Advertising Information and Communication Technologies over time: An analysis of text and visual complexity

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Abstract

In this paper we study how Information and Communication Technologies (ICTs) have been advertised over time. More specifically, our research objective is to explore and reveal how ICT advertisements have changed over the last 121 years, adapting ad technologies and content to diffuse innovations from niche into mainstream markets. We do so by using machine learning approaches to identify relevant ICT advertisements in a data set of historical print ads ranging until 2014. We find that first, the diffusion of different ICTs in advertising differs. For example, while the fax was heavily advertised during a short period of time, the typewriter or TV were advertised for a prolonged time. Second, we show that ICTs tend to be characterized by relatively complex advertisements, with content-rich images and more words. This is especially true in the beginning of the product lifecycle of new innovative ICTs but less so towards the end.

1. Introduction

Information and communication technology (ICT) is a term used to refer to any communication device or application [1]. This includes the radio, television, cellular phones, satellite systems, computer and network hardware and software, but also the diverse services associated with such technologies [1]. While the technological aspect is important, such devices benefit us by enabling the transfer of information or communication. This is likely one reason why such technologies have become increasingly important in our daily lives.

ICTs have been among the most important and significant innovations in the last 121 years and have also been substantial growth factors in all industrialized countries. Marketing in general and advertising in particular have played a central role in the diffusion of ICTs, which were mostly radical innovations that fundamentally changed or expanded the way of informing or communicating. To be more specific, advertising plays a two-fold role in the diffusion process of innovative technologies: On the one hand, advertising helps to inform about the innovative information technologies, on the other hand it also has a persuasive character in many cases.

Like all other innovations, ICTs gradually penetrate the market over time rather than being immediately embraced by all. For example, while less than 20% of households owned a mobile phone in 1996, already 95% had at least one mobile phone in 2018 [2]. By understanding how past ICTs penetrated the market, we can learn how to design the marketing material for future technologies. Diffusion models are often used to understand this spreading of a new product in the market. While the innovators and early adopters are particularly contemporary and among the first 15% of consumers adopting an innovation, the vast majority only follow later waiting on experiences from others [3]. This behavior of the different consumer types generally leads to a S-shaped cumulative diffusion curve of innovation adoption over time [3]. Thereby, advertising serves to inform consumers of the existence and value of the new ICT and accelerates its diffusion process [4]. Through advertising, companies inform early adopters that the ICT innovation exists and make claims about its benefits and quality. Furthermore, the early majority of all adopters rely heavily on information through advertisements and sales people [4].

Acknowledging this important function of advertising in the diffusion process and recognizing the continuously increasing market penetration of ICTs, this study analyzes the print advertisements for various ICTs over time. The study's objective is to show how ICT advertising has changed over the past 121 years compared to other advertisements. Due to the innovative nature of the ICT advertised, such ads adapt to new ad technologies and content styles earlier than advertisements of brands and companies in other industries. More specifically, the complexity

of the advertisements is explored, considering both the text and visual components. In doing so, the authors leverage image and text analytics to compute the ad's complexity.

We find that the diffusion of different ICTs as expressed in the number of advertisements varies. While some technologies, such as the typewriter or television (TV), are advertised over a longer time span, ads for other ICTs, such as the fax, occur only for a limited time. This may occur since some ICTs are replaced by substitutes after a relatively short period of time, whereas other technologies are continuously improved, so that no suitable main market alternative is developed. For instance, email quickly rendered fax machines nearly obsolete, while TVs are still improved and adapted to consumer needs up to this day. Additionally, advertisements for ICTs are generally characterized by a relative complexity of both the textual and visual components. This is mostly driven by the need to inform consumers about each technology's benefits.

The rest of the paper is structured as follows: After a brief overview of the related literature, detailing the ad characteristics for innovations and various text and visual complexity measures, the authors introduce the data set. Finally, the findings are discussed and critically reflected.

