Design, Implementation, and Evaluation of a Food Price Monitoring Tool for Supporting Data Journalists

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Abstract: Data journalism is a valuable emergent and growing trend, which can lead to higher quality journalism, based on real-life data and not on prejudice and pre-existing stereotypes. However, the effective realization (i.e., the 'real-life' implementation) of this concept requires the development of high-quality software tools that enable journalists to access useful data sources, are easy to use, and provide clear, understandable and intuitive presentations of the data, as well as practices and processes for using them. In this direction our paper is making a contribution. It describes the design, implementation and evaluation of a software tool that utilizes open data sources concerning food prices in Greece, in order to support data journalism on this topic, which constitutes one of the most critical topics that the societies of many countries face. It is a fully automated solution that can generate new visual reports whenever the data provider updates the food prices data and requires minimal intervention from the journalists; this makes the above data usable for journalistic purposes. The results of the evaluation were positive, indicating a high degree of journalists-users satisfaction, and at the same time revealed difficulties in using these open data for journalism purpose due to quality problems, and also revealing directions for future development of the tool.

Keywords: Open Data, Data Journalism, Journalism, Food Price, Information Systems Success Models

1   Introduction

Food prices hold immense significance as food insecurity can substantially result in social unrest and threaten the legitimacy of governments [1], [2]; therefore, close monitoring of food prices can mitigate such evolutions, as it can allow addressing the problem in an early stage. In the contemporary socio-political landscape dominated by the Russo–Ukrainian conflict [3], rising energy prices and increased inflation, especially in Europe, monitoring and communicating the rising food prices to the public, as well as putting pressure on governments to take actions for addressing this problem when required, is of pivotal importance for maintaining social and political coherence. Journalism, often seen as the 'Fourth Estate', can play an elevated role not only in raising

public awareness of this crucial subject, but also in acting as a watchdog and applying pressure on the government by holding them accountable for their actions or lack thereof concerning the control of food prices.

In our increasingly interconnected world driven by information, the open data movement promoted the release of data that is freely available, accessible and reusable by anyone. In 2009, the USA government launched Data.gov. After that, other countries joined the open data movement and started to release their data to increase innovation and transparency. Embracing open data can revolutionize business operations, drive innovation, and create new opportunities in the digital landscape [4]. Most importantly, it holds immense promise for fostering transparency, accountability and informed decision-making across various sectors, including improving public services [5]. Among a variety of stakeholders from the public and private domains that can significantly benefit from this explosion of available data, journalists can particularly reap its benefits. This abundance of data led in part to the formation of a new trend in journalism, the data journalism. Veglis and Bratsas (2017) [6] define this new form of journalism as the use of data in all the stages of the journalistic process, the extraction of information, the compilation and the visualization, in a comprehensive way. By utilizing open data, high quality journalism can be developed, which is not based on prejudice and pre-existing stereotypes, but on data from real life, and can go into more detail in analyzing effectively the important societal problems, such as the increase in food prices; this will improve the trustworthiness of journalism, build trust with the public and enable policymakers to make more informed decisions to address the social problems. However, this still abstract concept has to evolve into a set of specific easily applicable ICT-based practices: the effective realization (i.e., the 'real-life' implementation) of this highly valuable data journalism concept requires the development of:

a) High-quality software tools that enable journalists to access useful data sources, are easy to use even by low digital skills journalists, and provide clear, understandable and intuitive presentations of the data; this is very important, as the data are usually provided in tabular forms, which make it difficult for the journalists to understand the data and make sense from them, so they have to be converted into more understandable visualized firms

b) Appropriate practices and processes of using these software tools and data, as well as integrating them in the wider journalism processes.

Our paper makes a contribution to the former. In particular, it presents our research, which was conducted at the news portal HuffPost (Greece), and included the design, implementation and evaluation of a software tool that utilizes open data sources concerning food prices in Greece, in order to support data journalism on this topic, which constitutes one of the most critical topics that the societies of many countries face. The big increase of the prices of food that has taken place recently has undermined substantially the quality of life of millions of citizens, which – if not properly addressed by governments – might give rise to social unrest and political extremism, with quite negative consequences. In particular, our main objective was to provide a fully automated solution that requires minimal intervention from the journalists, which uses as input data provided (as Excel files and also through an API) and can generate new visual reports whenever the data provider updates the data; therefore, these visualizations will

be immediately ready to be used by the journalists, enabling them to understand the data easily and make sense of them; this makes these data immediately usable for journalistic purposes. Our research included also an evaluation of the tool by gathering feedback from its users to assess its usefulness and potential impact in supporting journalists in their work. With our findings, we aim to take a step forward in exploring the open data journalism domain.

