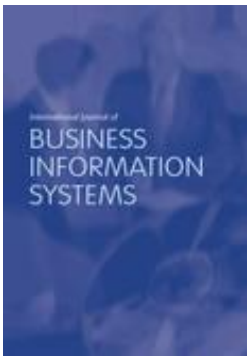

International Journal of Business Information Systems

ISSN online: 1746-0980 - ISSN print: 1746-0972
https://www.inderscience.com/ijbis

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DOI: 10.1504/IJBIS.2021.10041841

Article History:
Received: 17 December 2020
Accepted: 29 May 2021
Published online: 24 January 2025

The contribution of data visualisation tools towards better customer relationship management

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Abstract: Data is a valuable asset for businesses if it is visualised to enable decision-makers to gain insights that help them earn a competitive advantage or better market share. The visualisation process not only supports decision-makers but also scientists, journalists, and healthcare workers. Many visualisation software evolved to help general users and experts better present their data easily and attractively. In this study, we conducted a new comparison among six available tools based on specific criteria, and we tried to build a framework for the questions to be explored concerning customer relationship management (CRM), data visualisation (DV) activities, and how DV tools can contribute to building better CRM activities and processes. The studied tools have never been studied together and in the same context.

Keywords: data visualisations tools; D3.js; GoogleCharts; FusionCharts; Tableau; RAWGraph; Datawrapper; customer relationship management; CRM.

Reference to this paper should be made as follows: Ghozlan, B.R. and Abu-Shanab, E.A. (2025) 'The contribution of data visualisation tools towards better customer relationship management', *Int. J. Business Information Systems*, Vol. 48, No. 1, pp.72–98.

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1 Introduction

1.1 Data visualisation in CRM

The immense amount of data generated every day from modern systems is challenging both the experience and non-experience users in data processing. This is because of the dynamic nature of this data in addition to its huge size, diverse sources, and format (Zion and Tripathy, 2020). This kind of data called 'Big Data', which has lately become a fundamental part of modern database research.

In the business world, corporations have this kind of database that represents the data of their products, services, and customers. It is a valuable asset for these corporations if its IT technicians can convert it into insightful intelligence which is a new field that has been appeared recently and had equivalent terms such as; business intelligence (BI) or Big Data analytics (Jalali and Vanani, 2018). Actually, the theory of 3Vs clearly summarised the three main characteristics of big data which are: volume, variety and velocity (Majeed et al., 2021; Runsha et al., 2021). So, to control this kind of data, there are many applications that collect, store, analyse, mine, and visualise them (Runsha et al., 2021). As a result, the level of user engagement will increase, and data will be more beneficial and attractive to the readers.

Indeed, using visualisation in the business field is crucial for its success, especially when decisions that rely on big data are needed to be taken in a short time. In fact, the ability to make decisions by humans, from a specifically complex set of data, in complex environments is considered an important research topic that comprises management, psychology, and engineering (Vingerhoeds et al., 2020). For instance, some researchers studied the application of big data analytics in the fashion industry on social media to increase customer satisfaction (Vingerhoeds et al., 2020). In this section, we will explore the concept of visualisation and CRM cycles.

The concept of visualisation appeared very early in the 2nd century in Egypt where they used tables to arrange the astronomical information to help Egyptians in the navigation process (Few, 2007). In 1980, visualisation emerged as a distinct discipline; it implied two areas; science and information visualisation. However, by the end of the 1980s, the information visualisation field emerged as a branch of the human-computer interaction discipline.

Consequently, data visualisation (DV) implies converting text-based data and displaying it in a visual format like graphs, figures, maps or bars (Batt et al., 2020). This converting process produces a fascinated colourful story of data, which can attract the

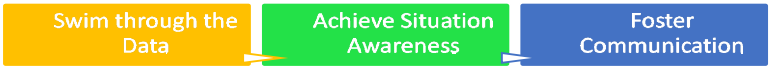
readers and help them to extract information from the dataset in an easy and effective manner. Table 1 shows the general benefits of DV.

Table 1 Data visualisation benefits

Supporting the decision-making process	Managers can take the right decisions or change their workflow according to the analysis of the charted data (Raghav et al., 2016), which is closely related to major revenues of many companies.
Saving time	A graphical representation of data makes it easy to understand than textual format.
The aesthetic and memorisation factor	DV convert complex data into readable format. Furthermore, the graphical images are more attractive for people and increase the memorisation and comprehension of data (Brigham, 2016).
Information Sharing	Creating graphics helps the designers to share their knowledge easily by publishing or sharing them, and make this data more accessible. This opens the door for more analysis and discussion; some call this feature as 'knowledge transfer and communication' (Biljon and Osei-Bryson, 2020; Renaud and Biljon, 2019)
The DV tools technical advancement	The availability of many types of DV tools (especially the free with simple GUI tools), helps in increasing the number of DV users worldwide and among all fields (Zhang et al., 2012). This is the case since the beginning of developing these kinds of software.

DV is also referred to as '*visual communication*' because of the easy language and the useful insight of data that the visualisations graphs provide for different kinds of users (Zion and Tripathy, 2020). As for decision-makers and the importance of DV to them, Figure 1 mentioned three of them. However, there are five stages of big DV Figure 2 summarise them.

Figure 1 The importance of visualisation to decision-makers (see online version for colours)



Source: Vingerhoeds et al. (2020)

Figure 2 Data visualisation process for big data (see online version for colours)

Source: Chawla et al. (2018)

In fact, the *visualisation* process is a mix of art and science, where the designers supposed to build interesting and engaging visuals that best described the raw data to help experience and non-experience users grasp the intended content and convince them (Schwabish, 2021). To achieve that, *visualisation tools* are used. Scientists defined visualisation tools as 'software which accepts the data, processes it, and present it in the

graphical format' (Gokhale and Mahajan, 2020). These products include libraries of graphical components or graphical objects and software editors for building and deploying data displays for applications (Sangam and Mogali, 2012).

There is no doubt that the ultimate goal of businesses is to generate profit. Indeed, managers take thousands of decisions to improve their competitive advantage and generate profit. Decision-making basically depends on information and how businesses can present such information for decision-makers (Khasawneh and Abu-Shanab, 2013). To increase revenue and generate profit, businesses focus on acquiring and retaining more customers. In CRM, businesses utilise information to select customers, acquire them, retain them and extend them. The CRM cycle requires an enormous amount of data about customers and their preferences. Such data can be represented in different forms, but still, it is Big Data. This means that it needs specific and different types of techniques and methods of analysis.

Based on that, the researchers tried to generate techniques, methods, and tools to support executives in the decision-making process. While businesses try to reach new customers, retain their existing ones, and extend their services, such objectives necessitate the use of new technology and specifically DV. Visualisation is one of the new directions of presenting data and thus improving business, and especially marketing and CRM environments. Such mix is a great opportunity to help business people make decisions in a fast manner especially if they have been overloaded with data that needs to be analysed and explored to realise its patterns in a short time (i.e., trends, gaps, and outliers) (Raghavan et al., 2018). To create such an advantage, users need to understand the features of the software that they may need to use to visualise their data. In this paper, we bridge the gap to help users choose the best visualisation tool that meets their needs by providing comparisons among six of some of the most famous tools, and building a framework of questions to understand such context and benefit from such new tools and techniques.

