Introduction

Sometime in 1787, just two years before France was plunged into revolution and chaos, the Count of Vergennes delivered a package to the royal court of France for the attention of the king. The gift for Louis XVI had come to Vergennes from Lord Lansdowne, an English politician who was on intimate terms with many in the upper echelons of Parisian society. Vergennes was certain that Louis XVI would be very interested in the contents of the package.

The gift was a book written by a young Scottish engineer and entrepreneur who had recently moved to Paris with hopes of making his fortune. His book had been published in London during the previous year and was entitled *The Commercial and Political Atlas* but, unlike more conventional atlases in this era of great exploration, it contained no maps. It did contain charts, but of a new and unfamiliar variety. Louis XVI, an amateur of geography and the owner of many fine atlases, examined his acquisition with great interest. Although the charts were novel, Louis had no difficulty in grasping their purpose. Many years later, their author wrote that

> [the king] at once understood the charts and was highly pleased. He said they spoke all languages and were very clear and easily understood. (Playfair, 1822–3)

A further indication of the king's approval was the royal permit he granted for the establishment of a factory to work metals in Paris. Playfair had intended to use a steam engine to drive a rolling mill, modeled on the machinery and practices in the Birmingham factory

of Boulton & Watt, where he had worked from 1777 until 1781. In addition to his endorsement of the venture, Louis XVI donated the land.

The *Atlas* that had captured the king's imagination contained numerous tables and graphs that summarized trade between England and several other countries, as well as a variety of charts that displayed economic data. In total, the volume contained 44 charts. The king of France had grasped fully the significance and utility of the novel representations in the *Atlas*. Importantly, he had understood the universal appeal of the new diagrams. Of course, the use of tables to present economic data was not new, having been common for more than a century after John Graunt (1620–74), who had used them extensively in his *Natural and Political Observations Made upon the Bills of Mortality*, and Sir William Petty (1623–87), who had examined the role of the state in the economy in his *Treatise on Taxes and Contributions*. Coincidentally, both books were published in the same year, 1662. But the pictorial representation of statistical data was revolutionary. The *Atlas* showed, for the first time, how economic data could be represented by charts. The favorable assessment of the ill-fated Louis XVI – who was to perish under the guillotine less than six years later – was both fitting and prescient. A century and a half later, in 1937, the great American historian of statistics, H. G. Funkhouser, echoed the sentiment of the king when he said that "the graphic method is rapidly becoming a universal language."

Today there is scarcely a field of human activity that does not make use of statistical charts like those in the volume delivered to the king of France. The invention can lay fair claim to being one of the most versatile and useful tools for analyzing and displaying data in the sciences and humanities, in commerce and the arts, and in everyday activities that affect us all. Graphs convey comparative information in ways that no tables of numbers or written accounts ever could. Trends, differences, and associations are seen in the blink of an eye. The eye perceives instantly what the brain would take seconds or minutes to infer from a table of numbers, and this is what makes graphs so attractive to scientists, business persons, and many others. The charts allow the numbers to speak to all, and they transcend national boundaries – a Chinese can read the same graph that a Russian draws. There is no other form of human communication that more appropriately deserves the description "universal language."

WILLIAM PLAYFAIR

The author of the *Atlas* was no ivory-towered theoretician. William Playfair was trained as a practical engineer by giants of the Industrial Revolution. Although a craftsman by trade, he was also exposed to the best academic minds of the Scottish Enlightenment, which has so profoundly helped to shape our modern world (Broadie, 2003; Buchan, 2003; Herman, 2001). William was born on 22 September 1759, in the small rural village of Liff, near the city of Dundee. He was born a twin, the fourth child, in the family of the Reverend James Playfair, a Presbyterian minister of the Church of Scotland. Sadly, the twin brother, Charles, like too many other children in those days, did not survive to see his first birthday. In the early years, the Playfair children were educated at home by their father. However, upon the relatively early death of James Playfair, when William was just 12, the role of teacher was thrust upon the eldest brother John, then 24. John would soon gain worldwide fame as a mathematician, physicist, and geologist and would become one of the most distinguished professors at the University of Edinburgh. William Playfair was raised and educated in the presence of genius.

