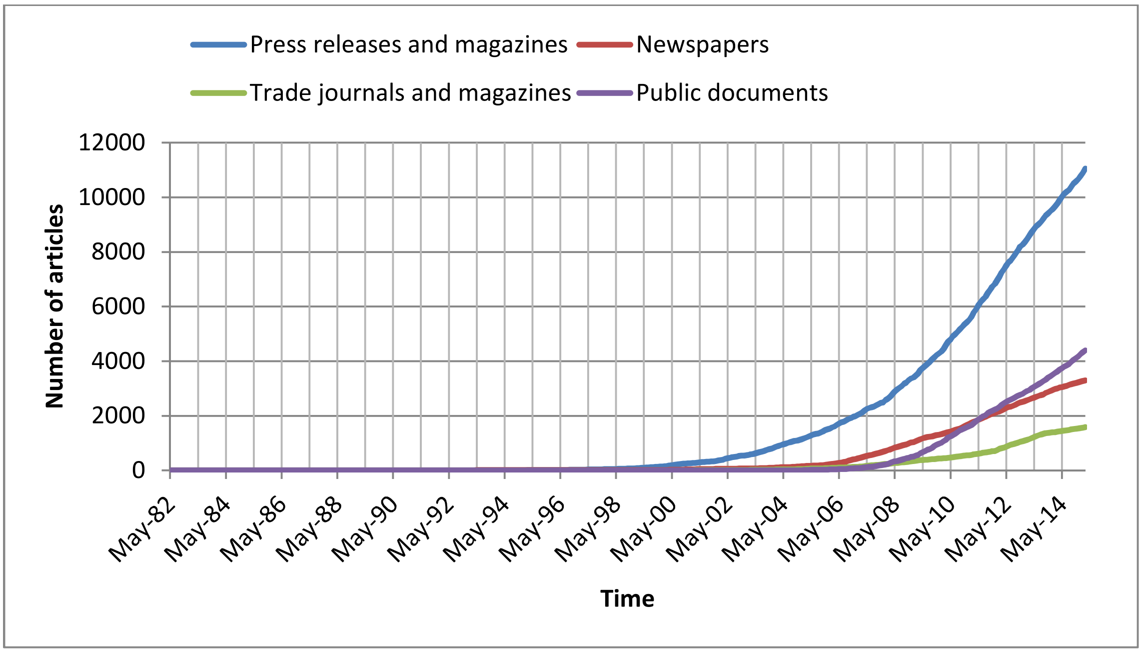

Figure 61. *Cumulative number of articles by source type in the United States from the first article to 31st of March 2015 for sustainable business.*

A familiar increase in interest can be observed for both newspapers and trade journals after year 2005 in figure 62, although it seems to have waned during the last two years.

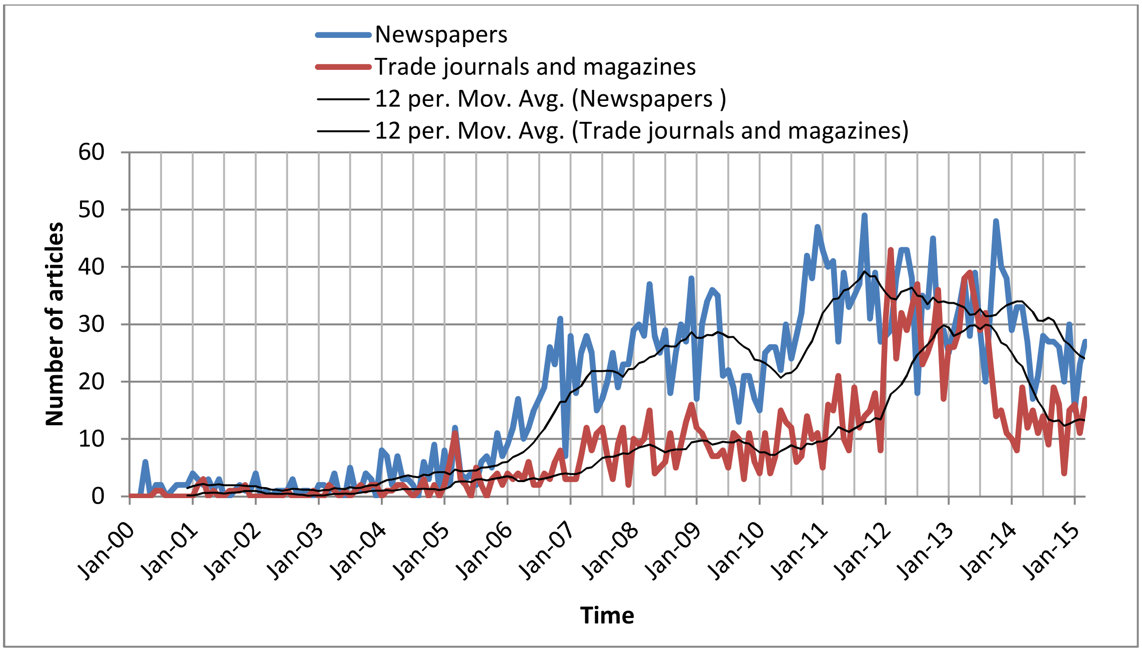

Figure 62. *Number of articles per month by source type in the United States from 1st of January 2000 to 31st of March 2015 for sustainable business.*

Trade journals clearly lag after newspapers. Different peak times can also be observed in 2011 and 2012.

4.13 Thermal depolymerization

The technology might be relatively new, as the first articles were published in 1999 and only one could be found for Brazil and none for Germany. Additionally, the rate of new articles seems to be fairly low for the United States as well, which is shown in figure 63.

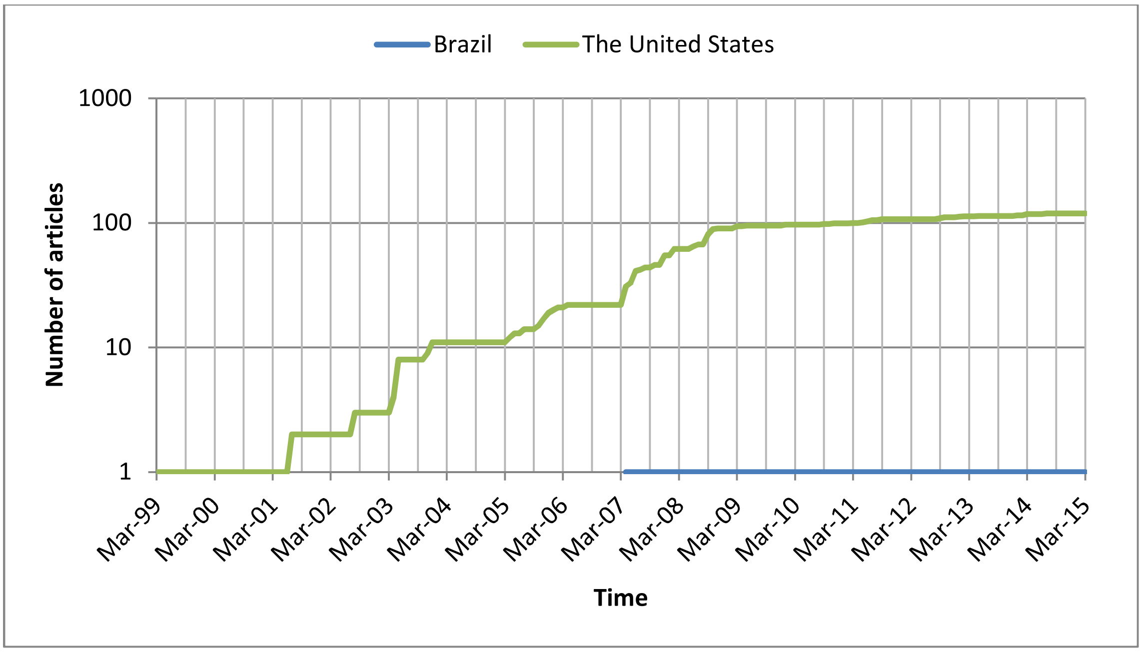

Figure 63. *Cumulative number of articles from the first article to 31st of March 2015 for thermal depolymerization.*

The growth rate is fairly similar with sources in figure 64 as well. The growth in sources seems to mirror the growth in articles closely, for example beginning in March 2005 and March 2007.

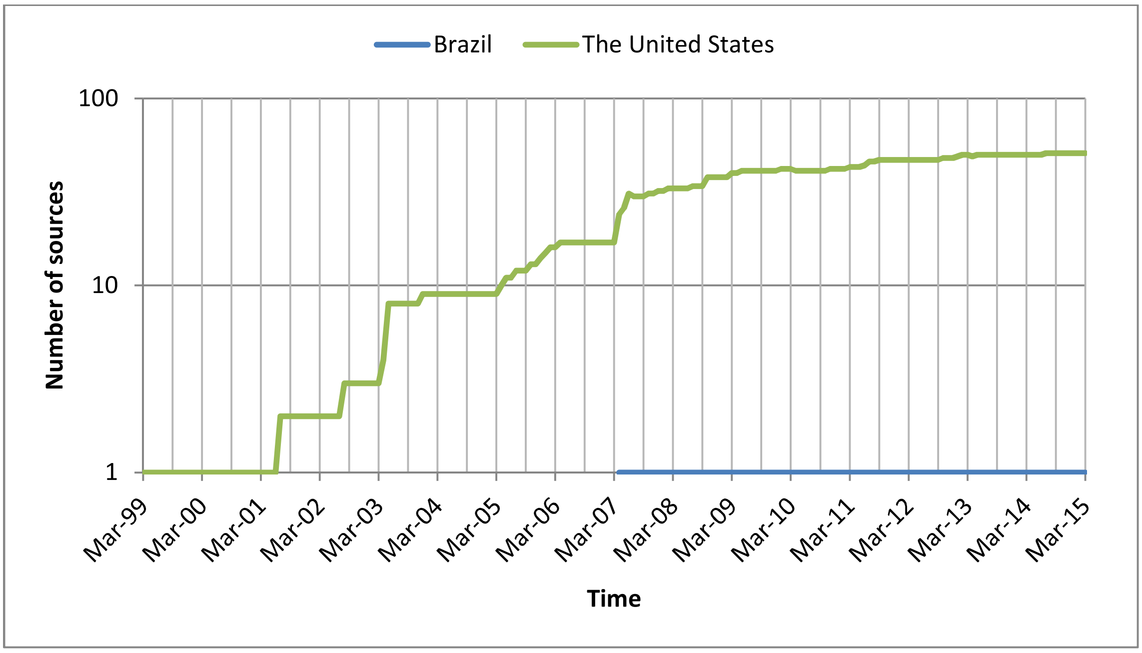

Figure 64. *Cumulative number of sources from the first article to 31st of March 2015 for thermal depolymerization.*

Most of the growth is concentrated between 2007 and 2009 with up to a year between new articles as shown in figure 65.