1.2 Research objectives and method

This paper has two major objectives: First, to contrast six major and popular visualisation tools. It is crucial to understand each tool and its characteristics, which serves the purpose of future research in utilising such tools toward a better implementation framework for DV. Second, to link CRM with the DV tools. Such a step serves future research in testing the framework proposed with a set of questions and dimensions and to explore whether such frameworks improve our understanding of how to improve all CRM processes and activities using DV tools. This study is an exploratory one in nature, where we assume that DV tools are not well assigned for CRM activities and are used without understanding the tool characteristics. DV tools are important for the data analytics process and for better a decision-making process also. It is vital to understand the context of DV to better serve managers in their pursuit of customer satisfaction. This is a first attempt to discuss the selected tools in this context and build a framework where researchers can utilise them to conduct future studies and understand such domain.

2 Literature review

A considerable amount of literature studied one or more DV tools, some of them utilised specific case studies to identify software's capabilities, compare two or more DV tools, or investigated their strength and weaknesses.

Ganapathy et al. (2004) explored a set of visualisation tools (visIT, Girafa, kartoo, etc.) and techniques that improve the different stages of CRM function, they also suggested a framework for IT leaders to apply these technologies in customer attraction, acquisition, and analysis areas (Ganapathy et al., 2004). Nevertheless, and because the old age of this study, it couldn't mention any of this paper's software.

ElTayeby et al. (2013) conducted a comparative study between only two JavaScript libraries D3.js and HighChart, and discussed the capabilities of them in terms of a set of criteria (ElTayeby et al., 2013). They only discussed two tools and based on a specific domain.

Another study discussed the challenges of big data and compared several DV tools (Tableau, Power BI, Plotly, Gephi, and Excel 2016) in terms of a set of criteria, such as integration with popular data sources, interactive visualisation, open-source or not, client type, tutorial availability, and application programming interfaces (APIs) availability (Ali et al., 2016). Again they didn't discuss the tools and the criteria that we did (Ali et al., 2016).

Moreover, Ling et al. (2016) carried out a comparative study between two visualisation tools (Gapminder and Tableau Public). They asked 47 participants about their understanding of the visualised data and the degree of ease of use of each tool (Ling et al., 2016).

Nair et al. (2016) also made a visual analytic comparison between two visualisation software Tableau and D3.js. They explored the effectiveness of these tools, and to which degree it succeeded in getting useful insights into the dataset. Besides, the authors classified some popular DV tools based on a set of criteria (Nair et al., 2016).

Cota et al. (2017) discussed the challenges of representing big data and the traits of the most important charting tools used in this field. They reviewed D3, FusionCharts, HighCharts, Leaflet, R, Tableau, Google Fusion Tables, Quadrigram, and Datawrapper. The study is based on the visualisation types, load data files, and development time (Cota et al., 2017). They didn't discuss RAWGraphs, and mention all the criteria that we have.

Moreover, a comparative evaluation of different modes of presentations (tabular and graphical) was studied in (2018) to measure the accuracy and user comprehension of such visualisations using R language (Version 3.2.1) for analysis. They concluded that the two presentations had different displays, and they emphasised the need for enough awareness of such differences, where this will lead to a better choice of the best presentations needed for visualising complex datasets (Raghavan et al., 2018).

Some researchers studied the behavioural intentions of some executives with regard to big data, to understand their intentions to transform toward a data-driven business model in their firms (Ylijoki and Porras, 2018).

In the biology field, Yokoyama and Kasahara (2020) aimed to help biologists identify the suitable SVs tool for their needs, so they analysed more than 30 visualisation tools in biology (Yokoyama and Kasahara, 2020). The tools selected are related only to the biology domain.

The authors (Kameswaran and Enigo, 2020) suggested a tool called 'ScrAnViz' to structure, analyse and visualise unstructured business data that was generated by

e-commerce websites. It can also be integrated with any visualisation software (Kameswaran and Enigo, 2020).

In the context of 'economics of education', a study provided a tutorial exercise for Tableau to help undergraduate economic students and instructors who want to teach data literacy in their course work (Du et al., 2020). They explained how to produce a success story out of a cleaned dataset, which helps in studying customer behaviour (or customer switching from one service provider to another for takeaway services) (Du et al., 2020). They also provided a visual analysis system for retailers that tracks the customer switching behaviours among stores, and then they evaluated it using case studies to validate this behaviour-tracker (Du et al., 2020).

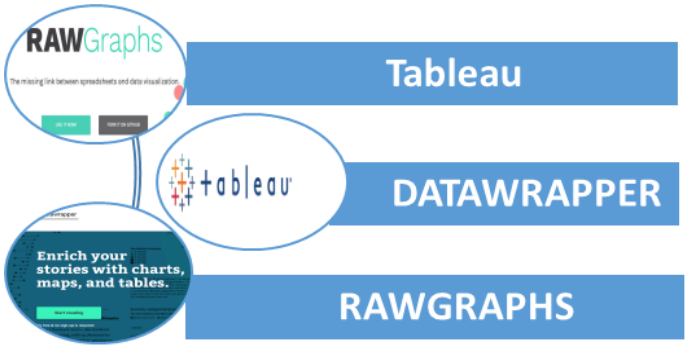
Besides, Desimoni and Po (2020) conducted a comparison and a function-based evaluation process for a list of linked data (LD) visualisation tools, then they tested 14 tools on a big LD dataset (Desimoni and Po, 2020). Again this study did not discuss any of the tools that are chosen for this study.

Another effort studied D3.js and GoogleCharts tools for retail customer data. The authors performed paired sample t-test to compare them and measure their effectiveness, efficiency, and user preference (Smatt et al., 2020).

Korobkov et al. (2021) carried out a comparison among a set of selected visualisation tools for graphs visualisation. The authors compared them based on many criteria, and by the end of their work, they chose the most convenient application (Korobkov et al., 2021). But they have never discussed any of these paper tools or bound them to CRM context.

In this study, we will explore the capabilities of a new set of visualisation tools and provide a conceptual contrast between them, which might not be covered by previous research in one study. The focus will be on six applications: Tableau, Datawrapper, RAWGraphs, D3.js, FusionCharts, and GoogleChart. We will show the differences among them based on their development skills requirements, cost requirements, input/output format, mobile capabilities, and browser compatibility. Due to the importance of the awareness of the available DV tools and techniques, which help stakeholders deciding the appropriate knowledge visualisation solutions that meet their needs (Biljon and Osei-Bryson, 2020). Finally, we will propose a framework that sets the stage for future researchers on the specific questions to be answered to implement a successful CRM initiative.

Figure 3 DV tools for non-professional users (see online version for colours)



3 Development-free DV tools

The tools that are chosen to be discussed in this section are a set of the most popular and common visualisation software for non-professional users (Figure 3).

3.1 Tableau

One of the popular DV software is Tableau. [Wesley et al. (2011), p.1] Defined it as a "*graphical system for performing ad hoc exploration and analysis of customer datasets. It also a commercial continuation of the Polaris research project*". Tableau is also described as the grandmaster of DV software since it has over 57,000 accounts across many industries and disciplines (Olshannikova et al., 2015). It is also used in the academic, government, and business sectors. And for both corporations and individual users (Chawla et al., 2018).

