CMS NOTES

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William Playfair (1759–1823) was a man of contradictions. On one hand, he was known as a good statistician and economist. He pioneered the use of statistical graphs and made substantial contributions to the first posthumous edition of Adam Smith's *Wealth of Nations* [12]. He was also one of the first to formulate a theory of how wealthy nations decline and fall [8]. On the other hand, he participated in criminal activity that resulted in his spending a few months in jail. When pressed for money, he engaged in a variety of scams to make ends meet. A lawyer representing one of Playfair's intended victims called him "a daring worthless fellow." (See, for example, [13].)

Playfair's dual nature carried over to his greatest statistical accomplishment, his graphs. On the positive side, graphs provide an easy way to digest complex information. On the negative side, graphs can be an intentional font of misinformation, a convincing depiction of alternate facts. Even when their creators do not intend to be misleading, graphs are only as good as the data going into them. Makers might not know they are using a bad data set, or they may be too lazy to obtain good data. Playfair's graphs exhibited all of these positive and negative characteristics.

Most of his constructions were motivated by his attempts to illustrate economic issues in a simple and understandable way. For example, he invented the bar chart to illustrate the size of imports and exports of various trading partners with Scotland. He is best known among statisticians for two types of specialized graphs: (1) his unique time-series charts related to English trade and its surplus or deficit; and (2) displays of multivariate data that compared a number of statistics for several European countries. Playfair also invented the now ubiquitous pie chart to illustrate the relative sizes of various states and territories of the United States. Here I will present three of Playfair's innovative graphs and comment on what motivated them, as well as their good and bad features. A full account will be given in my forthcoming book, *The Flawed Genius of William Playfair: The Story of the Father of Statistical Graphics*, to be published by University of Toronto Press.

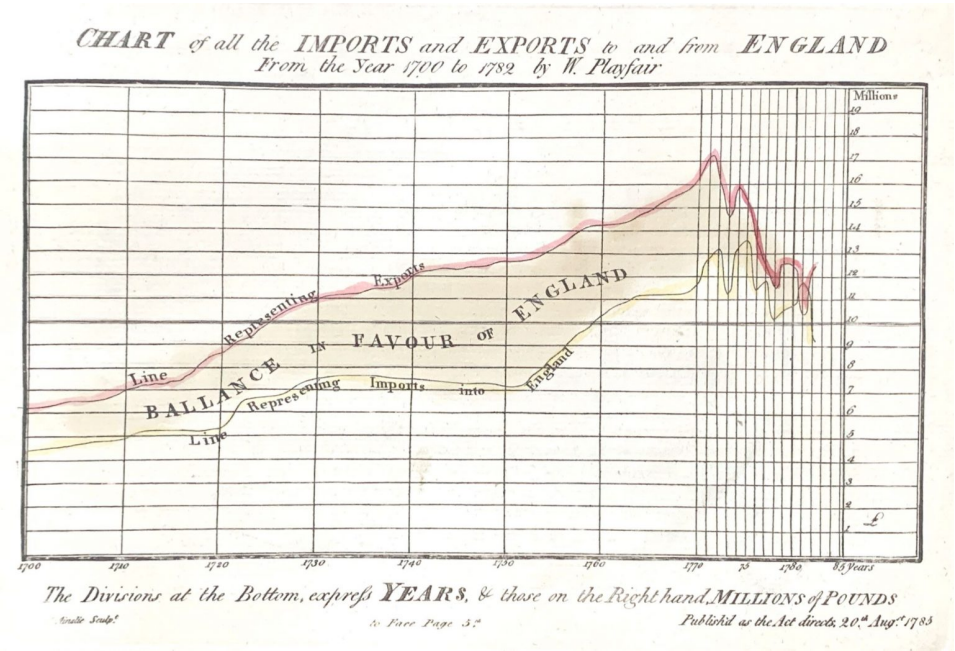


**Figure 1**. Total Exports and Imports for England 1700–1783.
Image courtesy of Stephen M. Stigler, Chicago.

One of Playfair's early innovations was his use of comparative time-series plots. Several of these graphs appear in his 1786 *Commercial and Political Atlas* [6]. The graph in Figure 1 shows the total amount of exports from England and the total amount of imports, all valued in pounds sterling. The coloured area between the lines shows the trade surplus or deficit. Why this was important had to do with the gold standard. Bank of England pound notes were then backed by gold. Gold was flowing out of England in order to pay for wars in Europe and then America and then Europe again. Gold flowed into England because of the trade surplus. As can be seen in the graph, the surplus had shrunk over time, so that by the end of the American Revolution trade was in a deficit position. Playfair saw this as a problem to be addressed.