2. Related literature

This study aligns itself with the existing work of researchers on advertising effectiveness, the special characteristics of ads for innovations, and various analyses of text complexity and the design of advertising images.

2.1. Advertising effects

Advertising is omnipresent around the world, exerting a strong influence on human behavior [5]. This partly justifies why the spending of companies such as L'Oréal, Pfizer, Procter & Gamble and Kraft Heinz on print ads in magazines together exceeds 2 billion U.S. dollars [6]. Throughout the entire last century, advertising has been pervasive in fulfilling its role of informing, reminding, and persuading [7]. For instance, past economic and management research shows that advertising positively affects sales in the short-term [8, 9, 10, 11, 12] and increases both brand loyalty [13] and market-share stability [14] in the long-term. Above and beyond these direct effects, advertising research has also considered its positive association with profits [15, 16, 17], the creation of entry-deterrence effects [18, 19], but also the facilitation of entry [20, 21].

2.2. Advertising innovations

While advertising indeed plays a role for all types of products and services, innovations generally have specific requirements. Young markets, given whenever a product is new, are characterized by participants having only little information on the product and limited communication (or word-of-mouth) existing about it [22]. This occurs since only few innovators and early adopters have purchased the product and the majority of market participants have not yet bought or used it [22].
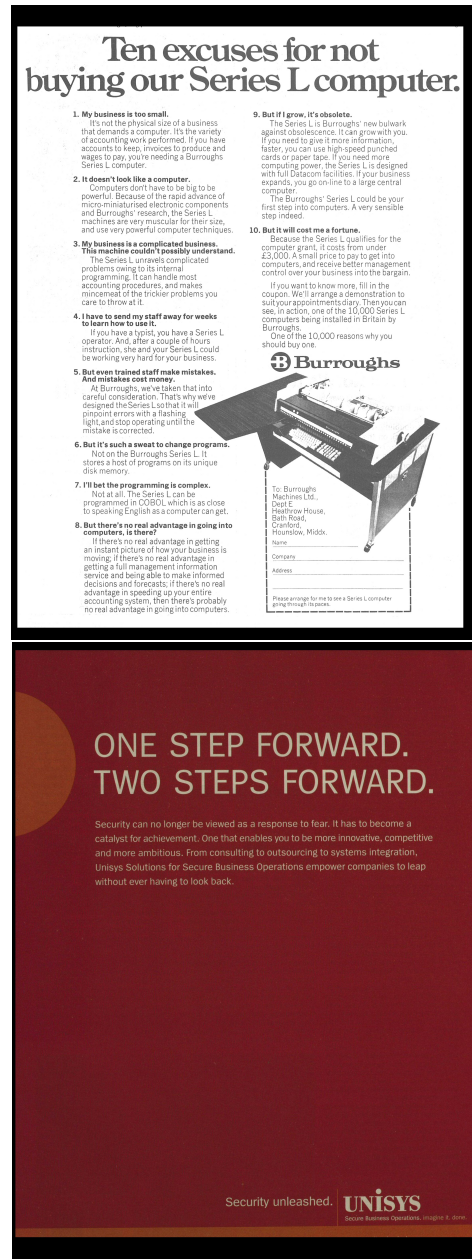

Figure 1. Exemplary ICT Ads (1970 & 2007)

This lack of information on the product results in consumers' higher motivation to take a closer look at the corresponding advertisement and process its information [23]. This especially holds if both the product and advertisement are a novelty for the consumer [23]. Thereby, consumers' lack of experience results in uncertainty about the product itself, its properties, and qualities [22]. In an effort to minimize this uncertainty, consumers have a higher motivation to process the available product information, with advertisements being an important source in young markets [22].

Figure 1 shows two ads illustrating the special characteristics of innovation advertisements. The first, published in 1970, provides a long explanation why Burrough's computer is highly beneficial for firms. Instead, a more recent advertisement by Unisys (created through the merger of Burroughs with Sperry [24]) displays a much simpler design with the text providing far less factual information.