Table 2 Tableau paid products vs. Tableau free products updated information

	Tableau paid products	*Tableau free products*
Tableau product	Tableau desktop, Tableau server and Tableau online	Tableau public, Tableau reader and Tableau mobile
Input files types	It supports more options including the ability to connect directly to a variety of databases	It supports basic file options like Excel, CSV, etc.
How the files shared?	Users can embed files in certain website, or export files to the free Tableau Reader app	Can be embedded in a website or it can be opened by the same version of Tableau, e.g., Tableau public files
How to saved?	Users can save files locally or online	Tableau public users must save their files to the Tableau public website

Source: Deardorff (2016)

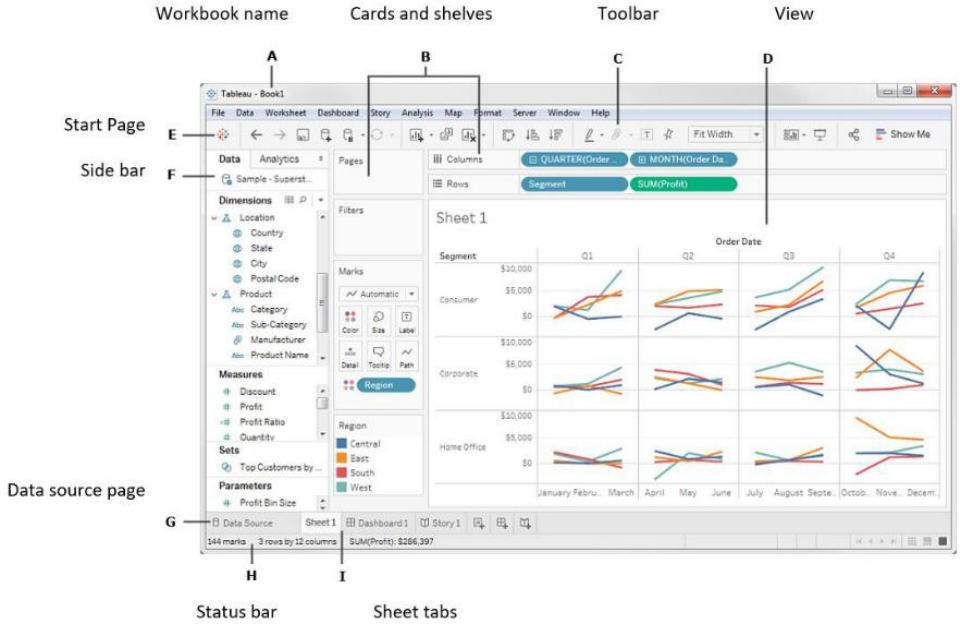
This tool has many features; it is available for both Windows and Mac operating systems (Deardorff, 2016). It also can filter many datasets simultaneously (Chawla et al., 2018). Furthermore, Tableau requires no coding or development skills; instead, it has a graphical user interface with drag-and-drop options (Figure 4), with a simple development dashboard exists to helps users visualise their data. Tableau's developer can connect to common database systems such as Microsoft SQL Server, MySQL, Teradata, Oracle, EMC Greenplum, HP Vertica, and more. It has an Open DataBase Connectivity (ODBC) protocol (Szewrański et al., 2017). Furthermore, it connects data sources such as Hadoop technologies and cloud sources; it provides a live connector to several data sources, in addition to its ability to connect to a plethora of file types and databases (see Table 4). Tableau Company offers many products, for more details (Figure 5).

Tableau GUI and the supporting documentation for all its products (except tabcmd and tabadmin come in nine languages; English, French, German, Spanish, Brazilian Portuguese, Japanese, Korean and Simplified Chinese). Furthermore, Tableau allows its users to store their data in any language (Tableau Software, LLC, 2018). Many data types can be visualised in Tableau, such as temporal, spatial, topical, and network data (Table 4) provides more details.

A study in (2017) analysed large datasets using Tableau and R. The authors found that Tableau was better than R in terms of many features like easy-to-use GUI, quick

visualisation process, interactive graphs that is produced, mobile device compatibility. Besides, the maintenance services and the Tableau forum are effective ways to support users (Rajeswari et al., 2017).

Figure 4 Tableau workspace area (see online version for colours)



Source: Tableau Software, LLC (2018)

Figure 5 Summary of Tableau products (see online version for colours)

Tableau desktop	• Used by single users or small-scale organizations (Nair *et al.*, 2016). It is also used as a BI tool (Szewrański et al., 2017).
Tableau server	• Provides a multi-user visualization service with the ability to share the graphs under development and offers multiple views with restrictions and security levels based on user's authorization (Nair *et al.*, 2016).
Tableau online	• It is a cloud-based version of the Tableau server
Tableau public	• It is a Tableau free cloud-based version (visualizes small data size with no ability to save it locally to the user machine). • Users can share the file, which will be accessible to the public with an option to prevent anyone from downloading the workbook and the raw data (Tableau Software, LLC, 2018).
Tableau reader	• A free version of Tableau. • The correct solution to view and read a visualization, but not to create it. If a user saves a visualization using Tableau Desktop as a ".twbx" file, then this workbook can be opened, viewed, or interacted with and filtered by another user using Tableau Reader (Tableau Software, LLC, 2018).

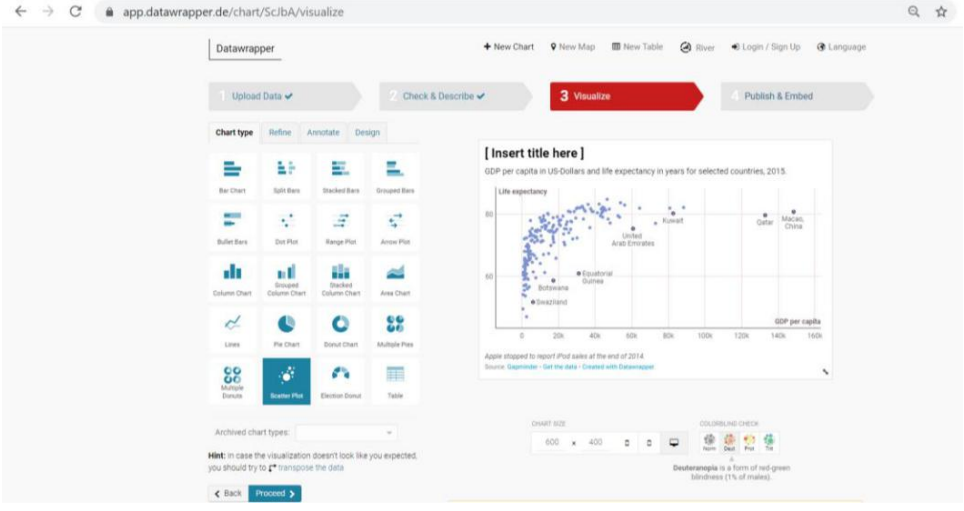
Another study used Tableau in BI, where the researchers analysed and visualised an online order dataset extracted from a logistics services company. The goal was to help this company to get a clear image of its customer's behaviour, shopping trends, types of products, and product delivery time (Sharawi and Sammour, 2017). Using Tableau helped managers to improve the company's marketing campaigns, future collaborations with other companies, etc.

Researchers utilised Tableau for facilitating the library functions. A survey made in 2015, showed that many respondents preferred Tableau over any of the other 19 visualisation tools included in the survey, and about 35% of respondents were interested in learning Tableau. Consequently, the library adopted Tableau in its training and visualisation work (Federer and Joubert, 2018). Finally, in the healthcare sector, Tableau allows users to discover and understand their data interactively due to its easy-to-use GUI, in addition to its compatibility with almost any database (Ko and Chang, 2017).