Our paper consists of six sections. The following Section 2 describes the background of our study, and in Section 3, we outline our methodology. In Section 4, the results are presented and then discussed in Section 5, while in the final Section 6, the conclusions are summarized, and future research directions are proposed.

2   Background

In this section we outline the background of our study; it includes: a) the research that has been done concerning data journalism tools that use open data (in 2.1); and b) the widely recognized and used Delone and McLean model of Information Systems Success, which has been used as a basis for evaluating the abovementioned data journalism software tool (in 2.2).

2.1   Open data journalism tools

Previous research on the intersection of open data and data journalism, referred to as open data journalism, is limited according to the literature review [7]. Most of the publications on open data journalism revolve around creating software tools that can assist journalists with data collection and analysis, as well as visualization of their findings, aiming to provide technological solutions to the lack of technical skills on the journalistic side. However, most of these tools were not focused on specific problems; they could enhance journalists' capabilities in the fields of the journalistic process: data collection, data analysis, visualization, and presentation. Furthermore, only some of these technical solutions were accompanied by real-world case studies [8], [9], [10], or even limited evaluation scenarios [11], [12], and in other cases, they only provide a demonstration of the tool [13], [14].

For instance, Gupta et al. [8] contributed a paper about the state elections in India that focuses on communicating electoral insights by employing interactive visual techniques and promoting engaging data communication. Petricek [11] describes a user-friendly low-coding tool, named Gamma, for data exploration and analysis, and demonstrates its capabilities by evaluating it with a user study involving 13 participants; however, this experiment was conducted in a controlled environment. A paper by Bozsik et al. [9] showcases the creation of an affordable housing dashboard with the involvement of local stakeholders in the town of Charlottesville; however, there is no evaluation of the tool and the impact it can have on the journalists. Shehu et al. [10] present a tool for gathering, analysing, and visualising findings based on data for public procurements in North Macedonia, utilising data organisation techniques and the application of data mining algorithms. Another notable publication by Evequoz et al. [12] presents a tool

for visualising and analysing parliamentary voting. The study also includes an evaluation of the tool's usefulness, although it was conducted with limited exposure of the users to the platform. The paper by Cao et al. [14] presents a technological solution that can assist journalists in enhancing fact-checking functionalities by extracting linked open data from Excel sheets. In the Belink [13] paper, a tool for fact-checking is presented for use in data journalism; the authors use complex SPARQL 1.1 queries to extract timed facts, statements, and beliefs.

The majority of these publications lacked an evaluation of the tools and while they seem to hold value for the journalistic community, no concrete evidence supports this claim. In the case of Gamma, an evaluation of its usability was included in the publication, but it was conducted in a controlled environment. In the publication by Evequoz et al. [12], analyzing parliamentary voting in Sweden, users had limited exposure to the tool. Therefore, it becomes evident from examining these studies that more research on the usefulness of these tools is required to accurately measure their impact and, if necessary, guide their development to better suit the needs of journalists based on solid evidence. So, this paper describes another useful software that supports data journalism concerning a critical topic, which affects negatively millions of citizens undermining their lives: the food prices.