John's scientific approach was unequivocally empirical; one task that he gave his younger brother was to keep a graphical record of daily temperatures. Many years later William acknowledged this childhood exercise as the inspiration for his economic time series line chart. Additionally, and also significant for his intellectual development, John introduced William to many of the great figures of the Scottish Enlightenment, such as the philosopher Dugald Stewart and the economist Adam Smith. John also commended his brother to William and Robert Small, educators who were exceedingly well connected in the 18th-century world of letters, science, medicine, and politics. The Small brothers would play a crucial role in the future training of William Playfair.

The Rev. Robert Small and the Rev. James Playfair were well acquainted, being fellow ministers in nearby parishes in the Presbytery of the city of Dundee. Both had received their Doctor of Divinity degrees from St. Andrews University, the oldest in Scotland, and both were enthusiastic teachers; they had many interests in common. Robert's brother, Dr. William Small, was trained as a natural philosopher and physician at Marischal College, Aberdeen. In 1758 he joined the faculty of William and Mary College in Williamsburg, Virginia, where he served as a professor of mathematics and natural philosophy for six years. By Thomas

Jefferson's own admission, William Small was his most important mentor at William and Mary, and the pair maintained a close private friendship and correspondence through the difficult years surrounding the American Revolution. In his autobiography (1821), Jefferson wrote:

> It was my great good fortune, and what probably fixed the destinies of my life that Dr. Wm. Small of Scotland was then professor of Mathematics, a man profound in most of the useful branches of science, with a happy talent of communication, correct and gentlemanly manners, and an enlarged and liberal mind. He, most happily for me, became soon attached to me and made me his daily companion when not engaged in the school; and from his conversation I got my first views of the expansion of science and of the system of things in which we are placed. (4)

On his return to Britain, William Small became a founding member of the Lunar Society of Birmingham (Schofield, 1963; Uglow, 2002). In many ways, he was the central figure of the group, and his early death at 41 caused great distress to James Watt and the other members.

At the age of 14, William Playfair left the family home to apprentice with Andrew Meikle, a well-known Scottish engineer and the inventor of an early threshing machine. Meikle was miller and millwright to the Rennie family, owners of the Phantassie estate at East Linton, near Edinburgh. One of the Rennie boys, John, also worked at the Houston Mill under Andrew Meikle's instruction during the same years that William Playfair served his apprenticeship. John Rennie would later become the renowned engineer responsible for the London, Waterloo, and Southwark Bridges, as well as several other significant engineering structures. After three years with Meikle, William was recommended by Robert Small to the position of draftsman and assistant to James Watt, during the early days of the Birmingham steam engine factory.

James Watt (1736–1819) ranks among the most famous of all engineers. This consummate craftsman and scientist did not build the first steam engine, as is so often popularly supposed, but there is no doubt that his improvements converted a primitive, balky, awkward, and inefficient device into the workhorse of the Industrial Revolution. His development of the Newcomen engine was so successful that for all practical purposes we may say that Watt did "invent" the steam engine. His most important contribution, in 1765, was the separate condenser, which he included in his first patent of 1769. The work was largely completed at the University of Glasgow, but it was not until 1776 that the first practical

engine was built, and the construction of such engines did not become routine until the mid-1780s. Had it been left to Watt, a man subject to despondencies, his momentous ideas might never have come to full fruition and achieved great commercial success. The eventual success was based on Watt's collaboration, starting in 1774, with Matthew Boulton, who had established, in the Midlands city of Birmingham, an engineering factory called the Soho Manufactory that became world famous for its organization and novel equipment. It was William Small who introduced Boulton to Watt and who had encouraged the partnership that led to the development of the steam engine manufacturing company, Boulton & Watt, which was to revolutionize work throughout the world in the most fundamental way.