3.2 Datawrapper

A popular charting software that does not need coding or design skills. It is an open-source tool, which creates maps, charts, and tables (Datawrapper, 2020). Because of its limited capabilities compared to other visualisation tools, it is suitable for small businesses. It also allows 10,000 views for each chart (Ali et al., 2016). What makes this tool appealing for users is the usability and charting time; its interface is simple and takes minutes to accomplish the visualisation task or even seconds in some cases. Thousands of journalists rely on this tool to visualise their stories and publish them on news websites. It is widely used to provide data insights into media organisations (Datawrapper, 2020). This is due to its clear and simple interface that helps in presenting statistics, creating charts and maps, and embed them rapidly into reports (Olshannikova et al., 2015).

Figure 6 Datawrapper environment (see online version for colours)



Source: Datawrapper (2020)

Datawrapper's website offers some extra-paid features that increase the tool's capabilities, like its customised solution with custom maps, print-export, and CMS

integration. Generally speaking, this tool creates interactive, responsive, website-embedded charts and an automatic update of data (like stock market data), by connecting these data to a database, and when this data changes, Datawrapper automatically update the graph with no need to re-visualise or republish it from scratch. For more information, see Figure 6.

Datawrapper launched in November 2012. In 2014, paid services were introduced, such as Datawrapper single, Datawrapper team, and Datawrapper Pro. In 2016, Datawrapper issued three upgrades that helped in making visualisations readable on smartphones (mobile-first charts). Figure 7 explain these new features, while Figure 8 shows an example of a smartphone interface.

Figure 7 Datawrapper mobile features (see online version for colours)

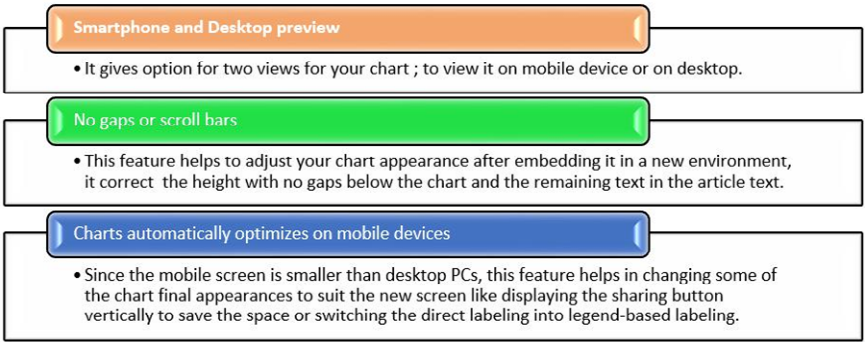
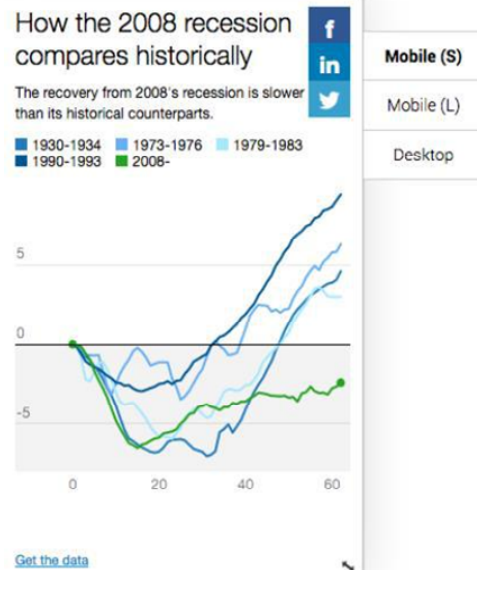


Figure 8 An example of the mobile-first feature in Datawrapper (see online version for colours)



Source: Datawrapper (2020

3.3 RAWGraphs

RAWGraphs is an open-source web visualisation tool. Its charts are developed on top of AngularJS and D3.js JavaScript libraries and can be used directly without registration via its official website. It does not need software installation into users' machines, and this is why it is described as cross-environment since it is an online platform (rawgraphs.io, 2020). This tool has about four chart types (models) built into it, as shown in Table 3.

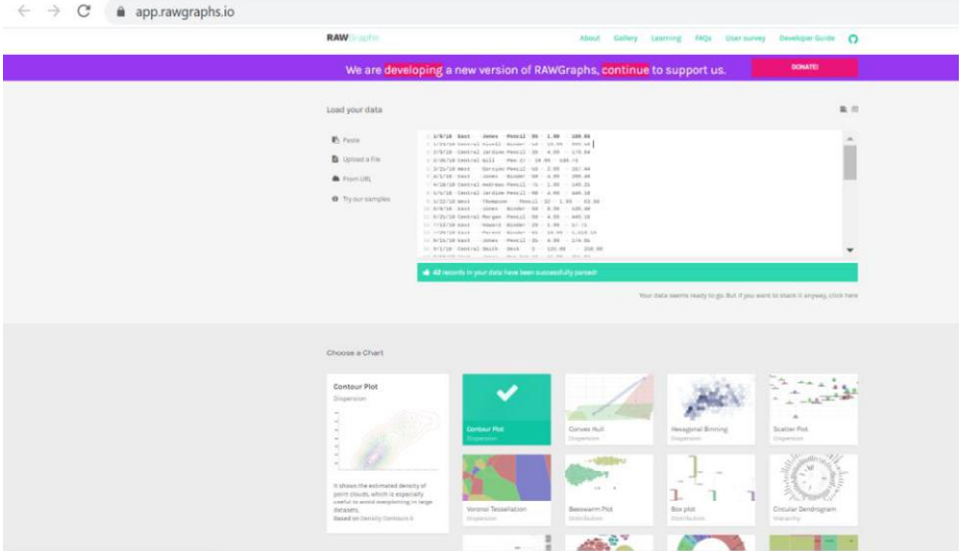
Table 3 RAWGraphs charts main models

Model type	*Usage*	*Chart example*
Points	For Cartesian distributions	Convex hull, scatter plot
Trees	To define hierarchies	Treemap
Graphs	For node-links structures	Alluvial diagrams
Time series	For time-based visualisation	AreaGraph, StreaminGraph

Source: rawgraphs.io (2020)

Accordingly, the user can easily copy and paste the data into the RAWGraphs webpage, then proceed with a step-by-step process, with a drag-and-drop simple interface to reach the final required graph (Figure 9). The designer can enhance the output more (Table 3) using any favourite vector graphics edit (rawgraphs.io, 2020). Furthermore, the RAWGraphs team called this tool a 'front-end-only solution' because of the data safety it provides, where all the processing of designer data happens on the clients' browsers and local machines (no server-side operations or storage are needed). Moreover, RAWGraph users can create custom vector-based visualisations on top of the D3.js, but at the same time, it is not possible to insert it in web-application for the customised charts (Liu et al., 2018).

Figure 9 Rawgraph interface (see online version for colours)

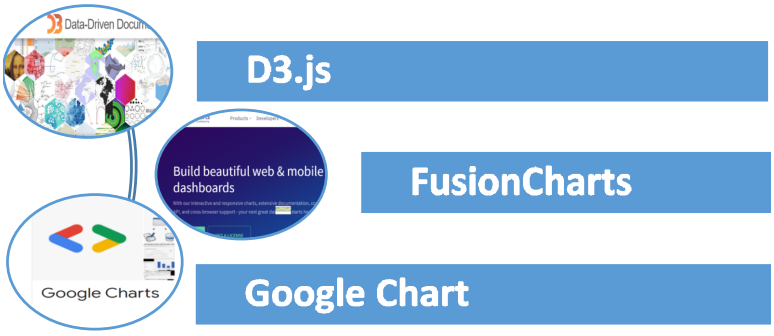


Source: rawgraphs.io (2020)

4 DV tools that need development

The applications that are chosen to be discussed in this section are a set of the most popular and common charting libraries that need coding knowledge (Figure 10).