2.3. Measuring textual and visual complexity

Evidence suggests that especially innovations require a substantial amount of information in the initial advertisements. But how should marketers design the corresponding campaigns to still capture consumer attention? After all, very complex ads bear the risk of consumers ignoring the entire message.

Text complexity itself is a multifaceted construct, but one key dimension is syntactic complexity. The term syntax refers to the formal structural components of language [25]. Hence, syntactic complexity is related to the variability and difficulty of a text's structural characteristics [25]. Psycholinguistic research suggests the semantic and grammatical structure of print ad texts should be kept relatively simple, for example by avoiding the use of synonyms or negations, to ensure effectiveness and understandability [26]. Similarly, ads characterized by a simple syntax have better recognition [27] and ensure strong claims are more persuasive, regardless of customer involvement [28].

Research has introduced and compared various measures of the components of syntactic complexity. Sentence structure is generally assessed through metrics such as mean sentence length or the number of verbs per sentence. Instead, textual readability is either captured through basic counts of the number of words or developed measures that combine multiple factors, such as the sentence length and percentage of complex words [25].

Additionally, this study considers the visual complexity of advertisements, since this pictorial part also plays a substantial role in ensuring effectiveness and capturing consumer attention [29]. Indeed, ads with dense perceptual features negatively affect consumer attention towards the brand and attitude towards the advertisement [29]. This feature complexity is reflected in unstructured variation and more detail in the visual features of the individual image pixels [29]. Hence, a common measure of feature complexity is the JPEG file size of an image [29]. Image compression methods like JPEG are often inspired by the way humans perceive images, combining neighboring pixels of similar colors to lower-resolution squares. A side effect of this compression method is the correlation between resulting file size and image complexity.

3. Data and measurement

As mentioned, the data used in this study covers print advertisements. This advertising medium has been used for a long time, allowing for a better discussion of the actual development of ads over time [7]. In fact, print advertising was already widely popular throughout the 19th century and still reaches a considerable number of readers today [7].

More specifically, this study considers those advertisements published in the international English-language weekly magazine "The Economist". This magazine is useful not only for its international recognition but also for the long-standing history with the first publication appearing in 1843. From the inception until 2014, 520,841 advertisements were printed in the publication. Additionally, "The Economist" enjoys a high circulation, with more than 700,000 subscribers in 2020 [30]. Therefor, this sample should be able to capture those advertisements characterized by the greatest exposure and hence substantial potential cultural consequence [31].

One could argue that the general readership of this publication does not reflect the overall population. Studies suggest that the typical reader has a job with an above-average pay and is more likely to be male [32]. Nonetheless, the authors believe this data source to be valid for the study at hand, since innovations, especially those of technical nature, are often a costly purchase, suggesting early adopters must be somewhat affluent to consider buying. Furthermore, the assumption is that publications such as "The Economist", rather than a special interest journal for ICTs, are more useful for firms in their goal of diffusing innovations throughout the general market. Instead, specialized journals rather target the innovators and early adopters.

Although the number of issues published per year did not change, the number of ads included per issue

| ICT	N ads	Earliest	Latest
Telecommunication	2654	1912	2014
Typewriter	477	1893	2006
Camera	330	1902	2014
Radio	204	1909	2008
TV	293	1952	2013
Computer	4502	1956	2014
Fax	77	1987	2005

Table 1. ICT ads in "The Economist"

of "The Economist" has been constantly increasing. Indeed, the amount printed in the year 2000 is more than double the number of ads included per issue from the beginning until the 1930s. Interestingly, the median space on a page taken up by a single advertisement (ad size) also increases around the same time, suggesting that "The Economist" not only printed more, but also larger advertisements.