2.2   The DeLone and McLean information systems success model

The DeLone and McLean information systems success model [15] was based on the previous work on Mason [16] concerning the measurement of the output of an information system. DeLone and McLean identified six critical dimensions of information systems success: System Quality (technical level), Information Quality (semantic level) and Use, User Satisfaction, Individual Impact, and Organizational Impact (influence level) (Fig 1).
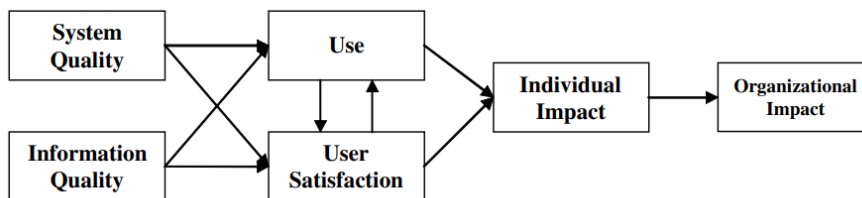

Fig. 1 DeLone and McLean IS Success Model (1992)

This model was designed to be complete and parsimonious, aiming to provide a holistic view of information systems success while maintaining simplicity. Since its initial formulation in 1992, researchers have widely adopted and cited the DeLone and McLean model. However, the model did not remain static. Researchers in the field of information systems began proposing enhancements and modifications shortly after its publication. Recognising the dynamic nature of information systems, feedback loops were incorporated into the model to account for system evolution and maintenance.

These adjustments, based on both empirical studies and constructive feedback, led to an updated version of the DeLone and McLean Model in 2003 [17]. So, we have used this model as a basis (with some adaptations) for evaluating the data journalism software tool we developed (see 3.3 and then 4.2).

3   Methodology

This section outlines the methodology employed for the design, development, and evaluation of the open data journalism tool we developed. Our methodology consisted of three interrelated phases, each contributing to the creation of an automated tool for transforming raw open data about food prices in Greece into compelling visual narratives.

3.1   Understanding the needs

The first phase involved a comprehensive literature review of Open Data, Data Journalism, and Open Data Journalism, combined with discussions with journalists from HuffPost Greece concerning their data needs. This investigation revealed the need for an automated solution that could translate open data into visual representations to boost their data-driven storytelling with minimal intervention of them.

3.2   Software development

The second phase focused on designing the tool, where we prioritized robustness, simplicity, and automation, ensuring it met the needs identified in the abovementioned first step. The adoption of Scrum for agile and iterative development assisted us through weekly sprint meetings with the journalists and other stakeholders to align priorities, focus on the user's needs, and resolve uncertainties proactively. Emphasis was placed on refining the visual aspects of the tool, ensuring accuracy and user engagement. The tool was designed for automation, enabling hands-off operation and efficient data processing.

3.3   Evaluation

For the evaluation of the tool, we used as basis an elaboration of the DeLone and McLean, which has been proposed for digital government information systems evaluation [18], and made an adaptation of it to the data journalism context. The structure of our evaluation model is shown in Fig. 1. We can see that in its first layer it includes assessment of the five first layer dimensions proposed by the abovementioned elaboration of the DeLone and McLean Model [18]: information quality, service quality as well as three aspects of system quality (ease of use, capabilities (meant as functionalities provided to the user) and technical quality). In the second layer it includes an adaptation of the 'impact' evaluation dimension proposed by the model proposed in [18]: the business-level influence of the tool. Furthermore, given that our tool is designed for

journalists and intended for daily use by them, ensuring high user satisfaction is a dimension that greatly concerns us; therefore, the second layer of our evaluation model includes also an assessment of users; satisfaction..
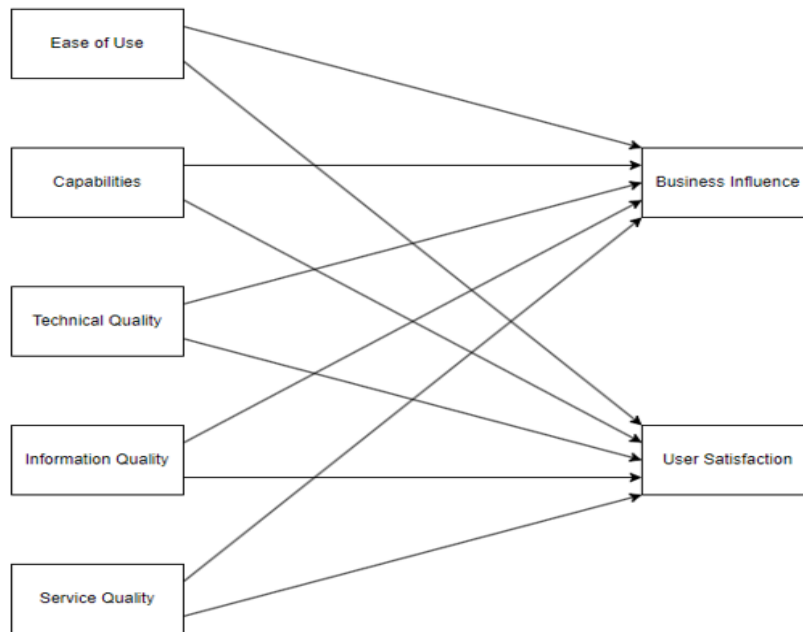