Figure 10 DV tools that need coding skills (see online version for colours)



4.1 D3.JS

D3 (data-driven documents) is a free and open-source JavaScript library used to create creative and dynamic visualisations. It was developed in August 2011. D3 designed in a way that helps in visualising data using HTML, CSS, and SVG (van Dierendonck et al., n.d.). Moreover, charting data imply binding arbitrary data to a document object model (DOM), after that data transformation and data-driven- documents are performed to produce interactive charts (Nair et al., 2016).

This transformative nature using web standards is a nice feature that helps in making any customised visualisation with high interactivity (Nair et al., 2016). Moreover, since D3 uses the standard web browser as its development and runtime environment; this means that there is no need for a proprietary framework (Calleya et al., 2016), or long installation and continuously updating process as other toolkits have. Furthermore, in (2016) a comparison study was conducted between MATLAB and D3. The study revealed that MATLAB needed much more time than D3 to execute a simple parse integer operation (Calleya et al., 2016). This indicates how D3 is a powerful visualising tool.

D3.js supports many devices and cloud clients successfully like PCs, smartphones and tablets (Jain, 2014; Nair et al., 2016). Besides, it creates and controls interactive charts running on all modern browsers and systems including IE 9+, Android, and IOS (Nair et al., 2016). Additionally, it has a nice gallery of many used charts (visit D3.js gallery: https://github.com/d3/d3/wiki/Gallery). D3 can also be used in many projects and newspapers such as The Guardian, The Huffington Postm, and The New York Times which reach thousands of viewers around the world. In fact, the availability of a big online community and its documentation side by side with different tutorials on the Internet makes this tool reachable, easy to learn, and discoverable.

Another advantage that D3.js has over other charting libraries is the ability to share the visualisation output with no particular plug-in or any software to render the content like Flare. The browser can simply do this task. Additionally, fast and easy debugging is

available because D3 is based on JavaScript, which is compatible with the browser's debuggers (van Dierendonck et al., n.d.). An important strength for this tool is the charting customisation freedom, where it provides a stable base to visualise any new chart the developer imagines or needs outside the available options.

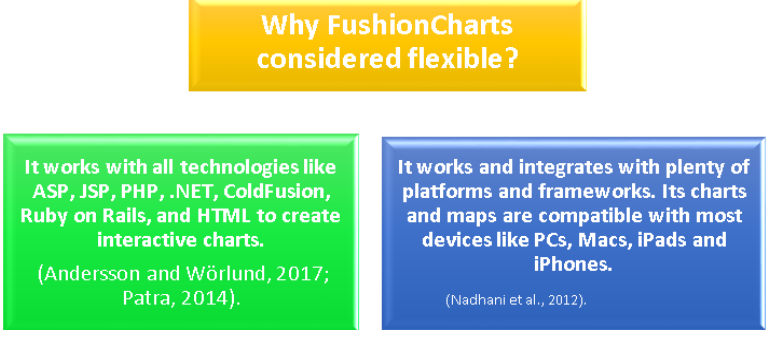
However, choosing D3.js means more development effort and time than some other tools, this is because D3 is built on technologies like SVG, HTML and JavaScript. So, the developer should learn these web standards first. Besides, D3 does not have any templates or pre-built charts (Hariharan et al., 2016), like the case in RAWgraphs. Therefore, when a new graph is to be charted, a developer has to write this chart from scratch by himself by using the API provided by D3. This point is a double-edged sword; it helps in serving the designer creativity, but it consumes more effort and time.

Regarding the user's authorisation and views, and according to (Nair et al., 2016), it is not easy to restrict access to part of the data using D3.js (while it is possible using Tableau). Another drawback that D3 has is that it does not support older versions of the browsers (Bao and Chen, 2014; vteams.com, 2015). Moreover, since the visualisation rendered by the browsers and there are some uses of specific layout algorithms while developing and visualising using D3.js, this uncovers some of the D3 weaknesses. When a big dataset (in Gigabytes for example) needs to be charted, the rendering of highly interactive visualisation is not very efficient (Supaartagorn, 2016). Unless this data is dividing into several subsets of the dataset and visualise each of them individually, then aggregate them.

4.2 FusionCharts

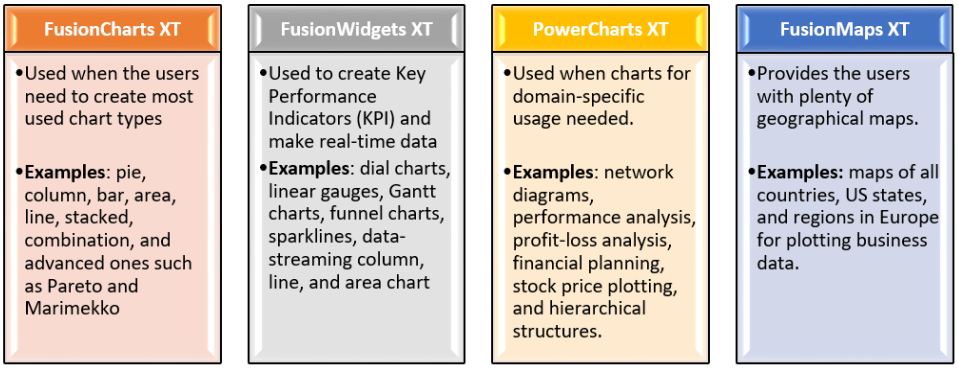
It is one of the most common JavaScript visualisation libraries that helps in bringing life and increases the aesthetic value of your web application through charts, gauges, and maps. FusionCharts is an open-source code tool. It takes the parameter as input and returns the overall chart as an output (Hariharan et al., 2016). It is described as a flash charting component, this is because it is used to render data-driven animated charts (Zhang, 2013). FusionCharts exploits the capabilities of HTML5 and Adobe Flash 8 to render powerful and dynamic charts with no need to learn flash programming in advance (fusioncharts.com, 2018). Moreover, the charts it produced can be shown in two or three dimensions (Zion and Tripathy, 2020).

Figure 11 Why FushionCharts considered flexible? (see online version for colours)



FusionCharts is a complete solution to create highly interactive visualisations, which is described as an industry-leading JavaScript charting library (Okpe et al., 2018). It enables users to pick from more than 90 predefined charts and 365 different maps (Zion and Tripathy, 2020). However, this feature plays a major role in decreasing the visualisation effort and time. Figure 11 answers the question 'why FusionChart considered a flexible tool?' (Andersson and Wörlund, 2017; Nadhani et al., 2012; Patra, 2014).

Figure 12 FusionCharts products summary (see online version for colours)



Source: (summarised by the authors from) Nadhani et al. (2012)

FusionCharts supports old and new browsers (Okpe et al., 2018), a point that makes it excel over other tools like D3.js, which only supports new browsers (Andersson and Wörlund, 2017). Another important point about FusionCharts is that it supports users' needs at both individual and enterprise levels. It also offers four different products (Figure 12).