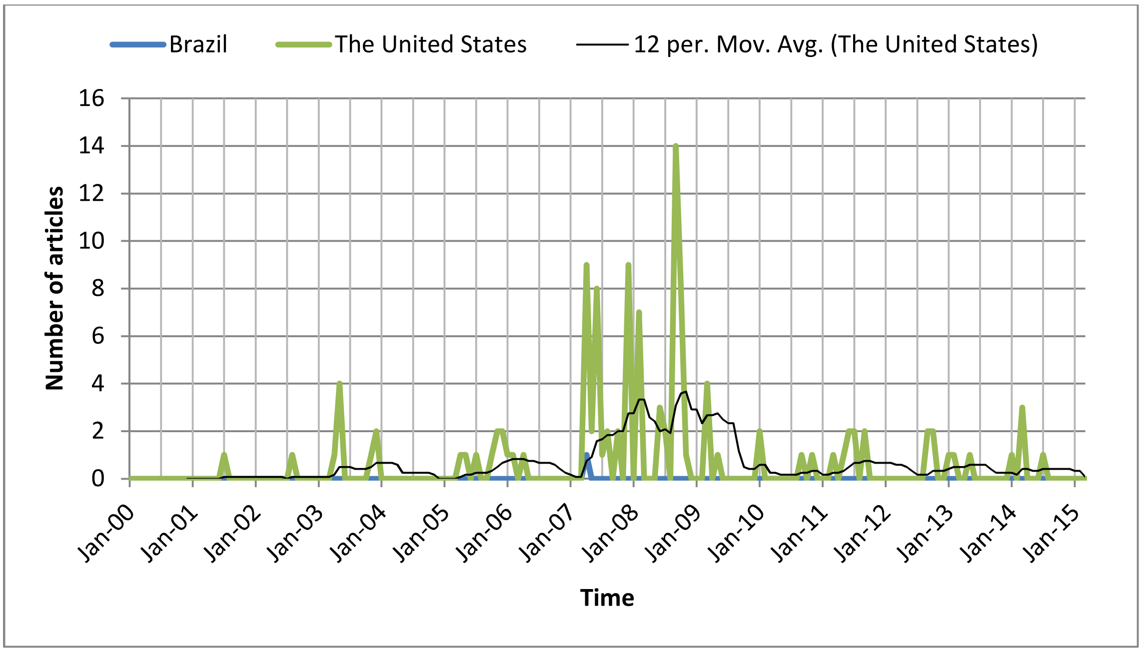

Figure 65. *Frequency of published articles per month from 1st of January 2000 to 31st of March 2015 for thermal depolymerization.*

According to figure 66, most of the growth seems to have come from public documents and trade journals. After a relatively rapid growth between 2007 and 2008 the growth of public documents seems to have stalled completely for almost 4 years.

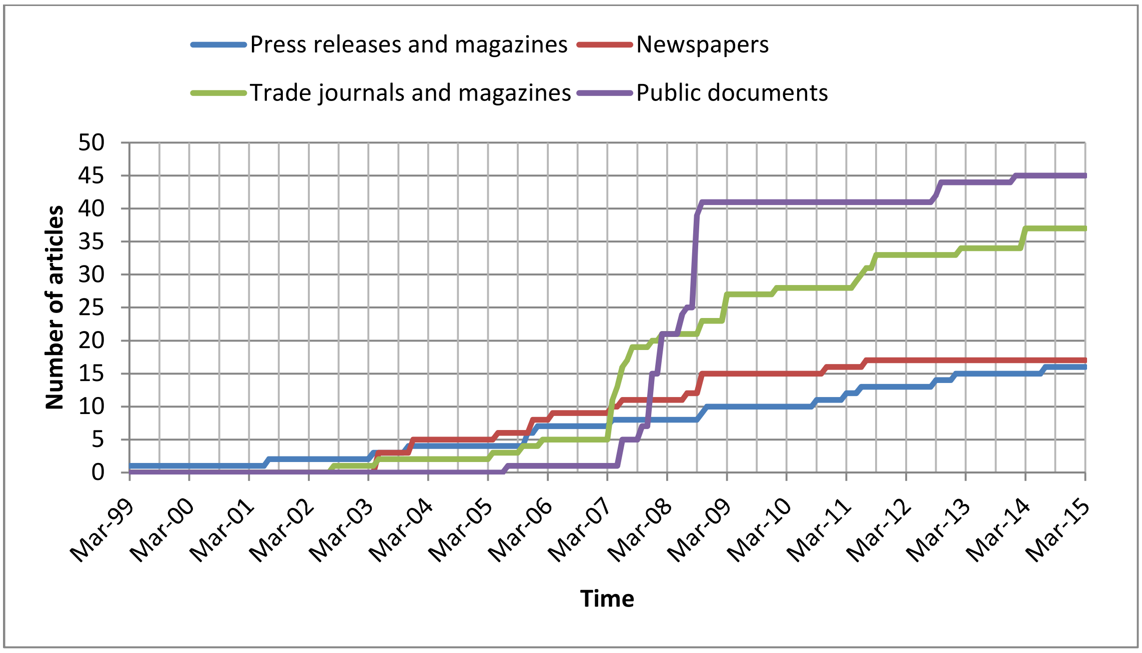

Figure 66. *Cumulative number of articles by source type in the United States from the first article to 31st of March 2015 for thermal depolymerization.*

Activity for press releases and newspapers is quite low, which might be due to the technical nature of the term.

4.14 Waste gasification

The time lag is almost 30 years concerning this technology but until 1995 the growth has stayed relatively low. Peculiarly, Brazil has only one article. These are presented in figure 67.

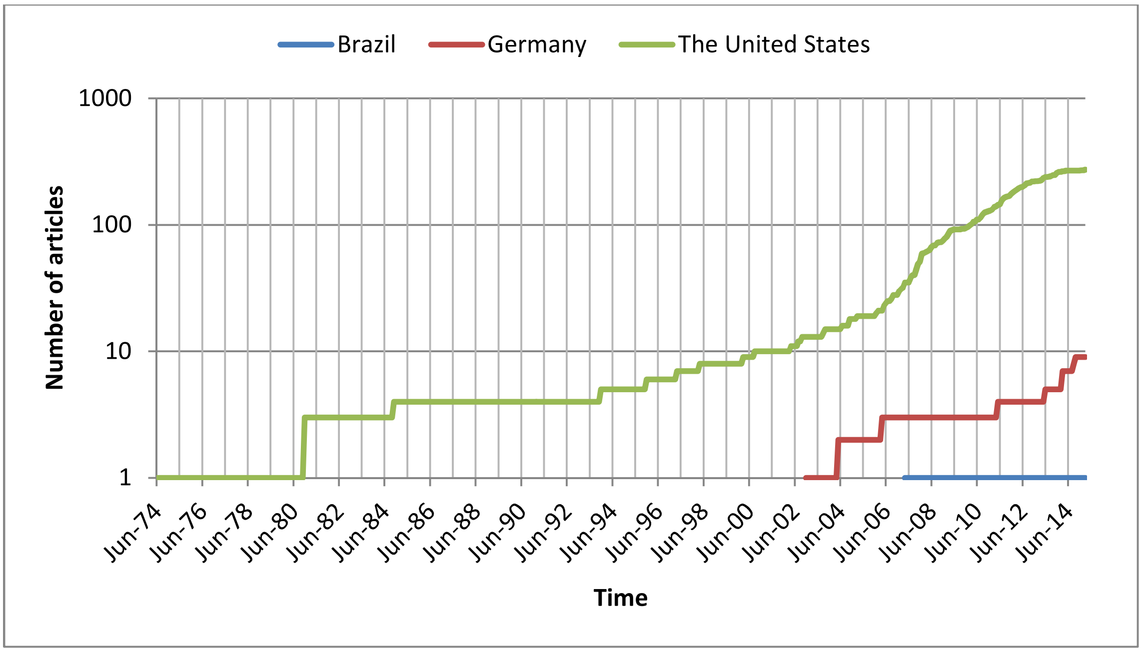

Figure 67. *Cumulative number of articles from the first article to 31st of March 2015 for waste gasification.*

Figure 68 mirrors figure 67 and its trends. The trends could mean that although the concept is old, the means to achieve waste gasification on an industrial scale were not available until after 2000.

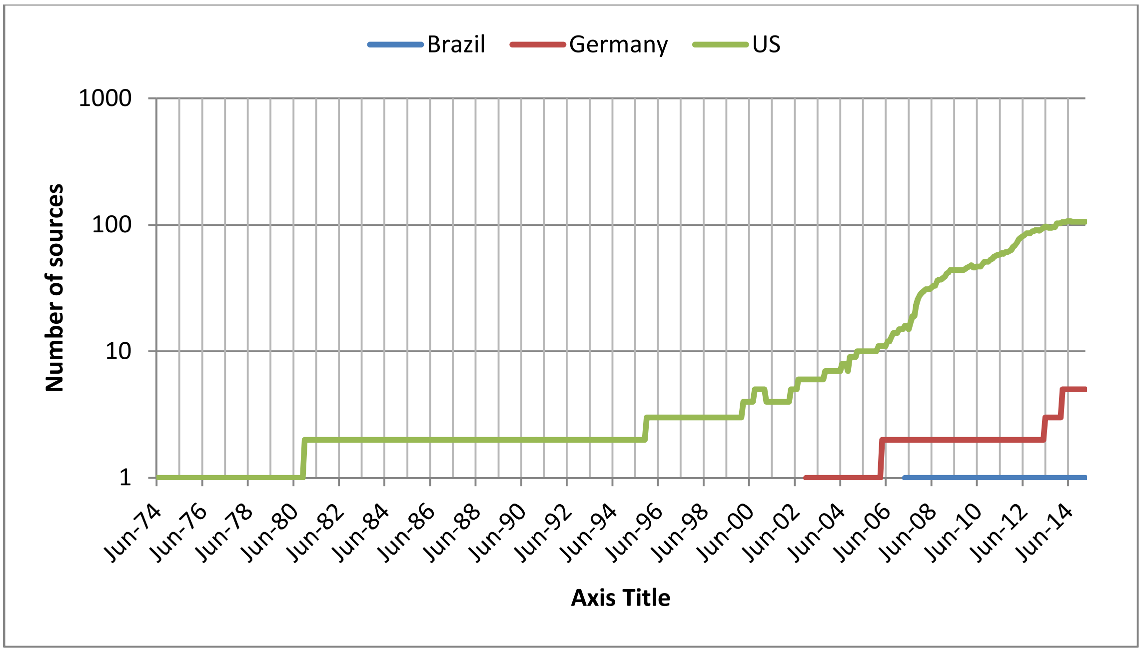

Figure 68. *Cumulative number of sources from the first article to 31st of March 2015 for waste gasification.*

As figure 69 shows, the United States publishes many more articles, although the month-to-month variation is great.