Fig.2 Structure of our evaluation model

So, our evaluation method comprises the above seven core evaluation dimensions, which are shown in Fig.2, forming the foundation of our assessment. The participants in our evaluation were users, including ICT professionals and journalists, who provided feedback tailored to their roles. We have used a combination of quantitative and qualitative evaluation methods in order to collect data about these four dimensions/aspects of our tool. In particular, we used a questionnaire, which included questions concerning these evaluation dimensions seeking nuanced perspectives; it is shown in the Appendix. The evaluation participants initially filled this questionnaire, and then we conducted direct interviews of them, in which we had in-depth discussions about the abovementioned dimensions/aspects of the tool.

4   Results

Our approach to creating a helpful software tool for journalists revolved around automation and simplicity. The dataset we used was provided by the Greek Organization of Central Markets and Fisheries (OKAA) and included the prices of the main food products. OKAA is the leading wholesale distributor of food in Greece and the most

significant food park management organization in the Balkans. Therefore, the provided prices would reflect the overall market situation and could be used to uncover potential problems (e.g., big price increases) in the local food retail markets. We also expected the system to be robust and the errors from the data source to be minimal. This dataset, covering food supply information in Greece, also met our openness and regulatory requirements.

4.1   Software Development: Challenges and Solutions

OKAA offered data access through both Excel files and an API. Given our preference for automation, we chose the API to acquire the data. Python was selected to implement the data fetching and transformation process due to its simplicity and widespread adoption. A script of 120 lines was developed to search the API URL for meat, fruit and vegetable products (which, according to interviewed journalists in initial needs elicitation phase, are the most important for the consumers, so there is high journalistic interest in them), and then process the open data into three JSON files, ready for use in the next steps of our pipeline. For the visualisations of these prices, we used the widely recognized and used Power BI tool, a user-friendly visualizations tool that allowed us to create complex visuals without intricate coding. The publication of the visualisations was simplified with the creation of HTML IFrame tags that can be easily embedded in any online media article. Automation was one of the most essential features of our tool. To facilitate this, we converted the Python script into an executable file and scheduled it for automated execution via Windows 10's Task Scheduler. The Power BI visualisations also received automated data refresh capabilities, ensuring that our visuals stayed up-to-date and the tool operated fully automated.

Challenges during development included discrepancies in historical data from OKAA and data formatting for Power BI. However, our commitment to day-to-day operations drove us to create a system for swift data rectification. Deploying our open data journalism tool presented new challenges. Differences in computing environments required careful adjustments for seamless automation. Software installations on deployment machines posed another challenge, demanding technical expertise and troubleshooting to resolve potential conflicts. Deployment underscored the importance of adaptability, attention to detail, and technical understanding. Comprehensive testing across diverse environments and robust documentation were essential. The deployment phase marked a crucial transition from development to practical utilisation, offering valuable insights for tool enhancement.

We scheduled the execution/activation of our tool three times a day with a four-hour window between them, considering that the maximum timeframe of the tool completing its processes is 20 minutes. This method has been proven highly effective since our tool has been up-to-date every day that new open data arrives from the source, emphasising its punctuality and dependable performance.

The simple and innovative approach we took benefits the tool in many ways; one of them is that the only requirements are a Power BI subscription and a typical PC with medium specs to be operational every day, since the only processes that take place are the script execution and the Power BI online environment checking for new data on our

PC. Leveraging state-of-the-art software as a service, like Power BI, has been an amazing opportunity to focus on the business aspects of our project rather than spending valuable time with technical difficulties.