The major disadvantage of FusionCharts appears when users want to make an imaginable visualisation. It provides the developer with many charts and map templates, but it is not a good solution when extended charting capabilities are required (Hariharan et al., 2016). It is a good solution when the developer knows in advance the basics of graphs provided by FusionCharts. Another drawback that the user will face when deciding to choose FusionCharts is the pricing issue; FusionCharts is not a free software it is licensed.

Patra (2014) compared HighChart, FusionCharts, Rickshaw, and D3 in Android and iOS devices in his study, to investigate the challenges that face the designer to choose the right library. He found that even though FusionCharts is a paid library but at the same time, it is easier to use compared to D3 for example, and thus it needs less development time due to the rich ready-to-use charts that FusionCharts has, which serve more than 75% of industry requirements. He concluded that FusionCharts was not the best tool in terms of performance, even that it is a paid library; D3 is better and outperforms it in some features (Patra, 2014).

4.3 GoogleChart

GoogleChart is one of the most widely used and open source tools for DV, it is a JavaScript-based charting library, released in 2007. Moreover, since GoogleCharts is based on pure HTML5 and scalable vector-graphics technology (SVG) it is considered a

free visualisation library (Zhu, 2012). It provides a set of APIs, which is very easy to use (Supaartagorn, 2016).

Developers can make a static or interactive chart. There are about 12 basic graph types (Zhu, 2012), for more information see (Table 5). When using GoogleChart, designers can add yellow sticky notes, callouts, thought bubbles, and pinned notes to their images (Agarwal, 2011), which makes it suitable for visualising maps as well.

This tool creates visualisations from the user-supplied data, where users can create charts from data sources and embed them in the intended web page. This happens in an easy way by using a data URL with an image tag while the actual image is rendered live on Google Servers (Agarwal, 2011). Flexibility is evidenced here when a change happens to the original data, the developers have to change the URL only and the chart will be updated automatically. Also, the charting tool provides the ability for creating a set of charts that refer to the same data table and visualise them with different views (Zhu, 2012). This data table on the client-side can be connected via a web service, to a server-side database, such as Google Spreadsheets or Google Fusion Tables.

Based on that, GoogleCharts has many advantages over its drawbacks. The main advantage is that it is a platform and browser independent (Supaartagorn, 2016), where designers can use GoogleChart using all modern web and mobile browsers with no plug-ins requirement (Zhu, 2012). Also, it is easy to learn (Supaartagorn, 2016), and programmed with JavaScript, and embedded in HTML files; this is why it is popular for charting purposes over other tools like D3.js. The free use of this tool increases its attractiveness either for individuals or for commercial use. Besides, the availability of good documentation, tutorials, examples online, and the existence of user forum for answering users' questions increase its popularity requirement (Zhu, 2012). GoogleChart does not support creating imaginable visualisations. It also doesn't support drawing graphs, and mostly supports graphing the 2D charts except the pie and doughnut Charts requirement (Zhu, 2012),

A research done by [Lee et al. (2014), p.2] implied that GoogleChart provided a high level of interactivity compared to others tools (D3.js, JfreeChart, Flex and OFC) with wide options of rendering features. The researchers measured the processing time and concluded that GoogleChart was the slowest in the layout and data transformation time compared to other tools. However, GoogleCharts and D3.js were faster than JfreeChart in the visualisation testing (Lee et al., 2014).

5 Comparative view of visualisation tools

[Bikakis (2018), p.2] Mentioned four features that modern visualisation tools need to address in an efficient manner: real-time interaction, on-the-fly processing, visual scalability, and user assistance and personalisation (Bikakis, 2018). Accordingly, in our study, we select some criteria for the studied software that directly affect the usability and the accessibility levels of these tools, to compare them. Additionally, Tables 4 and 5 provide a summary of the comparison that was done among tools based on these criteria.

Table 4 Comparison between Datawrapper, RAWGraphs and Tableau

Tool / *Criteria*	*Datawrapper (Datawrapper, 2020)*	*RAWGraphs (rawgraphs.io, 2020)*	*Tableau (Tableau Software, LLC, 2018)*
Browsers compatibility	IE, Firefox, Chrome and Safari	Any browser	Chrome, Safari, Firefox and IE11 + browsers
Input format	Spread sheet (Google Sheets, Excel) or CSV files	Spreadsheet data, CSV, TSV, DSV, XLSX, JSON, inserting an API URL, or data from public cloud platform (Liu et al., 2018).	Excel, CSV and the ability to connect directly to a variety of databases and files (R data file rdata, a tab-separated file.tsv, IBM SPSS file.sav, SAS data file.sas7bdat, Loca Cube file.cub) (Szewrański et al., 2017)
Output format	PNG image, PDF or an embed code interactive chart.	SVG, PNG, JSON, and of PDF.	CSV file, hyper file, Tableau data source.tds file (tableau.com, 2018) PNG, BMF, JPEG, and EMF (Nair et al., 2016)
Chart types	Basic charts available (bar, pie, line, column, stacked column grouped column, donut, election donut), data table and maps)	About 21 basic chart types (alluvial diagram, bump chart, circle packing circular dendrogram, etc.)	About 24 chart types (bar charts, line charts, pie charts, bubble charts, maps, Gantt charts, histograms, bullet charts, heat maps, scatter plots, tree maps, highlight tables, and box-and-whisker plots) (educba.com, 2020)
Coding requirements	No coding requirement	No coding requirement	No coding requirement
Documentation	Tutorial	Yes	Yes and big support community
Open source/ proprietary	Open source, and proprietary	Open source	Proprietary
Customisation level	Basics (Cota et al., 2017)	Medium (build on D3.js)	Law (not all desired visualisation can be made used this too) (Cota et al., 2017)
Mobile devices optimisation	Yes	No	Yes
Support big dataset	Yes (Chatterjee, 2016)	No	Yes

- Coding requirements

The development skills needed to make the desired graph is the major feature that the designer is looking for. Some charting applications are super user-friendly, they provide a drag-and-drop easy interface, while others need heavy coding effort. Figure 13 classifies the visualisation applications and libraries based on the coding requirement.

Table 5 Comparison between D3.js, GoogleChart and FusionCharts

Tool / *Criteria*	*D3.js*	*GoogleChart*	*FusionCharts*
First fired	2011	2007	2002
Browsers compatibility (fusioncharts.com, 2018).	Modern web and mobile browsers including IE 9+	All modern web and browsers, including IE6+	All modern web, old web and mobile browsers, including IE6+
Input format	CSV, JSON, GeoJSON and XML	SVG, GoogleChart, Google Spreadsheets or Google Fusion Table	JSON and XML
Output format	SVG, also as PNG and JPEG image are possible, charts and diagram (Gokhale and Mahajan, 2020)	HTML5 charts using SVG and V ML. interactive charts (Gokhale and Mahajan, 2020)	JavaScript HTML 5 charts using SVG, VML also as PNG, JPEG or as PDF. charts and maps (Gokhale and Mahajan, 2020)
Chart types	Any traditional and imaginable chart	About 12 basic chart type (bar charts, area charts, pie charts, column charts, scatter charts, gauge charts, geo charts, tables, tree maps, combo charts, line charts, candlestick charts, in addition to other users' contributions like annotated timelines (Lee et al., 2014; Zhu, 2012)	90 predefined charts and 365 different maps
Coding requirements (heavy, little)	Heavy	Little	Little
Documentation/ support	Yes	Yes, through Google support, forum. (Chatterjee, 2016; Zhu, 2012)	Yes
Open source/ proprietary	Open source	Open source	Open source
Customisation level (high, medium)	High	Medium	Medium
Mobile devices capabilities	Yes	Yes	Yes
Support big dataset	Efficient if the big dataset divided into many smaller subsets	Yes (Chatterjee, 2016)	Yes (Chatterjee, 2016)

- Cost requirements

Some tools are offered for free, while others are paid. Figure 14 provides a summary of the paid and free tools that are reviewed in this study.