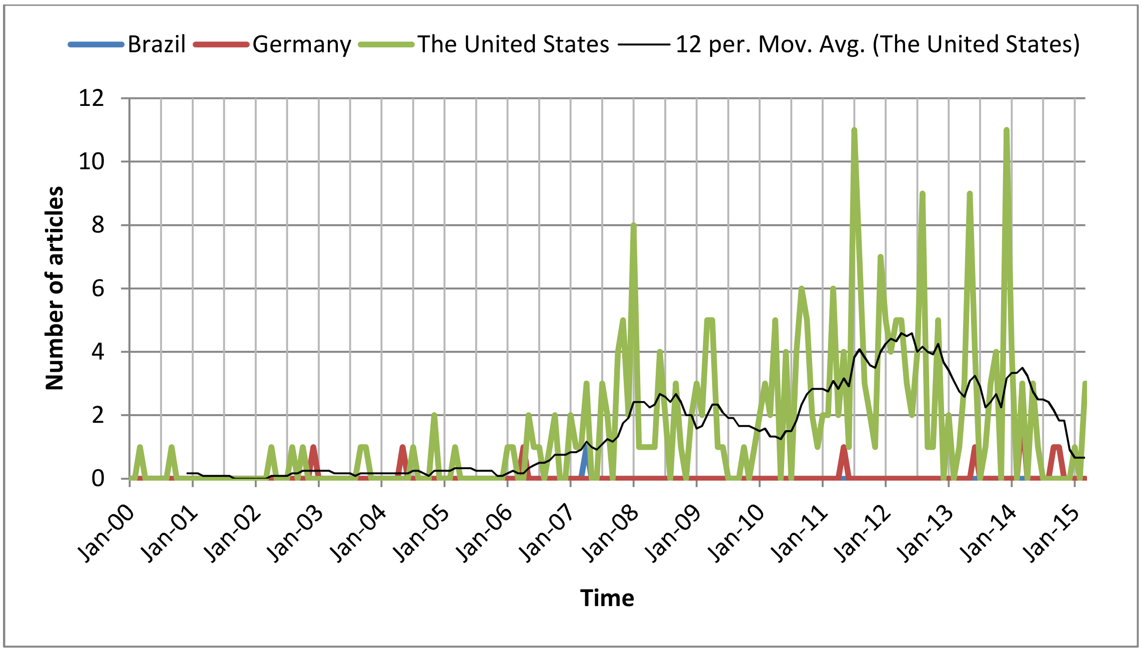

Figure 69. *Frequency of published articles per month from 1st of January 2000 to 31st of March 2015 for waste gasification.*

A rapid growth for all source types can be observed in figure 70. The first article was published in 1974 in a trade journal, and thereafter the beginning of growth took over 30 years.

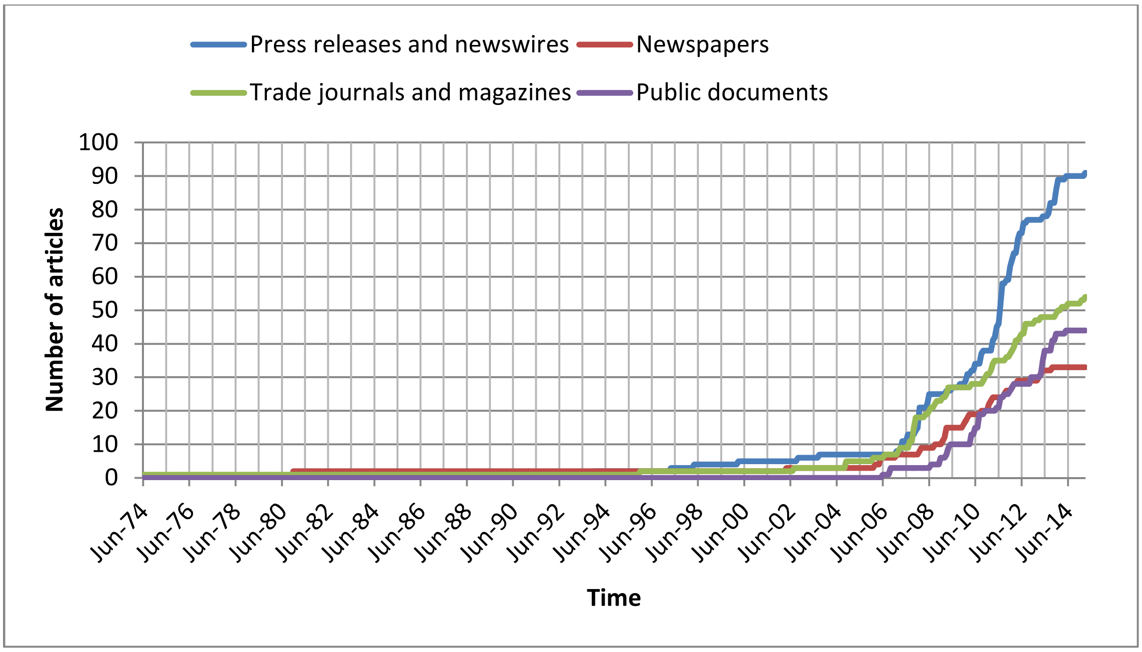

Figure 70. *Cumulative number of articles by source type in the United States from the first article to 31st of March 2015 for waste gasification.*

The increasing number of press releases and articles in trade journals could be the result of increasing technological knowledge and business opportunities.

4.15 Waste incineration

Although the first article in the United States was published before Germany, the interest in Germany has grown much faster and overall number of articles surpassed that of United States' in late 2005, as can be seen in figure 71.

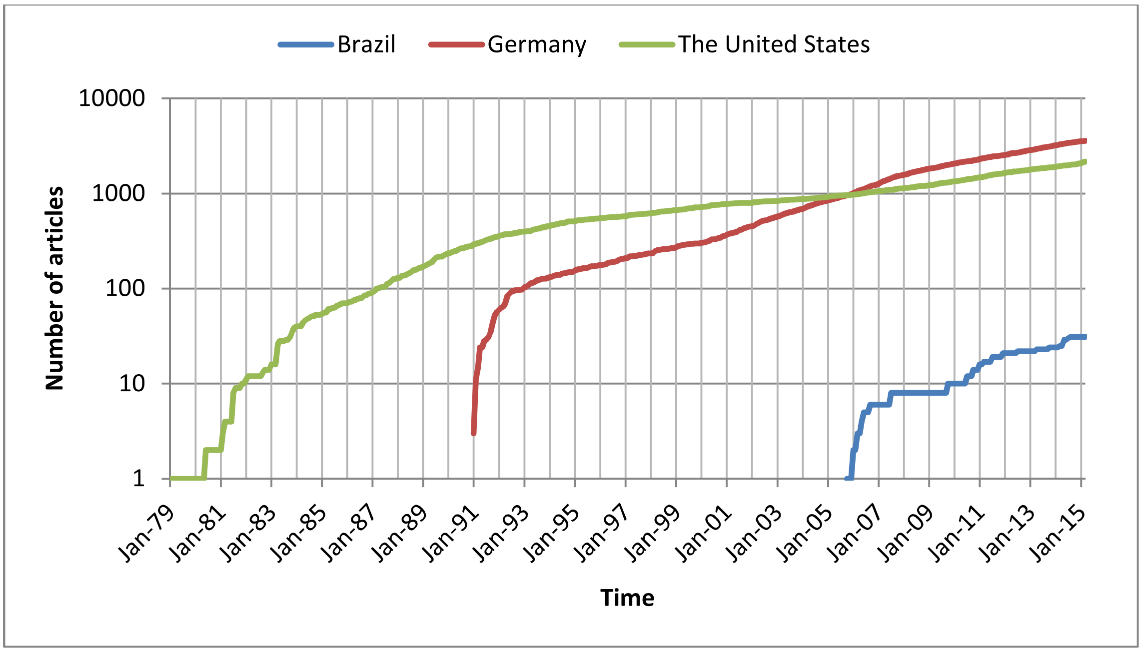

Figure 71. *Cumulative number of articles from the first article to 31st of March 2015 for waste incineration.*

However, the number of sources in Germany has not surpassed number of sources in the United States. Growth seems fairly steady in both countries, whereas Brazil has too few sources to indicate any trends. These trends are presented in figure 72.

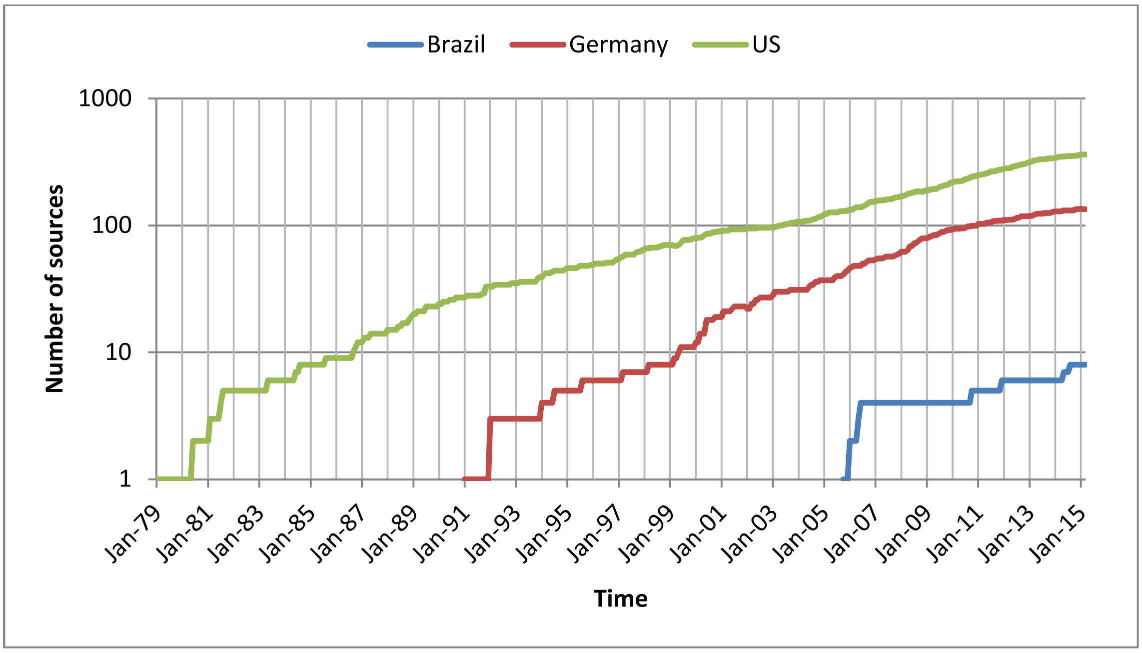

Figure 72. *Cumulative number of sources from the first article to 31st of March 2015 for waste incineration.*

Figure 73 show that German interest has been much higher than the United States' for most of the last 15 years, and a small steady rise can also be seen.