William Playfair arrived in Birmingham, England, in 1777. He worked in a variety of capacities at Boulton & Watt, but one of his most important duties was as draftsman and clerk to James Watt himself. Watt did not spend much time at the Soho Manufactory, preferring to work alone in his house at Harper's Hill. It was there that Playfair helped Watt with his engineering drawings, although Watt, who was always a demanding critic, did not have the highest opinion of Playfair's drafting skills, referring to him as a "blunderer" in a letter to Boulton in 1778. When it came to patent applications Watt prepared his own drawings, apparently because he was less than pleased with Playfair's efforts. Nonetheless, Playfair continued in this post until the autumn of 1781, so Watt cannot have been completely dissatisfied with his work. Indeed, Boulton indicated, in a letter to Watt, that he was sorry that Playfair was leaving, since Watt would no longer have his assistance in drafting. Blunderer or not, Playfair's experience in drafting and printing drawings for Watt would later serve him well when he turned his hand to writing.

During his time in Birmingham, Playfair became acquainted with several members of the Lunar Society. This distinguished group of businessmen and scientists included Boulton, Erasmus Darwin, Edgeworth, Keir, Priestley, Watt, and Wedgwood. The unusual name of the society derived from the meeting time of the group – they met monthly, from 1765 until 1813, on the Monday evening closest to the full moon so that there would be sufficient light for the late night walk home. The Lunar Society was second only to the Royal Society as an important meeting place for scientists and inventors. Its members were interested in more than pure science – they were passionately engaged in the application of new ideas in natural philosophy to manufacturing, mining, transportation, medicine, and education. The members of the Lunar Society were

the heart and soul of the Industrial Revolution, and they were convinced – with much justification – that they were changing the world for the better. Thus William Playfair was privileged to be at the cutting edge of science and industry in a Britain that was to dominate the world in the century following the Industrial Revolution – a revolution that was spawned in late 18th-century Birmingham. Playfair rubbed shoulders with the leading figures of the day in science, engineering, business, and politics, and they, unknowingly, helped to shape his statistical creations.

In 1779, while still at Boulton & Watt, Playfair married Mary Morris, and in 1780 their first child, John, was born. A draftsman's wages may not have seemed adequate to support the new family, and as soon as Playfair felt he had learned enough to strike out on his own, he left Boulton & Watt in 1781 with a fellow Soho employee, William Wilson, to form a silversmithing business in Marylebone, London. From the start, the new venture was plagued by disputation and bad debts. In a pattern to be repeated many times in the coming years, Playfair had embarked upon a speculative grand scheme that was doomed to failure. It seems that his reach always exceeded his grasp. Despite obtaining four patents for devices to fashion metal objects, from silver trays to horseshoes, the business was not successful and Playfair turned his hand to writing.

Playfair's developing interest in writing about economics was intensely practical. As Andrew Meikle's apprentice and James Watt's draftsman, Playfair had been a first-hand witness to the work of several great engineer-entrepreneurs, including not only Meikle and Watt, but also Matthew Boulton, John Rennie, Josiah Wedgwood, and James Keir. He had observed the development and success of Boulton's manufactory at Soho, the world's first factory to be organized and run in ways that we would recognize today. Playfair's first publication on economics appeared in 1785, but it contained no charts. A preliminary edition of the *Atlas*, with engraved charts, also appeared in 1785 – this was privately circulated to a select few for criticism. The *Commercial and Political Atlas* of 1786 was the first publicly available volume to contain charts, and it exhibits 43 variants of the time series line graph together with a solitary bar chart. Playfair issued a second edition, which was little changed, in 1787. Despite isolated critical approval, this foray into publishing made neither riches nor reputation for Playfair and he left England in 1787 to seek his fortune in Paris. British industry and commerce were leading the world, and Playfair believed that with his experience at Boulton & Watt he would be well placed to profit in a France striving to industrialize and catch up to her neighbor and traditional enemy.