The ICT ads considered in this study include advertisements for the typewriter, fax machine, radio, TV, telecommunication devices, camera, and computers. Thereby, telecommunication ads consist of those for landlines, as well as mobile and smartphones or network providers. Similarly, computer-related advertisements include those for personal computers, laptops, notebooks, and also software. After all, the term ICT does not only refer to the technologies themselves, but also the services associated with them. These categories represent those ICTs that contain enough advertisements in "The Economist" to provide a sufficiently representative sample. Whereas cameras are not per se devices of communication, the authors argue that this also represents a highly disruptive technical innovation, strongly affecting people's social lives by allowing for the transfer of images between (non-professional) individuals.

In total, the data sample consists of 8,537 ads. Table 1 provides detailed information on the number of ads observed in "The Economist" for each of the ICT categories, as well as the first and last instance of a corresponding ad. The data set contains by far the most computer-related ads, with telecommunication advertisements following at slightly more than half the amount. The remaining ICTs have comparably few ads in "The Economist". The earliest ad related to ICTs was published in 1893 (typewriter).

When considering some of the most life-changing innovations introduced throughout the past century, the majority are either ICTs (personal computer, telephone, and camera) or transport-related (airplane, automobile) [33]. Indeed, the use of general newspapers such as "The Economist" in spreading technical

innovations is not limited to those related to information communication, but also extends to various modes of transport, for example. This is supported by the more than 15,000 ads for train or airline travel and automobiles in "The Economist". Hence, Figure 2 illustrates the distribution of ads referring to the different ICTs in "The Economist" over time, also including the transport innovations rail, automobile, and airline for reference.
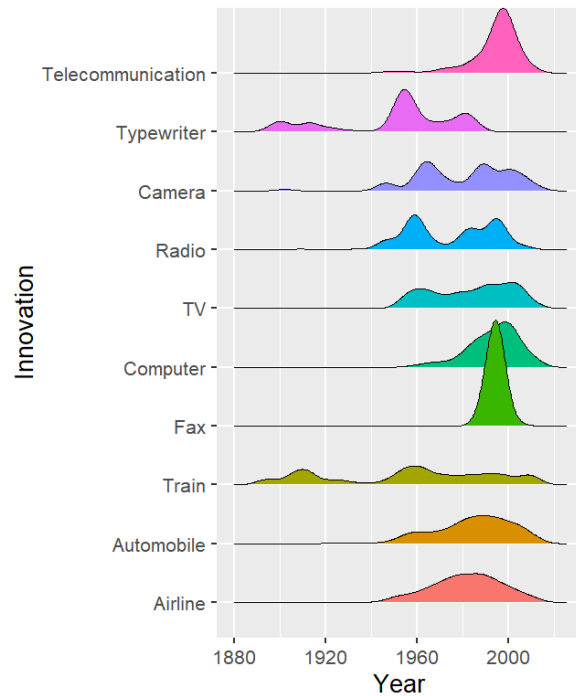
Figure 2. Occurrence of Innovation Ads (ICT & Transport) in "The Economist"

Interestingly, technology ads such as those for the camera, radio and TV occur somewhat consistently and frequently over a time span exceeding 50 years, while fax and telecommunication ads accumulate strongly during a certain period. Among the ICTs, only the typewriter is promoted over an extended time. To compare, the distribution of those advertisements published in "The Economist" related to the three transport innovations train, automobile, and airlines are also included in Figure 2. Ads discussing train-related services or travel opportunities span the longest period, by far. However, also automobile and airline ads are published over a substantial time, with none of these innovations displaying a single strong peak similar to that of fax or telecommunication. This supports the idea that some ICTs are characterized by a somewhat shorter lived popularity or hype before being replaced by an alternative.

In line with the literature (e.g. [29]), this study captures visual complexity through JPEG file size of the advertising images. As discussed in the previous chapter, multiple approaches to assess textual complexity have been suggested in the literature. Readability metrics such as the Fog Index or the Flesch Reading Ease Score are scaled combinations of the average sentence length and proportion of complex words (words consisting of more than two syllables) [34]. The assumption thereby is that words with more syllables or longer sentences make a text harder to read, ceteris paribus [35]. Alternatively, simple word count is a rather straightforward approach of measuring text readability. In this case, the reasoning considers longer texts per se more deterring and with higher costs of information-processing for consumers [35].