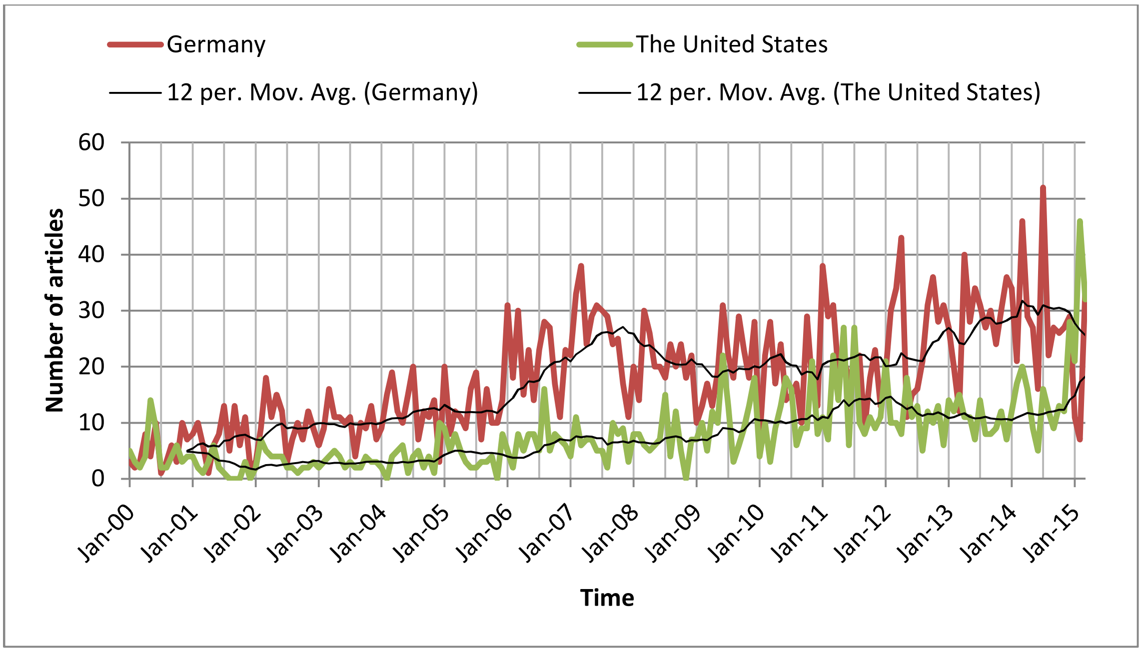

Figure 73. *Frequency of published articles per month from 1st of January 2000 to 31st of March 2015 for waste incineration.*

The ratios are clearly different for the countries in figure 74. While the United States mostly has ratios below three with few exceptions, Germany's sources have published many more articles per month, especially in the 1990s.

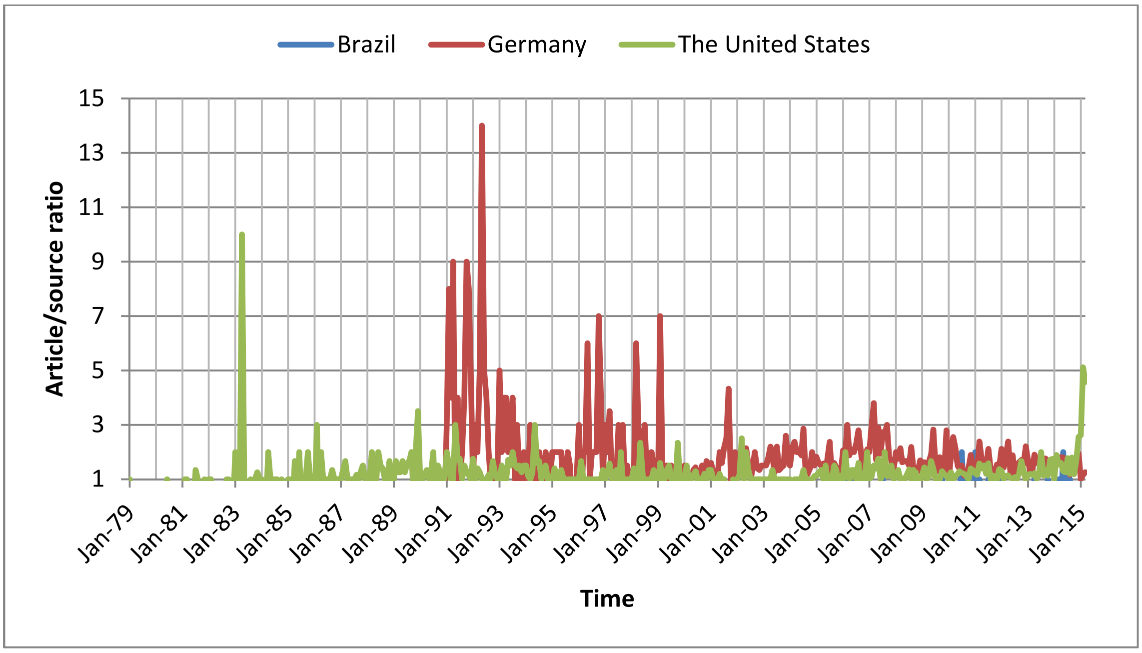

Figure 74. *The ratio of articles to sources per month from the first article to 31st of March 2015 for waste incineration.*

Waste incineration seems to have appeared in both press releases and newspapers almost from the beginning, whereas trade journals' interest seems to have begun later but is also increasing at a steady rate, as shown in figure 75.

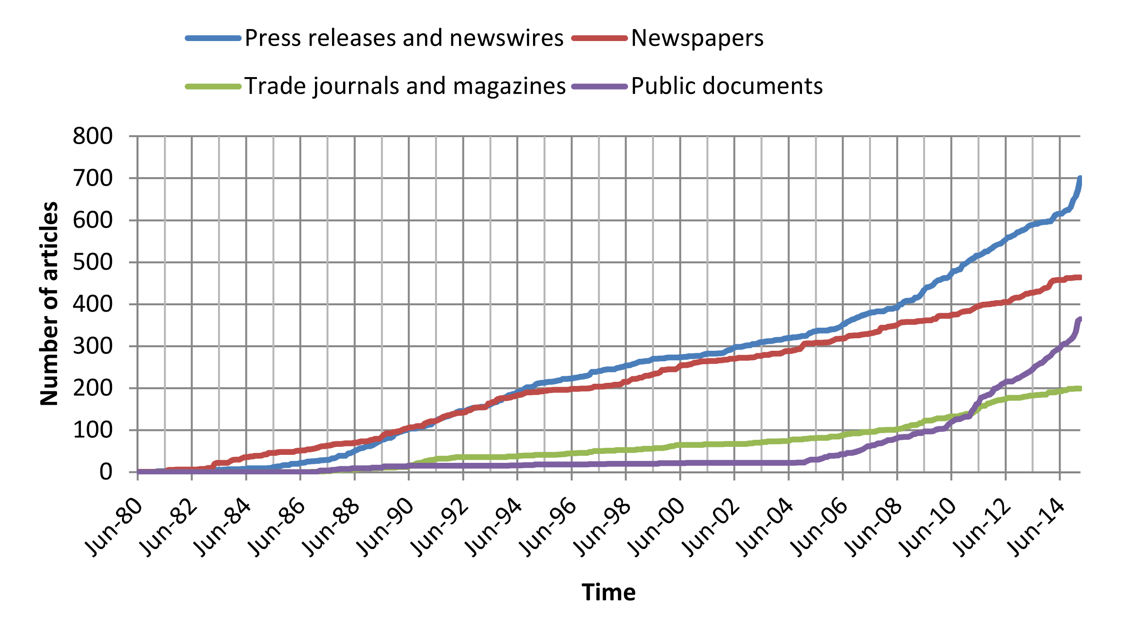

Figure 75. *Cumulative number of articles by source type in the United States from the first article to 31st of March 2015 for waste incineration.*

Something might have happened in 2005 and 2010 as the rate of growth for public documents increased at both points.

4.16 Waste pyrolysis

Data could only be found for the United States. The low number of articles and a recent introduction could indicate that either the technology is quite new or no applications exist which could interest the general public and mass media. The number of articles is expressed in figure 76.

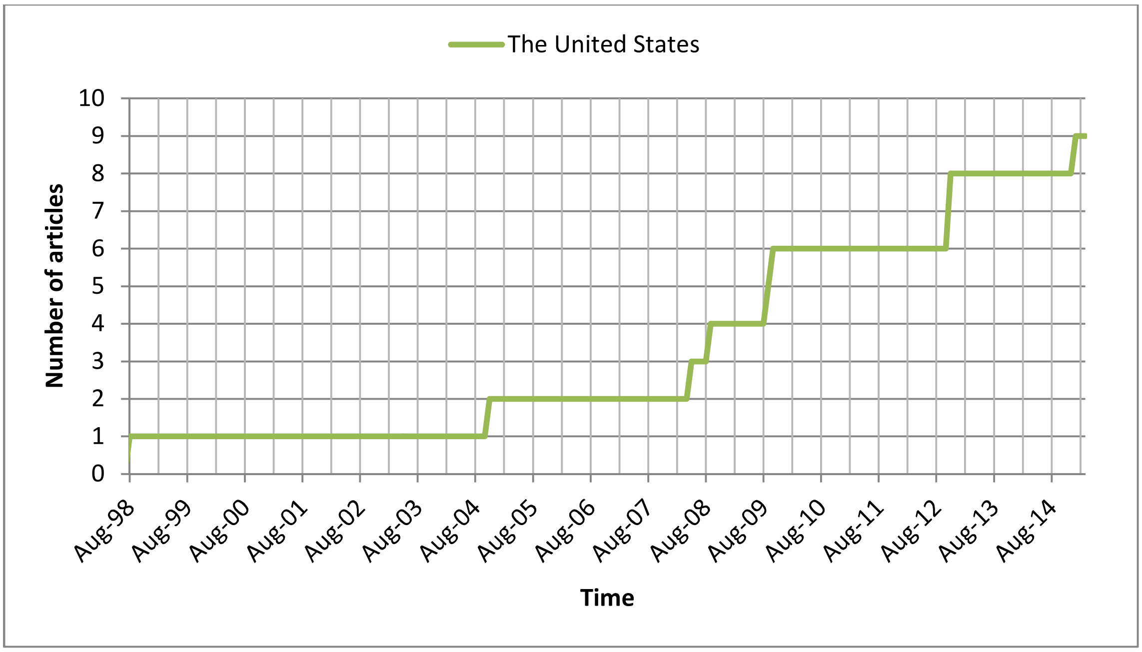

Figure 76. *Cumulative number of articles from the first article to 31st of March 2015 for waste pyrolysis.*

The same low growth in reporting sources is apparent in figure 77.