In Fig 3 we can see a typical visualization provided by the tool, which shows the prices of some important food products at a specific date
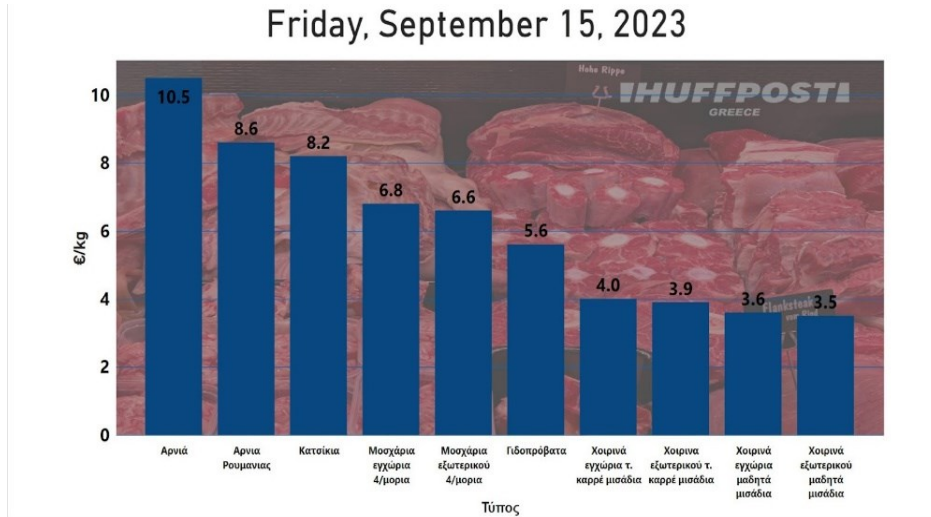

Fig.3. A typical visualization provided by the tool

4.2   Evaluation

In the evaluation phase we focused on assessing the effectiveness and usability of this open data journalism tool we meticulously developed. The evaluation encompasses two distinct yet complementary approaches. First, we employed a quantitative method by distributing a questionnaire (shown in the Appendix) to one journalist-user and one ICT employee to assess their satisfaction. Subsequently, we delved into the qualitative aspect of our research by conducting in-depth interviews with the above two users who participated in the quantitative evaluation. Through these interviews, we aimed to extract invaluable insights, gaining a deeper understanding of the tool's real-world usability, challenges, and potential for further refinement. This two-fold evaluation process, which combines quantitative and qualitative techniques, provides a comprehensive overview of the tool's performance and facilitates the refinement of our open data journalism solution in alignment with user needs and expectations.

4.2.1. Quantitative Evaluation

In Table 1 we can see the responses to the questionnaire. We can see that with respect to the with the ease of use and usability, the technical quality and performance, the ease of the routine required to update and renew open data and the level of service and

support/documentation provided both users are satisfied to a very large extent; also, both are overall satisfied with the open data journalism tool to a very large extent. With respect to the other questions one user expressed satisfaction to a very large extent and the other to a large extent. These indicate a high level of satisfaction with this tool

Table 1. Results of the quantitative evaluation

	not at all	to a small extent	to a moderate extent	to a large extent	to a very large extent
How satisfied are you with the ease of use and usability of the open data journalism tool?	0	0	0	0	**2**
How Satisfied are you with the capabilities and functionalities provided by the open data journalism tool?	0	0	0	**1**	**1**
How Satisfied are you with the technical quality and performance of the open data Journalism tool	0	0	0	0	**2**
How would you rate your satisfaction with the ease or difficulty of the routine required to update and renew open data?	0	0	0	0	**2**
How satisfied are you with the clarity and intuitiveness of information provided by the open data journalism tool?	0	0	0	**1**	**1**
How satisfied are you with the level of service and support/documentation provided by the open data journalism tool?	0	0	0	0	**2**
How satisfied are you with the business benefits the open data journalism tool has on your journalistic work?	0	0	0	**1**	**1**
What is the anticipated frequency of usage projected for this tool?	0	0	0	**1**	**1**

How satisfied are you overall with the open data journalism tool as a user?	0	0	0	0	**2**

4.2.2. Qualitative Evaluation

With respect to the Ease of Use dimension our findings from the qualitative interviews align with the positive trends observed in our quantitative data. Users comment positively the user-friendly interface of the tool, highlighting its accessibility, whch eliminate the need for extensive training. The cloud-based server on Power BI ensures 24/7 availability, further enhancing usability. From a technical standpoint, users reported smooth setup processes with minimal challenges, underscoring the tool's reliability and ease of implementation. These qualitative insights reinforce our commitment to a user-centric design, emphasising accessibility and robustness, paving the way for the tool's continued success in our data-driven journalistic endeavours. The Editor-In-Chief of the news portal HuffPost mentioned.