Playfair planned to establish a rolling mill in Paris and, for the moment at least, it seemed that writing was to take a back seat to engineering. Although the plan was approved by Louis XVI himself, it appears that the venture never got off the ground because Playfair was soon involved in other speculative schemes. One ambitious project was the débacle subsequently known as the Scioto speculation. This was a complicated, fascinating, and murky business originating far beyond the borders of France, in postrevolutionary America, and although much has been documented by historians of early American corporations (Belote, 1907), many of the crucial details remain shrouded, including Playfair's precise role in the collapse of the scheme. At the end of the Revolutionary War, syndicates were formed to purchase large blocks of land and to sell individual tracts at an advanced price to European settlers. The American Scioto Land Company established a branch in Paris to peddle the idea to minor French aristocracy, many of whom were becoming increasingly uncomfortable in the rapidly changing political climate of 1788–9. Joel Barlow, the unilingual American representative of the Scioto Land Company in Paris, needed an English-speaking partner who was familiar with the language and local customs. Playfair fit the bill. Although large sums were subscribed and several hundred French citizens emigrated to the wilds of Ohio, the venture ultimately failed and Playfair was accused of hastening the collapse by embezzling funds. However, mismanagement on the part of Barlow and Playfair, coupled with the unpreparedness of the early settlers in a difficult environment, seem equally likely reasons for the failure. Scioto was not the only problematic speculation to occupy Playfair during his years in Paris; he was involved in other legal and financial entanglements and was forced to leave France shortly before the Terror of 1793.

He spent the years between 1793 and 1814 in London, with occasional excursions to the Continent. During this time, he published several books that included charts, the most notable being *Lineal Arithmetic* (1798), the *Statistical Breviary* (1801), and *An Inquiry into the Permanent Causes of the Decline and Fall of Powerful and Wealthy Nations* (1805). In 1809–11 he published the illustrated *British Family Antiquity Illustrative of the Origin and Progress of the Rank, Honours, and Personal Merit, of the Nobility of the United Kingdom*, which included chronological diagrams; hopes of substantial subscriptions from the aristocracy were evidently the motivation behind this mammoth nine-volume endeavor. In business, always seeking new ways of making money, he attempted to import some of the freewheeling financial schemes that he had used in Paris, but the

Bank of England was even less tolerant than the French authorities and Playfair narrowly escaped prosecution in 1797. He continued to write – his output numbering more than a hundred books and pamphlets – but without great monetary success. His many writings on economics include a critical edition (1805) of Adam Smith's *An Inquiry into the Nature and Causes of the Wealth of Nations*. Smith's admirers thought Playfair's additions and commentaries to be insufficiently respectful, and the edition was not well received. In general, his political views were expressed in typically brash and forthright fashion, and his candor did little to win him friends. He coedited a daily paper, the *Tomahawk*, and also a weekly, *Anticipation*, but both soon failed. He frequently fell back on his engineering training, working as a gun-carriage maker, and from time to time he supplemented his income by dubious means. One swindle led to conviction at the Court of King's Bench in 1805.

When the Bourbon monarchy was restored, Playfair returned briefly to France. In 1789, he had initially been in favor of the revolutionaries, but their later excesses forced a change of mind and his subsequent royalist views, which he was never shy to express, made him unwelcome during the years of the republic and empire. In 1814, after the accession of Louis XVIII, Playfair felt that he might, once again, seek better times in Paris. He was appointed editor of an English language newspaper, *Galignani's Messenger*, and he wrote a number of pieces on the state of France. He does not seem to have engaged in business affairs of any consequence, and he eventually fled the country after being convicted of libel. Once more, his reckless and outspoken opinions had constrained his options.

Playfair lacked money in his final years. Writing did not produce the anticipated income and, in worsening health, he lost his enthusiasm for the grand scheme. Although his two sons were independent by this date, life was not easy for a man who was supporting a wife and two daughters, one of whom was blind. In 1816, short of cash, he descended to attempted extortion when he tried to sell some papers alleged to relate to the great Douglas Cause of half a century earlier. Lasting seven years, the Cause had been the longest and most expensive legal proceeding in Scottish history. The documents that Playfair offered to Lord Douglas were relevant to the alleged imposture of newborn twins conducted in Paris many years previously. The papers were said by Playfair to have cast doubt, yet again, on the legitimacy of the Douglas inheritance. These papers almost certainly never existed; they were merely a prop in Playfair's plan to extort money from one of the richest men in Scotland. Because

of Douglas's resistance and Playfair's weak evidence, the blackmail did not succeed and indeed did not come to light until recently (Spence & Wainer, 1997). This shameful affair demonstrates Playfair's straitened financial situation and his readiness to ignore the law when it suited his purposes.