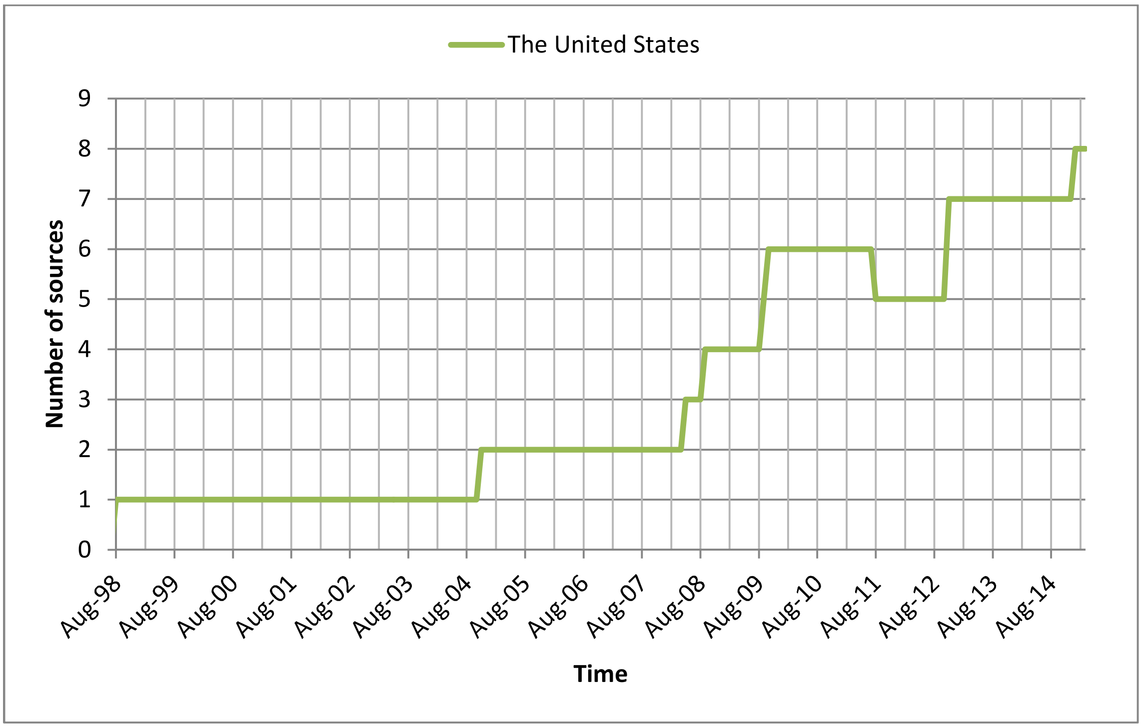

Figure 77. *Cumulative number of sources from the first article to 31st of March 2015 for waste pyrolysis.*

This level of very low interest could again be due to the technical nature of the concept. Other explanation could be that the technology is not yet ready for use, so it is of no use to report about it.

4.17 Waste to energy

The concept seems to be old in the United States and interest has been steady there with interest increasing again after late 2005. Publishing activity has also increased in Germany and Brazil, although there was an 8-year delay between the first and second articles in Germany. This can be seen in figure 78.

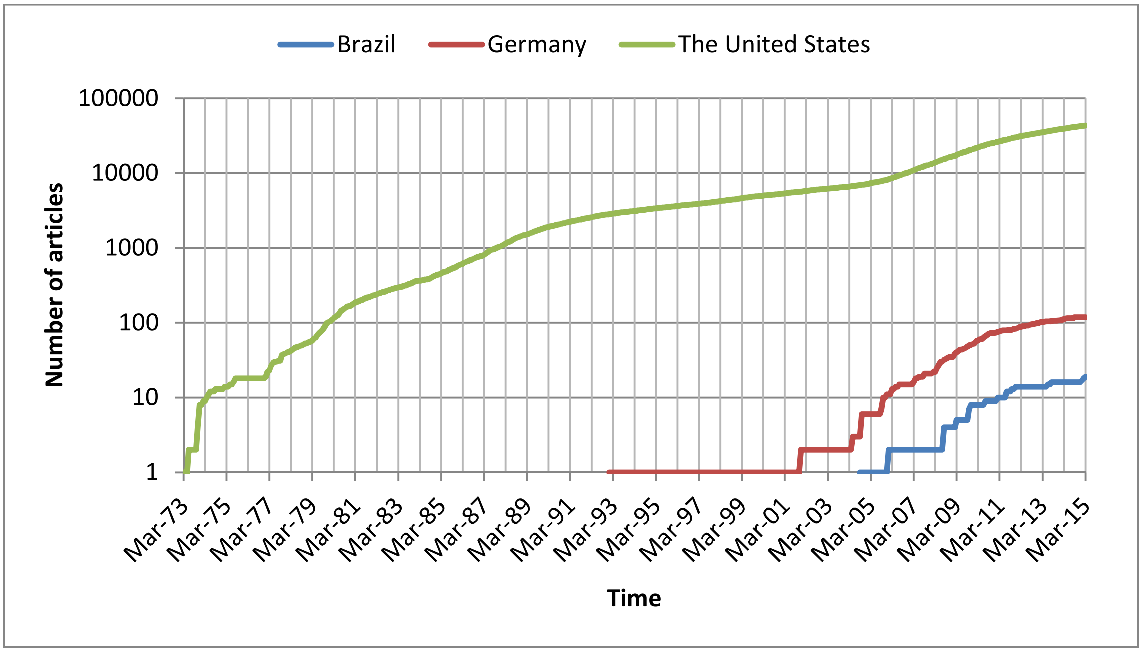

Figure 78. *Cumulative number of articles from the first article to 31st of March 2015 for waste to energy.*

Same trends can be seen in figure 79. The growth in late 2005 in the number of sources appears to predate the same growth in the number of articles by a year.

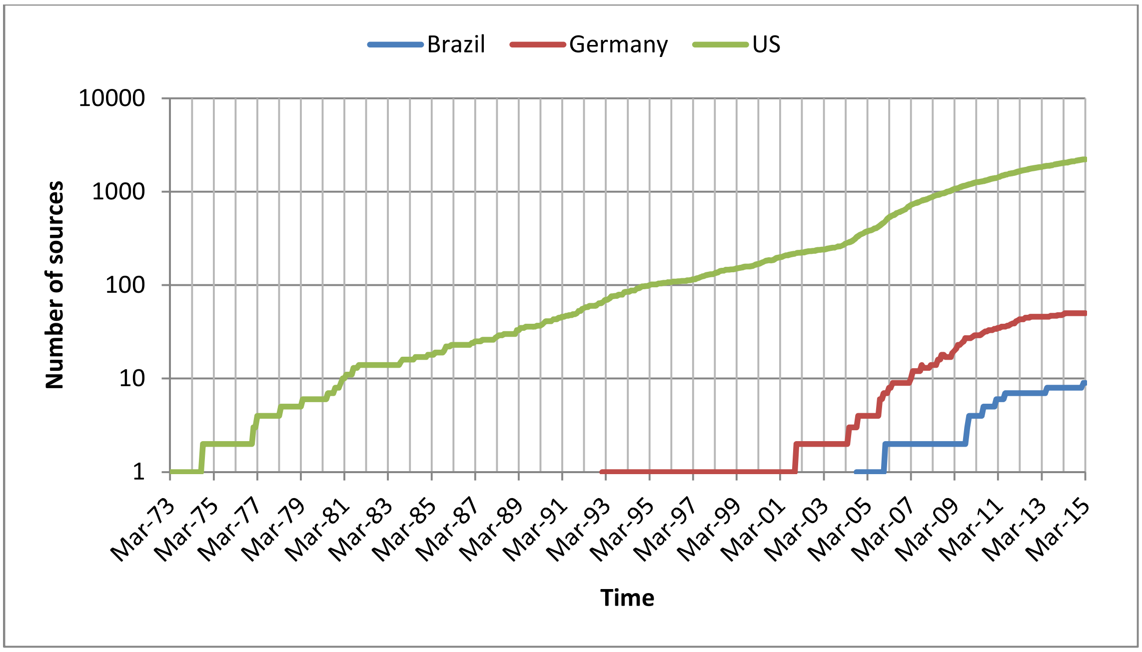

Figure 79. *Cumulative number of sources from the first article to 31st of March 2015 for waste to energy.*

As figures 80 and 81 show, the orders of magnitude are completely different between the countries.