"It is evident that our tool aligns excellently with our primary objective: to be user-friendly and require minimal training, particularly for individuals in our diverse newsroom with varying backgrounds."

In the Capabilities dimension, the interviews that we conducted gave us positive feedback about the tool's technical capabilities and highlighted some data-related issues that come from the source of the data. The Editor-In-Chief mentioned in the interview that naming convention variations and occasional grammatical errors from the data set are areas for improvement.

Regarding technical quality, our interview responses strongly endorse the tool's efficiency and reliability. Both users consistently reported that the tool completes updates within the appropriate time frame, aligning perfectly with our goal of delivering swift and effective performance. There have been no reported errors until the end of our research, underscoring the tool's remarkable robustness.

Regarding satisfaction with the routine for updating and renewing open data, user feedback was remarkably positive. The routine is refreshingly straightforward, primarily involving data upload validation. These insights highlight the tool's user-friendly design and emphasise its ability to streamline complex data processes, ensuring that users can focus on journalism's insights and storytelling aspects rather than grappling with technical intricacies.

In Information Quality, dedicated to assessing the clarity and intuitiveness of our open data journalism tool's information, the Editor-In-Chief's "good" satisfaction rating reflects the tool's strong performance and opportunities for refinement. Challenges linked to data quality, such as spelling errors and naming conventions misalignment, underscore the critical importance of data quality within our tool and the broader open data sources. Conversely, our discussions regarding colour schemes and data visualisation have yielded positive outcomes.

In the domain of service quality, feedback highlighted the substantial value of the installation process, described as "extra helpful", providing a robust foundation for further exploration and learning. This positive experience not only eased the initial setup but also empowered users to delve deeper into automation intricacies, unlocking a spectrum of possibilities, including data and source fusion for richer insights.

In the domain of business influence and the advantages our tool brings to journalistic work, enthusiasm and excitement were palpable. Our innovation centred around constant updates from open data sources, marked a significant milestone. It was commended for providing reliable, up-to-date information that builds trust with readers and fosters a unique and enduring relationship, setting the whole journalistic company apart. The Editor-In-Chief's perspective added an intriguing dimension, describing our endeavour as a "low-budget attempt" that had surpassed expectations, showcasing our ability to achieve automation and reliability aligned with our vision within budget constraints.

Regarding the tool's projected frequency of usage, it's essential to consider the unique rhythm of change of the food price data it processes. Unlike industries with constant data updates, food prices fluctuate based on market dynamics, seasons, and global events. Our tool's adaptability and relevance, and while it may not be in constant use, its effectiveness lies in its ability to respond promptly and accurately when required, demonstrating the versatility and practicality of our tool in the dynamic field of open data journalism.

In the User Satisfaction dimension, the final segment of our evaluation, both respondents expressed a high degree of satisfaction. They consistently lauded our tool for its exceptional user-friendliness and its immediate comprehensibility to viewers without the need for a learning curve. This innate simplicity and intuitiveness emerged as prominent strengths. Furthermore, our users emphasised the tool's effectiveness in aiding individuals to assess product affordability within their budget constraints.

5   Discussion

By developing and evaluating an open data journalism tool in a news media organisation, we had the opportunity to explore the boundaries of open data provided by OKAA and understand the journalists' daily needs. Furthermore, we had the opportunity to evaluate the use of the tool in a real-world setting. Our research targeted the day-to-day aspect of open data journalism due to the limited timeframe we had for its completion; tackling the investigative aspect of data journalism [19] would have required significantly more time and resources from the media organisation, and it would have also increased its technological complexity. Therefore, we removed it from the scope of the research.