Playfair's graphs stand out when compared to others of his day because he used elements that have now become standard. For example, Playfair pioneered the use of colour in his graphs, when colour was rarely used in the printing process. Also, in Figure 1 the plot is framed with the title placed outside the frame. Room is left inside the frame for labels and axis values. Grid lines have been added for ease in reading the chart. All of these elements provide a pleasing appearance. A thorough discussion of Playfair's use of graphical elements can be found in [3].

A feature that particularly stands out for me in the graph in Figure 1 is the way the volatility in the data changes near the end of the series. Further, the gridlines are placed closer together during the period when there is more volatility. This raises a question: Did Playfair smooth his data in some way? In order to answer this question, it is necessary to get at the original data. Playfair gives the data only by decade. In some late-18th-century and early-19th-century publications [4; 15], I found yearly data from 1697 for imports and exports drawn from the Custom House records. I took the yearly data and smoothed the years 1700 through 1770 using a modern technique called LOESS, while the years 1771 through 1782 were left unsmoothed. The result is shown in Figure 2. I have also inserted Playfair's data into the graph to show how closely my smoothed data come to his. While my smoothing does not exactly replicate Playfair's, it comes fairly close. Of course, he did not have this technology. My conjecture is that Playfair used a draftsman's spline to smooth his data. This spline is made of flexible wood which can be bent into curved shapes that are held in place by weights.

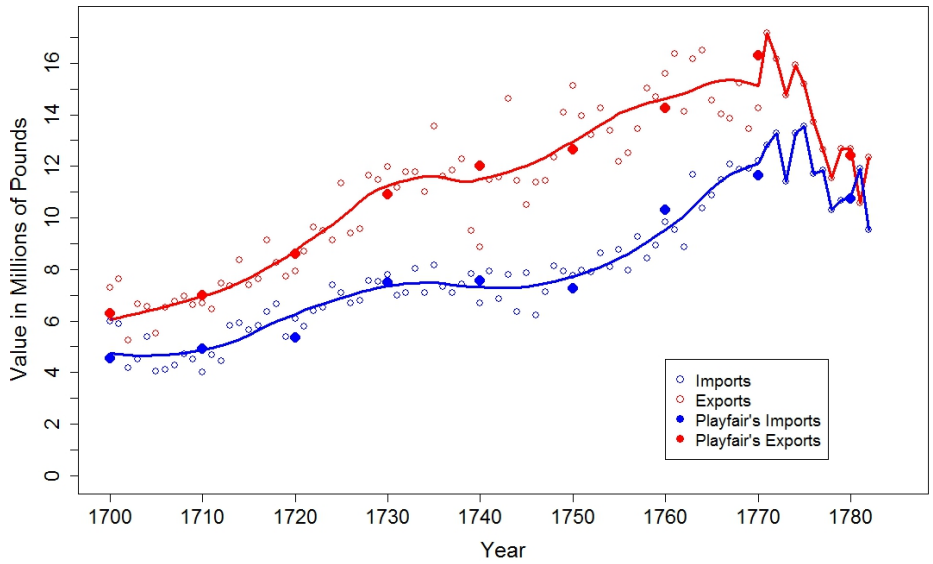


**Figure 2**. Total Exports and Imports for England 1700–1783, Original and Smoothed Data. Graph drawn using the R software by the author.