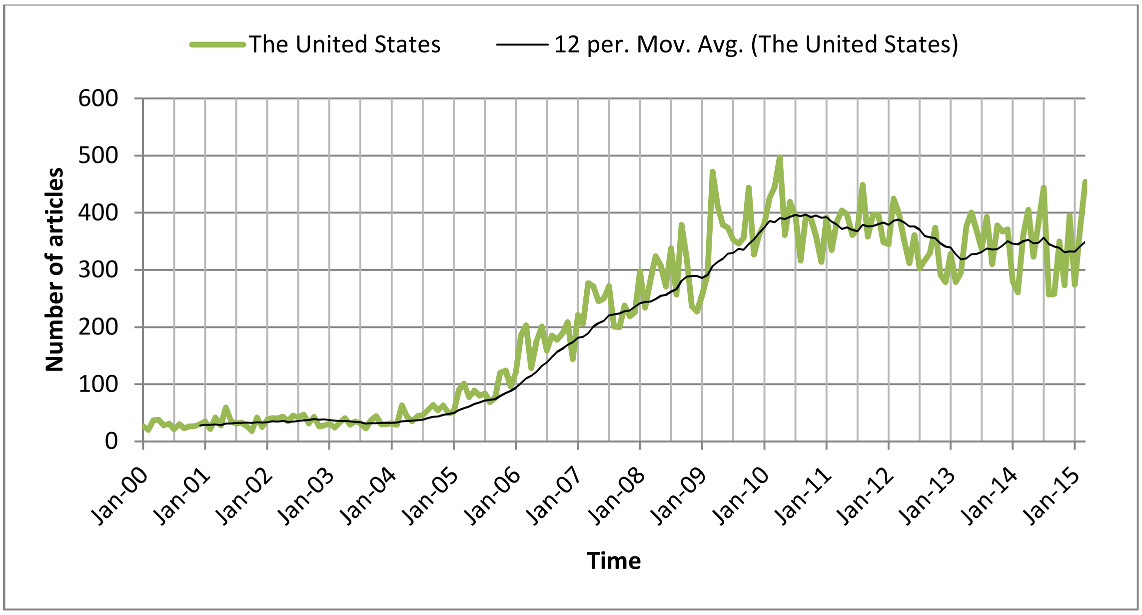

Figure 80. *Frequency of published articles per month from 1st of January 2000 to 31st of March 2015 for waste to energy.*

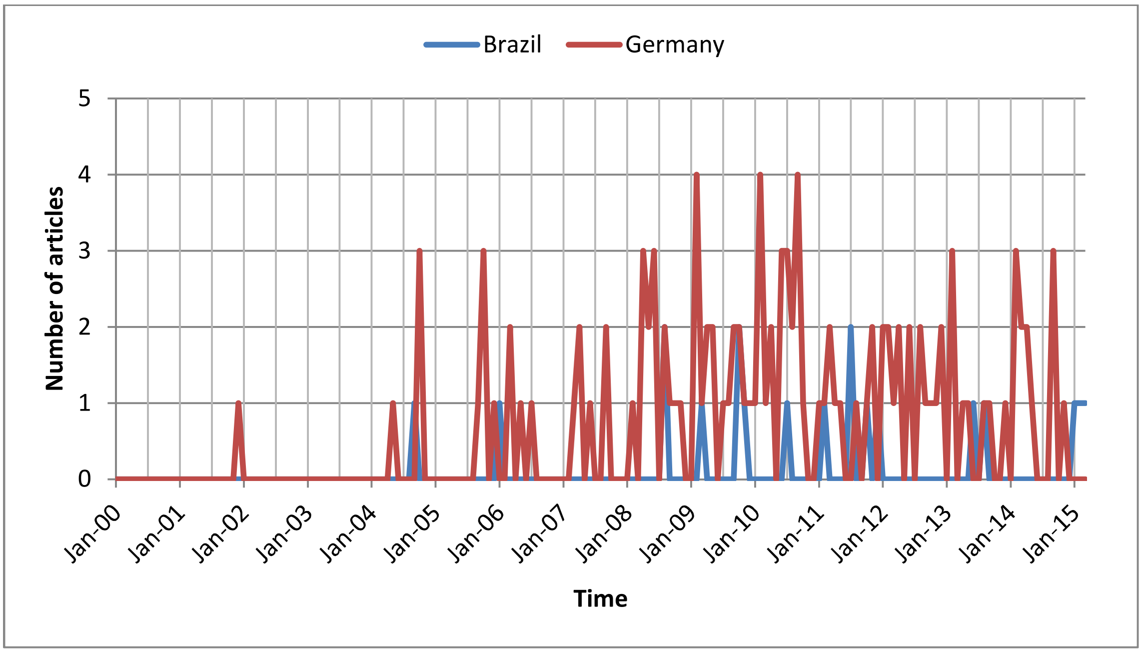

Figure 81. *Frequency of published articles per month from 1st of January 2000 to 31st of March 2015 for waste to energy.*

Interest seems to be steady in the United States, as shown in Figure 82.

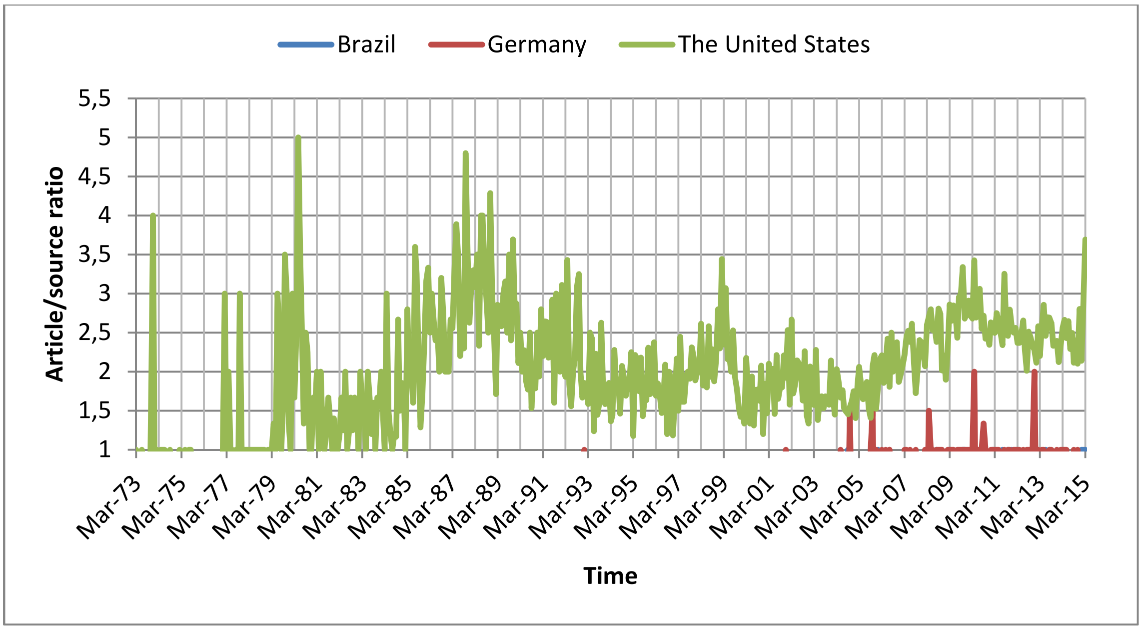

Figure 82. *The ratio of articles to sources per month from the first article to 31st of March 2015 for waste to energy.*

A lag between the first article and subsequent growth can be observed in figure 83. Even when the subject of waste to energy was originally introduced in a trade journal in the 1970s, the trade journals comprise the smallest category of all source types. Somewhat unusually newspaper and press release article counts seem to have grown almost in tandem until 2009.

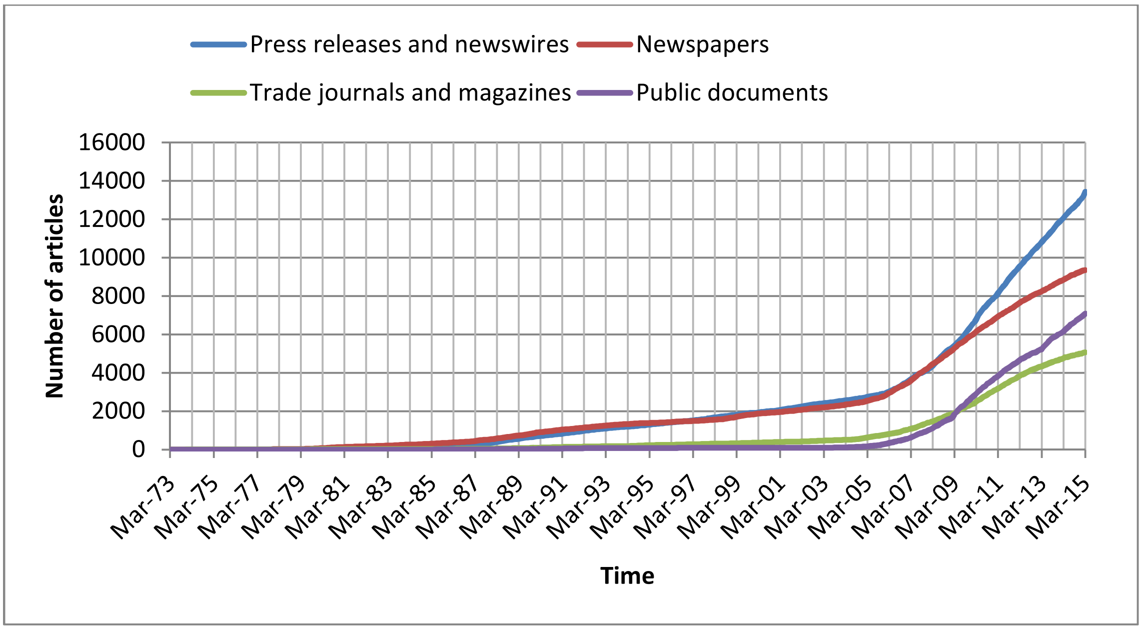

Figure 83. *Cumulative number of articles by source type in the United States from the first article to 31st of March 2015 for waste to energy.*

Figure 84 shows first increasing and then declining interest for both source types. Newspapers seem to have been more active in general.

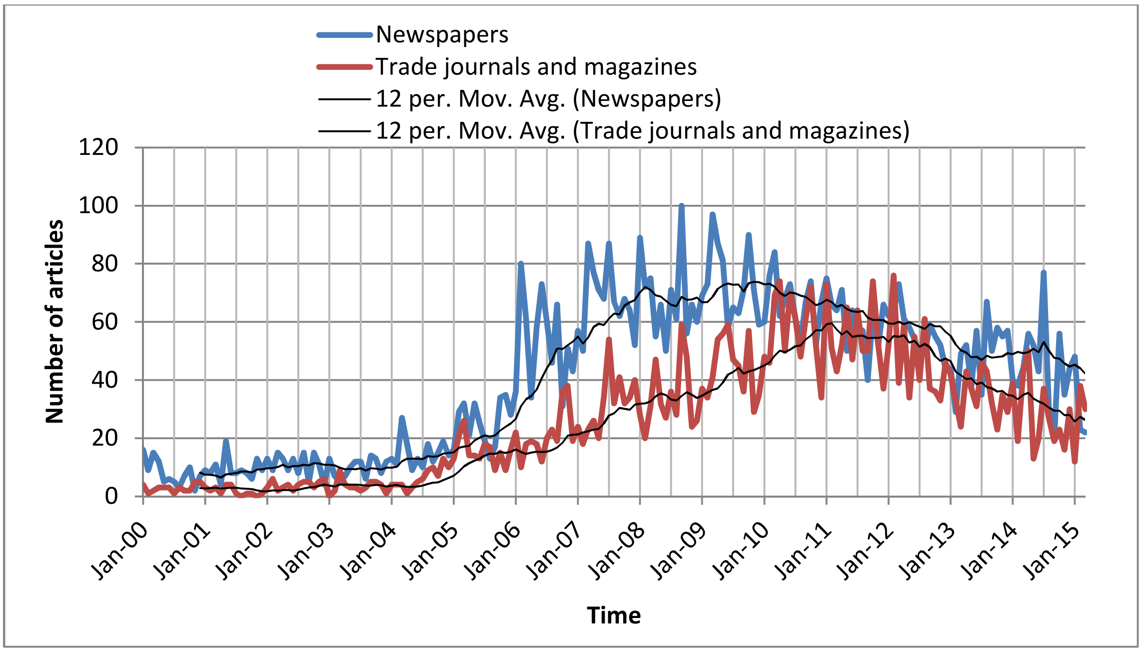

Figure 84. *Number of articles per month by source type in the United States from 1st of January 2000 to 31st of March 2015 for waste to energy.*

Trade journals seem to have lagged behind newspapers for most of the time. However, in late 2011 their activity surpassed newspapers' activity very briefly, after which it again followed the same general decline.