Figure 13 Classification of tools based on the coding requirements

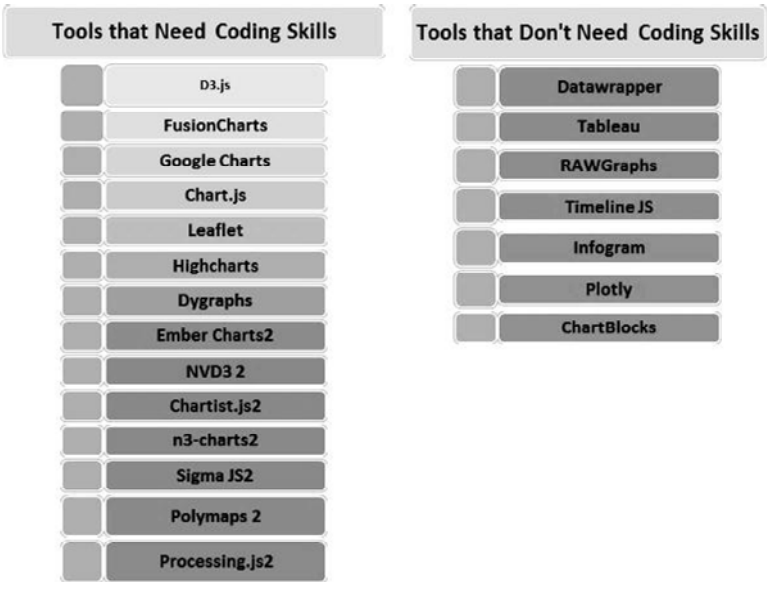
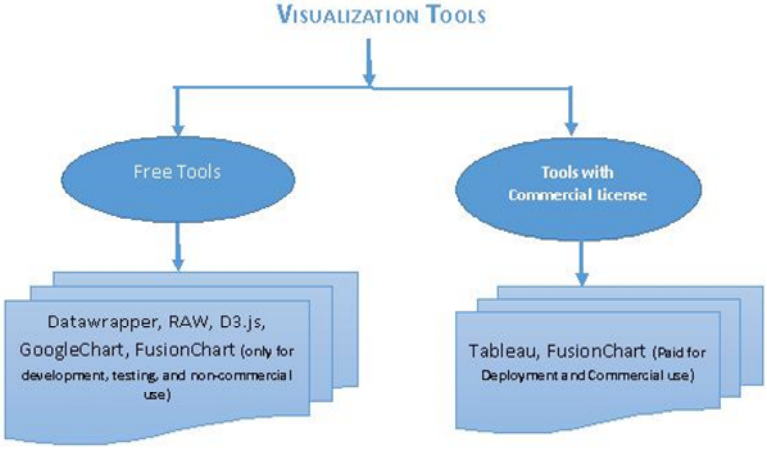


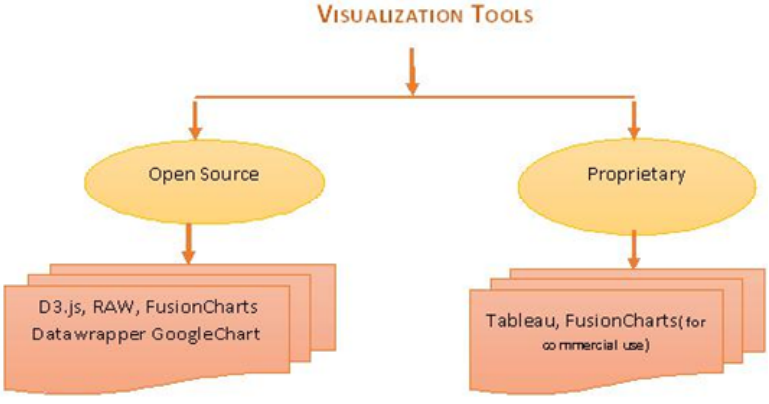
Figure 14 The studied visualisation tools based on the cost requirements (see online version for colours)



- Open source feature

Open-source software is software whose source code is transparent to the public, where they can use and modify. The open source is improved through an evolutionary collaborative effort by users and researchers. These tools are most of the time free and do not require any commercial license. In this paper, all of the studied tools are open source except Tableau. FusionCharts is an open-source and paid charting library at the same time (Patra, 2014). Figure 15 summarise this feature.

Figure 15 The studied visualisation tools classified based on the open source criteria (see online version for colours)



- Browsers' compatibility

Tools vary in how they adapt to a certain browser. They are influenced by the browser development style, the way in which they are designed, and the published year. Some charting software is friendly with modern browsers while others can work with both old (like IE6) and new ones. In this article, most of the charting tools are compatible with the modern web and mobile browsers.

- Input and output format

Like any other system, the tools take the data in different styles and types, processing it and finally producing a visually diverse output based on such input data. We summarised them in (Tables 4 and 5).

- Charts types

There are many traditional graph types that DV tools can produce. However, developers may think in a new imaginable way when they want to narrate a story from a dataset. The charting software varies in supporting the two trends. Some of them support only the traditional charts, while others open the door for the developers to imagine and create unconventional ones.

- Documentation

It is a soft or hard copy of a tutorial document that guides the users and illustrates the way a specific tool operates. The popularity of a tool depends mostly on the available, clear, and strong documentation. Most online or desktop software have documentation for it, which helps their users to navigate through the tool and understand its capabilities.

- Mobile devices capabilities

The exponential use of smartphones and tablet devices nowadays makes them a target for software companies. It has become necessary for their success to enrich their tools and make them friendly with mobile devices. So, tools must be able to adjust their parameters based on the settings and the available resources on these devices, such as the device screen size, and available memory. Thus, mobile device capabilities in our study mean

the ability to view the output (charts) on smartphones and tablet devices such as iPhones, iPads, and Android devices.

- Supporting big data

Big data are a challenge in today's digital world, where a huge amount of data generated every day from various digital sources needs to be stored, analysed, and sometimes visualised. Indeed, the visualisation software varies in supporting big datasets; some are unable to support such features especially the old ones. Meanwhile, the tools that support big data are varied by speed and performance. To overcome such obstacles, developers normally divide the data into smaller subsets and visualise them separately, then aggregate the results.

6 Customer relationship management

CRM is a multidisciplinary area, where its main concepts are rooted in the marketing discipline, but borrow many of its main features from human behaviour, consumer analytics, and electronic commerce (Abu-Shanab and Shihadeh, 2014), CRM is defined as a set of business activities to identify, collect, verify, maintain and develop a sustainable customer loyalty (Saeednia et al., 2012). Its main objective is to maximise the customer's total lifetime revenue and generated value (Sedighi et al., 2012). CRM extends the marketing concepts from the whole to the part, where it focuses on individual taste, behaviour, and preferences (Harb and Abu-Shanab, 2009). The aim of such a one-to-one focus is to reinforce customer loyalty and extend customer value to higher levels.