Our approach was to create a robust, easy-to-use and fully automated tool that will be easily integrated into the work of journalists and will require minimal training and maintenance. According to the evaluation, this fully automated tool was what the company required to tackle the critical social issues of rising food prices due to the

contemporary geopolitical situation. However, we encountered several limitations, and we have identified topics for feature research and improvements.

The most severe impediments we faced revolved around the quality of data provided by OKAA. We often encountered inconsistencies in the titles of the products, misspellings, and formatting errors in the data. Handling formatting errors were addressed with the use of data-cleaning techniques. However, dealing with the inconsistencies and misspellings posed challenges for the consistency of the visualisations. Additionally, the seasonal nature of the products created inconsistencies in the generation of historical charts and severely impacted their usefulness. Therefore, it became evident that the tool's functionality is inextricably linked to the data quality ensured by the provider.

To address these limitations, from our end, the tool has to be expanded in the feature cycle of development with more advanced data cleaning techniques for the normalization and standardization of the product names and formats to enhance data consistency. Another useful feature is an automated quality checker that could validate the updated data against predefined standards; this could enhance the overall data integrity of the tool.

Furthermore, in future research, we need to reevaluate the impact this tool has on the daily work of journalists and the business advantages it can provide to organisations. It is also important to expand our evaluation framework by incorporating technology acceptance and innovation diffusion models [20]–[22].

6   Conclusion

In the previous sections of this paper we have presented our research findings concerning the utilization of open data for supporting data journalism concerning the crucial societal problem, which undermines the quality of life of millions of citizens: the rising food prices. We embarked on this endeavour along with journalists from the news portal HuffPost (Greece) and used the open data provided by OKAA to acquire the food prices in Greece. We created a Python script to fetch and process the data so that they could be used by Power BI, our visualisation tool; we automated the data fetching process and generated the visualisations. So, we converted the above open data provided by OKAA to a visualized form, which can be easily and immediately understood by journalists, enabling them to make sense of the data, and draw conclusions from them, leading to high-quality 'evidence-based' journalism on this highly important topic. Despite the room for improvement, the evaluation of the tool's usefulness was ranked highly by the journalists.

Our study has important implications for research and practice. With respect to research, it contributes to the evolution of this abstract concept of data journalism towards a set of specific and easily applicable ICT-based practices; it creates new knowledge concerning the effective realization (i.e., 'real-life' implementation) of this valuable concept for improving the quality and trustworthiness of modern journalism through high-quality software tools that provide useful information to journalists and are easy to understand and draw conclusions from even by low digital skills journalists. With respect to practice, we have developed a useful ICT-based practice, which enables

media organizations (both paper-based and electronic ones) to make their first steps towards data journalism easily and at low cost, which can be extended to other types of open data concerning various social problems. Furthermore, our research has revealed various issues concerning the quality of the open data that restrict their usefulness for journalistic purposes.

Further work can be done concerning the enhancement of the present capabilities of our data journalism support tool with new features, such as historical price charts, as well as its evaluation by larger numbers of users. Moreover, we have to research more systematically to what extent the tool can be adopted by the rest of the journalists in the newsroom using technology acceptance and innovation diffusion theories [20]–[22].

Acknowledgements

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Appendix

The questionnaire included the following questions, which had to be answered in a five levels Lickert scale (1= not at all, 2 = to a small extent, 3 = to a moderate extent, 4 = to a large extent, 5 = to a very large extent)

Ease of Use:
How satisfied are you with the ease of use and usability of the open data journalism tool?

Capabilities:
How satisfied are you with the capabilities and functionalities provided by the open data journalism tool?

Technical Quality:
How satisfied are you with the technical quality and performance of the open data journalism tool?
How would you rate your satisfaction with the ease or difficulty of the routine required to update and renew open data?

Information Quality:
How satisfied are you with the clarity and intuitiveness of information provided by the open data journalism tool?

Service Quality:
How satisfied are you with the level of service and support/documentation provided by the open data journalism tool?

Business Influence:
How satisfied are you with the business benefits the open data journalism tool has on your journalistic work?
What is the anticipated frequency of usage projected for this tool?

User Satisfaction:
How satisfied are you overall with the open data journalism tool as a user?