5. CONCLUSIONS

Many different trends can be seen in media interest for the technologies. For some, interest has been steady or increasing, whereas for some there have already been peaks in interest and dwindling after that. The growth rates have also shown much variety. An overview of the results can be found in appendix D. Additional information regarding source types are presented in appendix E.

The lack of articles for some technologies in certain countries prevents analysis. For example, no articles could be found for “recovered fuel co-firing” in any of the countries. Either there is no media interest for this concept or the terms are too specific or technical for the media. It has to be also noted that this search term was the longest or strictest out of all the technologies studied, which could limit the number of results. Mostly it seems that the more technical or specific the search terms are, the fewer articles can be found and therefore it is harder to pick out any trends. Extensive concepts such as “reverse logistics” or “sustainable business” produce the most results, but are most susceptible to unrelated articles and other noise.

For all the other technologies at least some articles could be found. For Brazil, however, the low number of articles inhibits any detailed trend analysis. With just 676 articles overall for all the technologies combined almost any variation in the monthly frequency of published articles can result in a large relative change. Only “reverse logistics” has enough articles to cautiously interpret any trends. Most likely this is due to the source selection of LexisNexis, which only tracks and collects 20 Brazilian sources, out of which only 12 were being kept up-to-date at the time of the study. For comparison, the source selection for the United States and Germany comprised of 3614 and 211 up-to-date sources. Up-to-date in this case means that the source was being tracked at the end of the study period by LexisNexis. It is also possible that the tracking period for the Brazilian sources misses periods of high publishing activity. Other reasons for the lack articles could be incorrect search terms and an actual lack of media interest. All in all, a clear language bias can be seen in LexisNexis’ Brazilian source tracking, which inhibits analysis.

Regarding general trends for most technologies in the United States and Germany it can be seen that there has been an increase in interest after 2000, although there have also been periods of no growth. Some of these exceptions can be observed in “plasma gasification” in Germany and “thermal depolymerization” in the United States. The increases after 2000 can be seen even if the first articles about the technologies were written in the 1970s. There are also some gaps between publishing activity for some technologies, such as “plasma gasification” in the United States, where it took 8 years for the second article to appear after the first, “solid/specified recovered fuel” in the United States with a 3-year gap and a 6-year gap in Brazil, and “waste gasification” in Germany with a gap of 4 years. Again, it is not certain whether these gaps exist due to a lack of interest or missing coverage of the sources that have written about these technologies. However, it is possible that the technologies were developed far enough to produce promising initial results, which warranted media attention at first but faded away after subsequent assessment.

Another general trend seems to be either an arresting or negative growth in monthly articles in the later years after the general increase in early 2000s. Only “reverse logistics” in the United States, “municipal solid waste” in Germany, and “solid waste management” in both the former and the latter countries seem to be exempt from this phenomenon. There is variation in the start and end dates for both periods of growth and decline, so even if changes in the source coverage influence those periods, they probably do not cause them and the results are mostly due to actual media interest. Additionally, Germany has more published articles for some technologies than the US even when LexisNexis tracks over 17 times as many sources for the US as for Germany. Also, in an extreme and theoretical case with an unlimited number of sources and zero media interest would result in no published articles.

The strongest resemblance to the idealized hype cycle curve with a pronounced peak and a following trough can be observed in “fluidized bed combustion/boiler” and “landfill gas” in the United States, and “refuse-derived fuel” and “solid waste management” in Germany. A possible rising peak can be observed in “municipal solid waste”, “reverse logistics” and “sustainable business” in the United States, whereas the same can be seen in “solid waste management” in both the United States and Germany. Peaks and troughs also appear in some other technologies, but the reliability is limited because of a small number of articles. It is also not possible to determine if the peaks and troughs consist of positive or negative sentiments, or both. No previous studies could be found concerning the same technologies and hype cycles, so no comparison is possible.

Some technologies do not have much written about them yet. The late appearance of Germany and Brazil could be explained by the lack of earlier coverage in LexisNexis. However, since mentions of most other technologies in the United States begin from the 1970s, it could be assumed that mentions of some technologies truly are just emerging in the mass media. These technologies are “solid or specified recovered fuel” (first mentioned in 2006), “thermal depolymerization” (1999), and “waste pyrolysis” (1998). Again, it could be possible that the search terms are too technical and specific for the mass media.

A strong pareto distribution was found for many technologies regarding the proportion of articles and publishing sources. For example, roughly 73% of the articles about "solid waste management" were published by a bit over 4% out of all the sources that had published at least a single article about the topic. Almost 44% of these sources had published only one article. This could be due to most of these articles being about one-time local events and written by local news, syndicated content, or a sign of these sources engaging in the hype cycle. This would need additional research delving into the content of the articles, however.

The distribution was used in dividing the articles into source types in order to focus on only the most important and active sources. An average coverage of 87% all the articles was achieved, the minimum being 77%. This means that on average 13% of articles and a maximum of 23% regarding one technology are not taken into account in the results of source types. This might influence the ranking of the source types or the appearance of first articles, if the articles are not spread evenly. They do not have an effect on the rest of the study.

For six technologies out of fifteen, newspapers were the first source type to publish articles, followed by four by trade journals, by press releases in three, and public documents in two. First mentions in public documents are peculiar; as they would suggest that the technology would have warranted some type of government oversight before entering the market. The technologies in question are "plasma gasification" and "waste pyrolysis". For most technologies press releases and newswires were the most available source type, ten out of fifteen technologies in total. For "municipal solid waste", "solid waste management", and "thermal depolymerization" public documents were the most numerous. Managing solid waste is important for the public authorities, which could explain its characteristics. Trade journals and magazines comprised the most of "fluidized bed combustion or boiler" and "waste pyrolysis", whereas newspapers were not the largest category in any technology. Waste pyrolysis is somewhat new – appearing in 1998 – and not much has been written about it, which could explain why most of articles have appeared in trade journals. Fluidized bed combustion is much older - appearing in 1978 – but since most of the public discussion seems to have happened in the trade journals, it could be that the technology is still undergoing development and refinement.

It has to be noted that this study has only measured the volume and frequency of publishing activity and therefore not the actual contents of those articles, which results in only a very limited view on the subject. In order to better understand whether the expectations for the technology are approaching a peak or a trough, a distinction between positive and negative expectations found in the articles would have to be made. However, qualitative analysis is out of scope for this study.

A serious limiting factor when considering the reliability of this study is that only the later kinds of technology life-cycle indicators such as newspapers and trade magazines were utilized, and even then they were originally lumped together by necessity as LexisNexis would not allow proper separation. A better insight on the technology could be generated with proper separation of these indicators and by also tracking earlier and later indicators as well, such as articles in journals, patents, and search traffic when suitable.

Another factor that might influence this study is that all of the technologies or concepts relate to either potential infrastructure or business-to-business products and services, instead of consumer goods. It is uncertain how hype cycles differ for these two types of technologies.

It also has to be noted that the results might suffer from a lack of normalization, i.e. an increase in publishing activity might not result solely from increased interest in the technology, but rather from an increase in overall publishing activity. Unfortunately LexisNexis does not publish detailed accounts on the number of articles it serves each month or year, so normalization based on total article counts is not possible. The limits on downloading article metadata and computational power also set barriers for calculating the number of all articles manually. Ideally, other variables should be found for normalizing the research data.

Whereas the number of results for some technologies or concepts might suffer from too specific search terms, some - like “sustainable business” - might be too broad and include extraneous results. Even as “sustainable business” or green business is a separate and defined concept, the term is too close to a company’s business just being sustainable generally, which has probably distorted the results and ensued a higher perceived interest than in reality. Diametrically, the more specific search terms most likely do not contain much noise, but much more likely lack coverage as more general sources such as newspapers might not be as interested in the technical details, but rather what the technology provides or what kind of risks it might bring.

A serious drawback of this study is that it is hard to compare it to previous studies due to the selection of technologies. No other bibliometric or hype studies were found for these technologies and other relevant data, such as production capacity or the number of installations over the years exists for only some of the technologies.

As mentioned previously in section 3, the article meta-data in LexisNexis does not export correctly, there are many duplicate articles even when the service’s integrated duplicate checker is activated, the source selection for Brazil is too narrow, and there is no consistent way to separate the sources into classes. All in all, while LexisNexis can be used for finding research material, the possibility of bogus or distorted data has to be taken into account. Removing duplicates and separating the sources into categories needs custom scripts and manual work - which might differ from researcher to research-researcher - and consequently might reduce the replicability of this study. The custom duplicate finder also works only on exact but non-case-sensitive matches, so some duplicates can still remain, if they have faulty meta-data. Some trends can also be influenced by the faulty geographical filtering for the United States, as some foreign sources appeared as American sources.

It is also possible that the Excel scripts contain bugs as they have not been tested by any others besides the author, even if they were found to produce consistent results. Some of the earlier scripts could also be optimized much further in order to analyze larger data sets faster. The workflow used in this study might also need to be improved if using similar bibliometric methods and if the article counts in LexisNexis keep increasing at the same or at a higher rate, as the row limit of 1,048,576 rows in Excel 2010 was almost reached.