The last few years of Playfair's life saw a renewed interest in economics, and Playfair's final publications include some very fine charts (Playfair's two letters on agricultural distresses, 1821, 1822). These late works examined the difficulties experienced by English farmers in the early 19th century. Playfair died on 23 February 1823 in Covent Garden, likely in the house at No. 43 Bedford Street. He was survived by his wife and four of his children, one of whom, Andrew William, had emigrated to Canada where he was prominent in the military and successful in private business, eventually founding the town of Playfairville not far from the capital, Ottawa. Andrew William persuaded his older brother John to join him, and their descendants have prospered and spread throughout Canada.

During his life, despite the interest and approval of a select few, William Playfair's invention of statistical graphs went largely unacknowledged. Although he was a tireless advocate for his charts, he made few converts. His obituaries ignored the graphical inventions and concentrated on his political and economic writings, which were not held in high regard by his contemporaries, although they have attracted renewed interest today. One apologist wrote:

> Had Mr. Playfair cultivated his mechanical genius, there is no doubt, that he would not only have obtained considerable eminence, but have rendered no inconsiderable service to this country. Unhappily, however, for his own interests, he had the ambition to become an author. (Author unknown, *Edinburgh Annual Register*, 1823, 332)

18TH-CENTURY BARRIERS TO STATISTICAL CHARTS

Today, most people think that statistical graphs are such simple and obvious creations that almost anyone could have invented and published them. Indeed, it is their simplicity that accounts for much of their appeal, and that is why we give scarce thought to the ingenuity required to invent and promulgate statistical charts. Familiarity has dulled our appreciation of their significance, diminishing the importance of their creator, whose name until recently was largely unknown, even to professional

statisticians. But the idea of devising and publishing statistical graphs was not obvious two centuries ago and, even today, the form is not nearly so naive and self-evident as it might first appear (Cleveland, 1985; Tufte, 1983; Kosslyn, 1994; Spence & Lewandowsky, 1990; Wainer & Velleman, 2001; Wainer, 2000, 2005).

Large collections of economic statistics were widely available – and had been since the time of Graunt and Petty – more than a century before Playfair thought of publishing such data in pictorial form. The data necessary for the invention of statistical graphs were present in abundance, but no one else had the inspiration to represent them as pictures. There were various impediments to the publication of illustrations in serious writing. There were philosophical objections, concerns regarding accuracy and misrepresentation, and technical barriers to publication.

Plants have been portrayed in print since the introduction of the printing press in the 15th century. From early Renaissance herbals, through pictures of Baroque gardens, to increasingly naturalistic depictions of plants and flowers in the 17th and 18th centuries, printed illustrations of natural history had become fairly common and accepted. But there is ample evidence to suggest that similar illustration in serious scientific writing was viewed with suspicion, and eminent experimenters like Robert Hooke, who used illustration, did so with misgivings. About his *Micrographia* of 1665, which contained many illustrations, Hooke wrote that

> Pictures of things which only serve for ornament or Pleasure, or the Explication of such things as can better be describ'd by words is rather noxious than useful, and serves to divert and disturb the Mind, and sways it with a kind of Partiality or Respect. (64)

Hooke worried about the possibility of misrepresentation and took great pains to assure the reader of accuracy, or to point out possible distortions that the illustrations might produce in the reader's mind. Tilling (1975) has pointed out that in the 17th century information in charts produced by automatic graphical recording devices, such as weather clocks, was often translated into tabular form and that, with one exception in 1724, there was no publication of similar charts until the 19th century. Presumably no value was seen in graphical presentation or, more simply, the continuous graphical record was not regarded as being as trustworthy or informative as the corresponding sequence of numbers.

Biderman (1990) and Valois (2000) have argued that a mistrust of sense perception on the part of Descartes and his disciples was a powerful