Ten years prior to the creation of Playfair's graph, Adam Smith in his *Wealth of Nations* [11] questioned the accuracy of the value of the goods in the Custom House records. This reminds us of the adage that a graph is only as good as the data going into it. If we make a reasonable assumption that the bias in the Custom House records is constant over time and between exports and imports, then Playfair's graph provides a good look at the trends over time, particularly the trend in the trade surplus.

It often happens that peace following war is accompanied by an economic depression. Such was the case in Britain at the end of the Napoleonic Wars in 1815. Some of the hardest hit were factory workers in the cotton mills in the north of England. As a result, there were calls to repeal the corn laws. These were tariffs imposed on the import of grain in order to support the income of the landowners, the upper class of English society. Since the French Revolution, Playfair had supported these landowners as the natural ruling class. He was afraid of the democracy that he had seen evolve in France. Thus he argued against repealing the corn laws and claimed that wages were rising with the price of bread.

Playfair supported his questionable claim with the graph in Figure 3, taken from [9]. Here he has smoothed the data by calculating 25-year averages for the price of a quantity of wheat in shillings. He then calculates the number of days' wages it would take a "good mechanic" to purchase this wheat, as shown by the green bars in the graph. The price of the wheat is given by dotted lines in each of the bars. When the dotted line for price is higher than the days' wages, he colours the difference as a red bar on top of a green one. The vertical axis in the graph stands for both the number of days' wages and the price of wheat in shillings. As can be seen from this graph, although the cost of wheat in shillings was generally increasing over the time period, the number of days' wages required to buy that wheat is decreasing. Consequently, Playfair would say, any criticism of the corn laws vanishes.

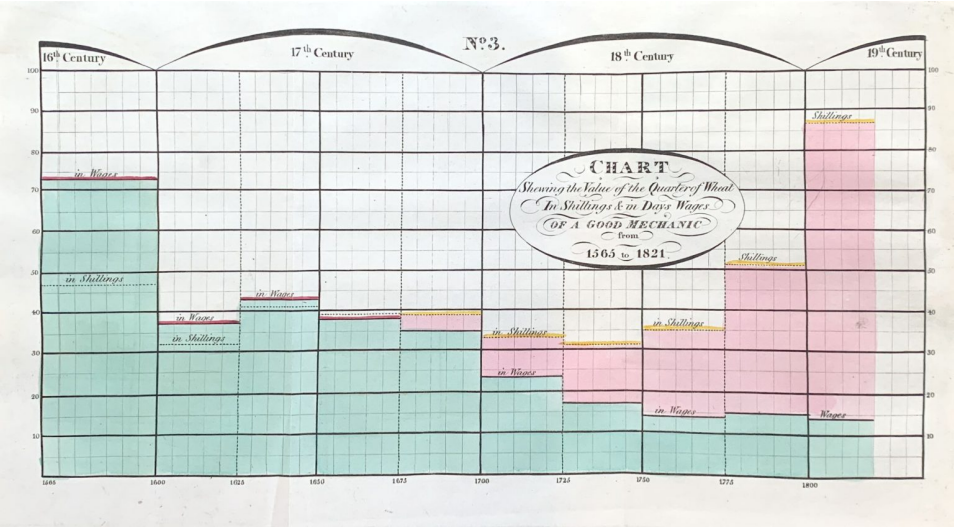


**Figure 3**. Cost of Wheat in Shillings and the Number of Days' Wages to Purchase the Wheat. Image courtesy of Stephen M. Stigler, Chicago.

The graph is pure propaganda designed to support the landowners. What Playfair meant by the phrase "good mechanic" was "artisan" or "skilled craftsman". Generally, wages for this group had in fact been rising. In that sense, the graph was accurate. But this group was quite different from the factory workers, whom Playfair had completely ignored. Their wages were on the decline and causing them hardship since the cost of bread, the workers' main food source, was rising substantially with the cost of wheat. This situation caused general unrest among the working class, making the government fearful of a revolution such as had occurred in France.