In the data, all three of the described text metrics behave similarly over time. Considering that innovations likely require more words to convey the necessary information, but do not necessarily benefit from complex text, the authors decide to adhere to word count to measure textual complexity. After all, the literature [22, 23] suggests that especially radically new products create stronger uncertainty for consumers, thereby rendering information even more important. ICTs, generally rather technical innovations, hence likely require more text in their initial promotions.

4. Results

To explore how ICT advertisements have changed over the last 121 years and helped to diffuse ICT innovations from niche into mainstream markets, the textual and visual complexity of ICT advertisements is compared to that of all other non-ICT ads published in the magazine "The Economist". This comparison is performed for textual and visual complexity of these advertisements separately. For the analysis, the median complexity of all ICT ads ($median(complexity_{ICT,j})$) published in a given year j is determined. This occurs analogously for all non-ICT ads ($median(complexity_{non-ICT,j})$) printed in the magazine "The Economist". Note that these computations are performed twice, once for textual and once for visual complexity.

Thereby, the median complexity is used to remove the effect of potential outliers, or single ads with uncharacteristic complexity values unrepresentative of the general sample. Otherwise, these instances could bias the analysis when considering alternative metrics, such as the mean. The resulting time series for textual and visual complexity of the different ads over time are visible in Figures 3 and 4. The graphs in these figures show a smoothed line, fitted on the corresponding data points using local polynomial regression.

The importance of providing product information, especially for innovations, has been acknowledged. Considering our interest in the changes in advertising complexity over time, Figure 3 shows the development of the number of words used per advertisement. The blue line indicates text complexity of ICT advertisements, while the red line conveys text complexity of non-ICT ads. The graph suggests that all ads, both those for ICT and non-ICT products and services, published in "The Economist" start with relatively long texts in the 19th century, before reaching a minimum length in the early 20th century. From the 1920s onward, although all ads increase in length, the text in ICT advertisements increases substantially more than for non-ICT ads. Figure 3 further reveals a second peak in complexity of ICT advertisements around 1975, nearly reaching the initial text length.
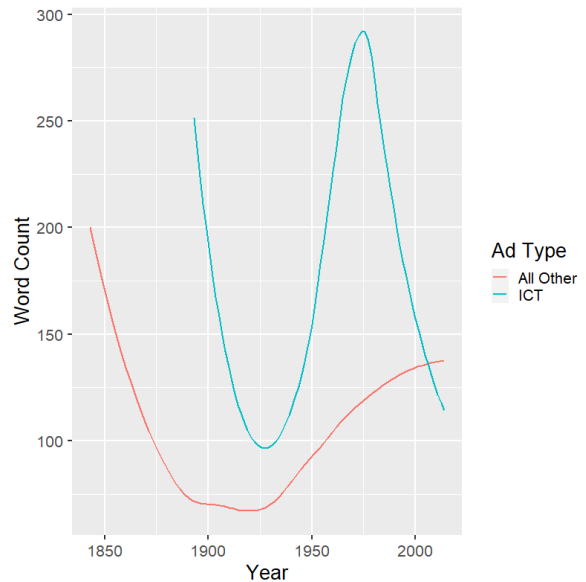

Figure 3. Textual Complexity of Ads in "The Economist"

To better understand potential causes of these observed changes in textual complexity, we first consider effects related to consumer attention before taking a closer look at the different ICTs themselves. The general trend of ICT as well as non-ICT ads is likely at least partially related to the observation that median ad size in "The Economist" increased throughout the 20th century. Since consumers' attention is given for an ad itself, regardless of its size, and bigger ads filling up larger proportions of a magazine page can hold more text without deterring readers, the intuition might be that

advertisers make use of the additional space. However, since the increase in text length is more pronounced for ICT ads, it seems an additional explanation is required.