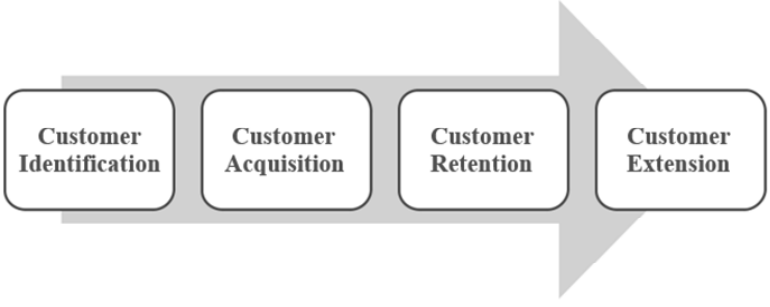
Research and scientific textbooks classified CRM into many typologies. Researchers classified CRM into customer-facing vs. customer-touching CRM (Turban et al., 2018). The bases of this calcification are related to what applications that customers interact with vs. other systems used by the company. Another common typology differentiated operational CRM from analytical CRM, where operational deals with the automated activities that interface with customers. Analytical CRM relates to the analysis done on customer data that would lead to better decisions regarding what offerings a company should have to fit with customer preferences and behaviours (Maroofi et al., 2012; Sedighi et al., 2012).

CRM has many advantages (as reported by previous research), where it increases and improves customer satisfaction, which increases revenue and customer value (Allameh et al., 2012). Similarly, CRM improves customer interactions, transaction accuracy, and speed, and offers convenience to customers and better decisions for firms (Dhingra and Dhingra, 2013). The authors analysed the concept based on a process that started by acquiring customers, improving the relationship between the firm and its customers, and finally, retaining them. Such a cycle is explored in previous literature with varying forms. With the advent of the Internet and web applications, the concept of electronic CRM (e-CRM) started to attract more attention, where it emphasised web-application utilisation to support CRM activities (Mishra and Padhi, 2013). E-CRM utilises available hardware, software, and different apps (like social media) to improve and support firms' efforts toward a better CRM (Bhatnagar and Saxena, 2013; Usman et al., 2012).

6.1 CRM cycle and propositions

In this paper we will adopt a process that starts with customer identification, then acquisition, followed by retention and extension. The following few propositions will set the stage for future research to benefit from DV towards a successful implementation of the CRM process. The set of questions proposed hereafter will help businesses utilise DV for business decision-making and objectives. In Figure 16 shows the CRM cycle adopted.

Figure 16 CRM customer-life-cycle



The previously mentioned process is related to how business pursues their customer relationship management and to what degree they can utilise DV tools to attain such targets. Businesses could follow the previous cycle in different methods, where many businesses can identify their customers using DV tools. To test such a cycle and how businesses can utilise DV to successfully implement CRM activities. The following section will build a set of propositions around the CRM cycle and link to DV tools capabilities.

6.2 Business propositions

The following framework introduces a set of dimensions and their related factors (questions that need to be answered) to better understand the context of research. The framework links CRM with the DV tools. Such a step serves future research in testing the framework proposed with a set of questions and dimensions and to explore whether such framework improves our understanding of how to improve all CRM processes and activities using DV tools.

6.2.1 Customer identification

Organisations attract customers to increase their market, share and improve their revenue. They need first to identify potential customers. The tools used for such phases range from web forms, viral marketing, lead marketing, and contact management. Firms try to ask the following questions:

- Whom do we target?
- What are the prevailing values?
- What value generated from such a category (targeted)?

- How long can we generate value from customers (total lifetime generated value)?
- Where/how firms can reach such a category?

DV tools can help businesses identify the value of customers and track the changes within markets. The business can identify customers on a segment or individual level. The DV tools previously mentioned can map customer segments and their associated values, where changes can be tracked across time and geographic areas.

6.2.2 Customer acquisition

The second phase is customer acquisition, where major activities focus on targeting the right customer, analyse data to align product offerings with potential customers. Businesses can track their potential customers identified and how far they can contribute towards business objectives. Firms try to ask the following questions:

- What segment to target?
- Where we target the segment?
- What is the best channel to reach the targeted segment?
- What is the cost of customer acquisition?
- What information can be collected from customers?

Similar to the previous CRM stage, the business can track through DV tools the potential customers' segments and the location of such segments. DV tools can be linked to specific communication channels that dictates certain requirements. Businesses need to select compatible channels that work well with the objectives of the CRM cycle.

6.2.3 Customer retention

Retention is the process of keeping customers and maintaining a healthy relationship with them. Firms try to ask the following questions in this phase:

- What is customer-life-value?
- What customers need and what offerings are suitable for them?
- What is the preferred channel to reach the customer?
- How/when/where to continue reaching customers?
- What aspects of service satisfied customers?
- What aspects of service did not satisfy customers?

The DV tools can be utilised in mapping the distribution of existing customers and their value distribution within certain regions.

6.2.4 Customer extension

It is the process of convincing existing customers to use and follow new products and services. Firms try to ask the following questions:

- What are the cross-selling options?
- What are the up-selling options?
- How data analytics can be utilised to better understand customers?
- Are there better offerings for targeted customers (segment)?

Businesses will try to extend their customer value to more products and services. Such direction requires more understanding of the customer base and how they can relate to other company's products and services. It is crucial to map data related to changes in customer behaviour and how businesses can predict future trends among their existing customers and what services/products can be attractive.

7 Conclusions and future work

In this study, we explored six popular DV tools that have never been discussed together before in the same context. They are (Datawrapper, RAWGraphs Tableau, D3.js, GoogleCharts, and FusionCharts). We also build a framework of questions to explore CRM; customer relationship management, DV activities, and how DV tools can contribute to building better CRM activity and process. Finally, we open doors for future research to test such propositions and utilise different experiments. This will help researchers and any interested user to understand the similarities and the differences, as well as the advantages and disadvantages of these applications. Therefore, it will help them choose what suits their needs and goals. Besides. Besides, we classify the reviewed tools into two groups: Tools that need development skills and development-free tools. Moreover, the comparison that we have done is based on specific criteria, which serves the users usability and accessibility, like browsers compatibility, input format, output format, chart types, coding requirements, their documentation, open-source or proprietary software, customisation level, mobile devices optimisation, and big data support.

Based on our thorough inspection of DV tools, we conclude that no single tool is best for all kinds of uses, but each one is suitable from a specific point of view. D3.js is preferable to be used when a high level of customisation is required for visualisation. Datawrapper and RAWGraphs both are online visualisation platforms that suit non-professional users, and those who need only basic charts, because of their simple interface. Tableau the popular BI tool that produces an interactive visualisation that supports big dataset users from multiple domains who want a little amount of customisation side by side with an easy-to-use GUI, rich documentation, and a discussion forum. FusionCharts support big DV and required a little amount of programming comparing to D3.js. GoogleCharts also help users who want to make basic visualisation with a shorter learning time compared to other libraries like D3.js.

The last contribution of this work is to propose a framework that sets the stage for future researchers and practitioners on the specific questions to be answered to implement a successful CRM initiative. The set of questions need to be explored through a thorough process, where each DV tool can be used to see how it can serve each CRM phase. On the contrary, research can follow the opposite direction, where each CRM question can be tested and answered using a specific DV tool.

Future research can mainly test such a framework by utilising different research methods. Researchers can utilise the tools to contrast them; this can be done by selecting any two tools and contrast them. Another direction is to implement the whole framework on one tool and see if it has certain deficiencies in certain dimensions of the CRM framework.

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