As mentioned earlier, Playfair invented the pie chart. An anticipation appears in his 1801 *Statistical Breviary* [7]. In terms of an actual pie chart, Playfair was not fully aware of what he had done at that point. His fully-fledged pie chart, which appeared in 1805 in his *Statistical Account of the United States of America* [10], is shown in Figure 4. In this book, Playfair claimed to have newly invented the pie chart. The graph shows the fractions of the whole taken up by various states and territories of the United States in 1805. One can easily see, compared to the existing states, the relative sizes of the Louisiana Purchase, the recently-acquired western territories and parts of Florida. However, if you look closely, Playfair made some errors. For instance, he mixed up New York and New Jersey. Further, the data he used were questionable. I compared the areas of various states given in the graph to a map of the United States from about 1805 [1]. The areas don't match up. Sitting in England with little money and possibly in prison, Playfair did not have the resources to obtain a U.S. gazetteer. Instead, he relied on a book, *Éléments de statistique* [2], that had been sent to him by its author, Denis-François Donnant. In addition to a translation into French of *Statistical Breviary*, the book contains a large amount of material on the United States. For each state, Donnant gives the length and breadth of the state. What Playfair did was to multiply the two measurements together to get a state's area, ignoring the fact that the states were not rectangular.

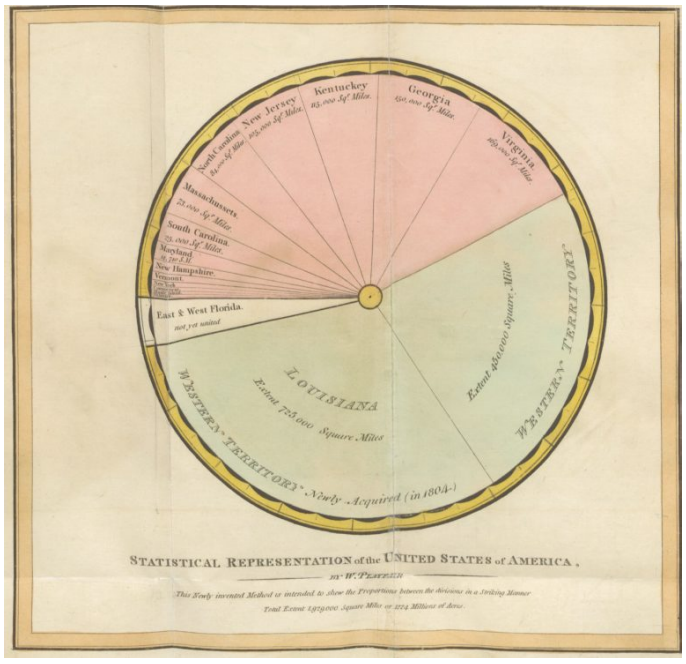

**Figure 4**. The Relative Sizes of the States and Territories of the United States.
Image courtesy of the British Library.

The pie chart is widely used and misused today. Its severest critic is Edward Tufte [14], one of the modern pioneers of data visualization. He wrote, "The only thing worse than a pie chart is several of them." In qualified support of pie charts, the eminent pedagogue of statistics David S. Moore suggests that they can be used to emphasize a group's relation to the whole [5]. Such is the case with Playfair's pie chart.

These are only three examples chosen from the dozens of graphs that Playfair produced during his lifetime, but they give a fair representation of the work he did. Over the past two hundred years, Playfair's work has sometimes been neglected or forgotten, corresponding to the ebb and flow of interest in statistical graphics. With the advent of new methods of data visualization via computers, interest in Playfair's work has picked up substantially. Reflecting this trend, in 2010 a copy of his *Commercial and Political Atlas* sold at Christie's auction house for $43,750 USD. Despite some of the shortcomings that I have mentioned, he laid a solid foundation for good graphical procedures.

*David Bellhouse is Professor Emeritus of Statistics at the University of Western Ontario. His historical research interests focus on the history of probability, statistics, and actuarial science through the 19th century. His publications include three books:* Abraham De Moivre: Setting the Stage for Classical Probability and Its Applications; Leases for Lives: The Emergence of Actuarial Science in Eighteenth-Century England; *and the forthcoming* The Flawed Genius of William Playfair: The Story of the Father of Statistical Graphics.

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