In line with the literature, newer products require more information for consumers, specifically at the beginning with higher consumer uncertainty. This translates to longer advertising texts for ICTs, far more so than for ads of other products and services printed at the same time. Generally, the mid-20th century is characterized by more ICTs diffusing into the mainstream market, as more households own radios or TVs and businesses rely on typewriters well into the 1980s, for example.

Accordingly, advertisements for many ICTs (computer, radio, camera, telecommunication) are characterized by increasingly longer texts throughout the mid-20th century, reaching a peak around 1970 and then dropping. Nonetheless, the deviance of ICTs from the general development of advertising text is strongly driven by the TV and typewriter. Interestingly, ads related to the TV display a very high word count, with the yearly median even double as high as that of the other ICT ads during the peak of textual complexity. During this time, many new products and variants were introduced, e.g., color TV and Video Cassette Recording (VCR), with consumers likely requiring a substantial amount of information for each. The text length of typewriter advertisements continuously increases but with a reduced slope. The fax machine is only introduced after 1980.

So far, the analysis has relied on a descriptive comparison of the textual complexity of the different advertisements. In an effort to statistically test the observed discrepancies for word count between various ICT and non-ICT ads published in "The Economist" at the same time, the authors use ordinary least squares to estimate a linear relationship between the difference in textual complexity of these ads and time. A corresponding model is fitted for each ICT separately, thereby comparing its ads' textual complexity to all other non-ICT ads printed in the same year. Table 2 gives the results for each ICT. In all cases, the explanatory variable is the year, while the dependent variable is given by the complexity difference between the corresponding ads and all non-ICT advertisements. Again, for each category the median textual complexity of ads per year is used in the calculation to limit the effect of outliers.

The regression estimates in Table 2 suggest mixed results. Generally, the authors expect the difference in complexity to decrease over time, with consumers becoming more familiar with the various ICTs and hence requiring less information. Hence, at later stages

ICT	Intercept	Year	R^2	N
Telecomm.	-200.37	0.09	0.01	78
	(175.27)	(0.09)		
Typewriter	-1790.876***	0.90***	0.46	72
	(226.15)	(0.12)		
Camera	1608.62	-0.81	0.02	60
	(1491.38)	(0.75)		
Radio	218.80	-0.09	0	54
	(3104.17)	(1.57)		
TV	315.72	-0.17	0	59
	(757.80)	(0.38)		
Computer	868.40***	-0.45***	0.30	59
	(179.81)	(0.09)		
Fax	6222.51	-3.10	0.02	13
	(14406.01)	(7.22)		

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Note: Each row is a separate regression.
SEs in parentheses.

Table 2. Linear Regression Estimates for the Difference in Text Complexity

in the diffusion process, the advertisements for ICTs should not have to follow the rules of innovations anymore. This is also supported by the convergence of the two lines in the 21st century in Figure 3.

While nearly all coefficient estimates follow expectations and are negative, the only statistically significant result is found for computer-related ads. In this case, the simple bivariate regression with the year as explanatory variable is able to account for 30% of the variation in the complexity difference. The R^2 for nearly all remaining ICTs is consistently low and the coefficient insignificant, suggesting time is not able to explain much of the variance occurring and no linear relationship between time and the complexity difference.

Instead, the difference in textual complexity for typewriter advertisements is increasing over time. This finding is also statistically significant and the R^2 indicates roughly 45% of the variation in text complexity difference is explained by time. The observation that typewriter advertisements are characterized by an increasingly longer text support the findings here of a continued divergence rather than an eventual conformance to all other ads.

So far, the textual characteristics of the advertisements published in "The Economist" have been considered in depth. However, the high importance of visual ad components must also be acknowledged in this analysis of the development of advertising over time. After all, ad messages are often communicated through visuals, in line with the saying that a picture is

able to say more than a thousand words.