There are several improvements regarding methodology that could be used in future research. First, the search terms could be extracted automatically from journals as described by Mogoutov and Kahane (2007) to make sure that the search terms are actually relevant and used in literature. Secondly, the content of the articles could be analyzed for words or sentences that describe either positive or negative expectations, how strong those expectations are, and at what level (van Lente et al, 2013), and plotted and tracked separately. Although doing this qualitatively and manually would take a lot of time, it would also be possible to have a hybrid approach: count the same words automatically using text-analysis with either custom scripts or text-mining software, and utilizing sentiment dictionaries such as the Harvard psychosocial dictionary or IV-4 (Harvard), AFINN-111 (Nielsen, 2011), or the Loughran and McDonald Financial Sentiment (McDonald), for example. Tracking separate hype cycle indicators for each type of actor as might also provide understanding on the differing or overlapping levels of hype.

As for future research, the following is suggested: What kind of increases or decreases have actually happened in media interest and at what level? When monitoring a technology for a possible hype cycle, should there be thrice as many articles per month, or should the frequency be tenfold when approaching a possible peak? Does the ratio of positive to negative expectations increase to 3:1 or 10:1? Do some actors participate only at certain levels of public interest, and can that be used for tracking the hype? Are there other indirect indicators, i.e. does the peak of inflated of expectations correlate with company acquisitions, or does the trough of disillusionment correlate with bankruptcies and these with any bibliometric indicators, for example? Disregarding the linear model of innovation; are some types of actors more successful at hyping and engaging other actors?

Do resurgences of similar technologies produce a similar kind of hype curve, or is it heightened or dampened, or is just a part of the slope of enlightenment? Virtual reality, for example, has been around since the 1960s, received huge negative hype in the 1990s, and has again been gathering hype since 2010.

How much does meeting or failing expectations influence the level and trends of media interest? Not strictly dealing with technology, but one possibility of testing would be tracking media interest in cyclical events, such as the Olympic Games or world championships in sports, such as ice hockey. There is much coverage, meeting expectations can be quantified to some extent, the language used can be analyzed, and there are many consecutive and similar events to compare.

The tools developed for this study could be used in the future to track and monitor other technologies with minimal effort. Developing the tools even further might allow more granular ways of specifying the level of hype in the media. Identifying time ranges of interest quantitatively could provide venues to concentrate on for researchers to do more in-depth qualitative studies.

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APPENDIX A: TECHNOLOGY LIFE CYCLE INDICATORS

Function	Activity/Indicator	Sign/value
Entrepreneurial activities	Project started	+1
	Project stopped	-1
Knowledge development	R&D projects, Investment in R&D, Desktop/Assessment/Feasibility studies on technology	+1
Knowledge diffusion through networks	Workshops, conferences	+1
Guidance of the search	Positive expectations on technology, regulations by government	+1
	Negative expectations on technology, lack of regulations by government	-1
Market formation	Specific tax regimes, feed-in rates, environmental standards	+1
	Lack of tax regimes, lack of environmental standards	-1
Resources mobilization	Subsidies, investments for technology, other resources allocated to project	+1
	Expressed lack of subsidies, investments, other resources allocated to project	-1
Creation of legitimacy/counteract resistance to change	Support by government/industry that legitimizes the use of the technology	+1
	Expressed lack of support by government/industry	-1

APPENDIX B: TRANSLATIONS

English	Portuguese	German
Fluidized Bed Combustion / Fluidized Bed Boiler	Combustão (De/Em) Leito Fluidizado	Wirbelschichtfeuerung
Landfill Gas	Gás (De/Do/Em) Aterro(S) Sanitário(S)	Deponiegas
Mechanical Biological Treatment	Tratamento Biológico Mecânico	Mechanisch-Biologische (Behandlung/Abfallbehandlung/Vorbehandlung/Müllbehandlung)
Municipal Solid Waste	Resíduos Sólidos Urbanos	Siedlungsabfälle
Plasma Gasification	Gaseificação (De) Plasma	Plasmavergasung
Recovered Fuel Co Firing	Combustível Recuperado Co-Incineração	Kraftstoff Mitverbrennung / Gewonnen Brennstoffe Feuerung
Refuse Derived Fuel	Combustível Derivado (De) Resíduos	Ersatzbrennstoffe
Reverse Logistics	Logística Reversa / Logística Inversa	Reverse Logistik
Solid Waste Management	Gestão (De) Resíduos Sólidos	Abfallwirtschaft
Solid Recovered Fuel / Specified Recovered Fuel	Combustíveis Sólidos Recuperados	Ersatzbrennstoffe / Sekundärbrennstoffe
Sustainable Business	Negócios (Sustentáveis/Sustentável)	Nachhaltige Geschäfte
Thermal Depolymerization	Despolimerização Térmica	Thermische Depolymerisation
Waste Gasification	Gaseificação (De) Resíduos	Abfallvergasung
Waste Incineration	Incineração (De) Resíduos	Müllverbrennung
Waste Pyrolysis	Pirólise (De) Resíduos	Abfallpyrolyse
Waste To Energy	Energia (A) Partir (De) Resíduos	Energie Aus Abfall

Parenthesis denote possible conjunctions and forward slashes alternative translations.

APPENDIX C: SEARCH TERMS

English	Portuguese	German
"fluidized bed combustion" OR "fluidized bed boiler"	combust! w/2 lei! w/2 fluidiza!	wirbelschichtfeuerung
"landfill gas"	gás w/2 aterro w/2 sanitário	deponiegas
"mechanical biological treatment"	tratamento w/2 biológico w/2 mecânico	mechanisch-biologische **********behandlung
"municipal solid waste"	resíduos sólidos urbanos	siedlungsabfälle
"plasma w/2 gasification"	gaseificação w/2 plasma	plasmavergasung
"recovered fuel co firing"	combustivel recuperado co-incineração	kraftstoff mitverbrennung OR gewonnen brennstoffe feuerung
"refuse derived fuel"	combustivel w/2 derivado w/2 resíduos	ersatzbrennstoffe OR sekundärbrennstoffe
"reverse logistics"	logística reversa OR logística inversa	reverse logistik
"solid waste management"	gestão w/2 resíduos w/2 sólidos	abfallwirtschaft
"solid recovered fuel" OR "specified recovered fuel"	combustíveis sólidos recuperados	ersatzbrennstoffe OR sekundärbrennstoffe
"sustainable business"	negócios sustentáv!	nachhaltige geschäfte
"thermal depolymerization"	despolimeriza! térmi!	thermische depolymerisation
"waste gasification"	gaseifica! w/2 resídu!	abfallvergas!
waste w/2 incineration	incineraç! w/2 resídu!	müllverbrennung
"waste pyrolysis"	piróli! w/2 resídu!	abfallpyrolyse
"waste to energy"	energ! w/2 part! w/2 resídu!	energie aus abfall

APPENDIX D: OVERVIEW OF RESULTS

	Total number of articles	Total number of sources	Direction of trend in the last year	Direction of trend in the last 3 years	Existing peaks	Existing throughs
Fluidized bed combustion or boiler						
The United States	1872	183	Increasing	Decreasing	Mid-2006	Early 2004, early 2010
Germany	64	27	Not enough data	Not enough data		
Brazil	1	1	Not enough data	Not enough data		
Landfill gas						
The United States	13872	856	Steady	Decreasing	Late 2008	
Germany	883	85	Decreasing	Steady		
Brazil	10	5	Not enough data	Not enough data		
Mechanical biological treatment						
The United States	96	50	Not enough data	Not enough data		
Germany	150	30	Not enough data	Not enough data		
Brazil	0	0	No data	No data		
Municipal solid waste						
The United States	13586	923	Decreasing	Steady		
Germany	1270	111	Increasing	Steady	Late 2005, early 2006	Late 2007
Brazil	85	15	Not enough data	Not enough data		
Plasma gasification						
The United States	682	160	Steady	Decreasing		
Germany	5	4	Not enough data	Not enough data		
Brazil	0	0	No data	No data		
Recovered fuel co-firing (REF)						
The United States	0	0	No data	No data		
Germany	0	0	No data	No data		
Brazil	0	0	No data	No data		
Refuse-derived fuel (RDF)						
The United States	733	148	Decreasing	Steady		
Germany	1454	107	Steady	Steady	Mid-2008	Late 2010
Brazil	2	2	Not enough data	Not enough data		
Reverse logistics						
The United States	5165	305	Increasing	Increasing	Late 2006	Mid-2009
Germany	48	21	Not enough data	Not enough data		
Brazil	220	15	Increasing	Increasing	Mid-2011	
Solid waste management						
The United States	24627	1270	Increasing	Increasing		
Germany	16316	169	Increasing	Increasing		
Brazil	108	16	Not enough data	Not enough data		
Solid/specified recovered fuel						
The United States	16	9	Not enough data	Not enough data		
Germany	0	0	No data	No data		
Brazil	4	2	Not enough data	Not enough data		
Sustainable business						
The United States	28065	2118	Steady	Increasing		
Germany	314	86	Increasing	Increasing		
Brazil	197	16	Not enough data	Not enough data		
Thermal depolymerization						
The United States	119	51	Steady	Steady	2008-2009	After 2009
Germany	0	0	No data	No data		
Brazil	1	1	Not enough data	Not enough data		
Waste gasification						
The United States	273	106	Decreasing	Decreasing		
Germany	9	5	Not enough data	Not enough data		
Brazil	1	1	Not enough data	Not enough data		
Waste incineration						
The United States	2161	363	Increasing	Steady		
Germany	3585	134	Decreasing	Steady/increasing		
Brazil	31	8	Not enough data	Not enough data		
Waste pyrolysis						
The United States	9	8	Not enough data	Not enough data		
Germany	0	0	No data	No data		
Brazil	0	0	No data	No data		
Waste to energy						
The United States	43567	2221	Steady	Steady		
Germany	119	50	Not enough data	Not enough data		
Brazil	16	9	Not enough data	Not enough data		
Total number of articles						
The United States	134843					
Germany	24217					
Brazil	676					

APPENDIX E: SOURCE INFORMATION

Technology or concept	First source type to appear	Most numerous source type
Fluidized bed combustion or boiler	Newspapers	Trade journals and magazines
Landfill gas	Newspapers	Press releases and newswires
Mechanical biological treatment	Newspapers	Press releases and newswires
Municipal Solid Waste	Trade journals	Public documents
Plasma gasification	Public documents	Press releases and newswires
Refuse-derived fuel	Newspapers	Press releases and newswires
Reverse logistics	Press releases and newswires	Press releases and newswires
Solid waste management	Trade journals	Public documents
Solid/specified recovered fuel	Press releases and newswires	Press releases and newswires
Sustainable business	Newspapers	Press releases and newswires
Thermal depolymerization	Press releases and newswires	Public documents
Waste gasification	Trade journals	Press releases and newswires
Waste incineration	Newspapers	Press releases and newswires
Waste pyrolysis	Public documents	Trade journals and magazines
Waste to energy	Trade journals	Press releases and newswires