Therefore, Figure 4 illustrates the change in visual complexity of the ads published in "The Economist" over time. Again, the blue line represents complexity of ICT advertisements, while the red line portrays that of non-ICT ads. For the latter, the graph indicates that feature complexity, measured by JPEG size, generally decreases after the late 19th century. However, those advertisements printed in the last 30 - 40 years seem slightly more visually complex.
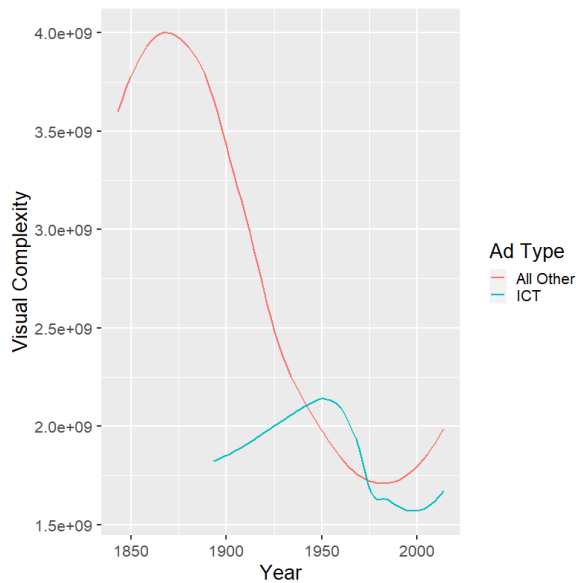
Figure 4. Visual Complexity of Ads in "The Economist"

While complexity is strongly decreasing for non-ICT ads in the early 20th century, the opposite is true for ICTs. Indeed, here feature complexity increases until reaching a peak in the 1950s. This development is mainly driven by advertisements for cameras and the radio. In the beginning, feature complexity for ICT advertisements is quite low, suggesting that advertisers could have explicitly kept the visuals as simple as possible to account for the longer text. This awareness of overall complexity is also indicated by the sharp decline in visual complexity after 1950, a time when text length reached its peak. The graph also implies that the visual complexity of ICT ads has followed the behavior of all other advertisements more closely in the past 40 years.

5. Discussion

Overall, ICT advertisements follow the characteristics of ads for innovations, innovative products and innovative services. Especially in the beginning of the product lifecycle, it seems that advertisers react to higher consumer uncertainty by providing more product information. This is visible in the clearly longer texts for these innovative ICT products at the time of the ad, compensating for the lack of consumers' own experience or word-of-mouth. Additionally, it seems that visual complexity is kept especially low during these times, suggesting advertisers are cognizant of overall ad complexity and the necessity to capture consumer attention without deterrence. Apparently, both textual and visual complexity of ICT advertisements behaves differently than for all other ads. Furthermore, it seems that ICT advertising might have adapted to new ad styles earlier than brands selling other products and services, for example making more use of larger ads to contain all required information and capture consumer attention.

Nonetheless, the ad characteristics also suggest a convergence in recent times, indicating that these ICT products and services were successfully diffused from the niche into mainstream markets, eventually rendering the special requirements for innovation advertising obsolete. Thereby, the distribution of ads for the different ICTs show that while some technologies accompany consumers for an extended time, others rather occur as temporary trends fading away quickly. These innovations likely represent less fundamental changes to our way of spreading information and communicating.

One potential limitation of this study is its reliance on a single data source, i.e. "The Economist". However, the far reach of "The Economist", as well as the readership characteristics suggest that this medium is likely used by marketers of innovations to extend diffusion beyond the most contemporary to the main market. Furthermore, the final analysis only considers a single textual and visual complexity metric. However, the authors compare various readability measures, concluding that text length is most suitable and valid for the specific context. After all, to provide information to consumers, advertisers likely require more text but do not necessarily benefit from more complicated or less readable text.

Overall, to the best of our knowledge, this study is the first to explore how ICTs are advertised over a time span of 121 years and allows for a comparison of ad characteristics to better understand the diffusion of ICTs from the niche into main markets in both business and society. Future work could perform a deep dive into the actual advertising image content, one extending beyond complexity. For instance, interactive machine learning approaches can enable valid object recognition to further assess the design of ads.

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