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Timing History : The Introduction of Graphical Analysis in 19th century British Economics

Harro MAAS
Mary S. MORGAN

Abstract

The introduction of time-series graphs into British economics in the 19th century depended on the « timing » of history. This involved reconceptualizing history into events which were both comparable and measurable and standardized by time unit. Yet classical economists in Britain in the early 19th century viewed history as a set of heterogenous and complex events and statistical tables as giving unrelated facts. Both these attitudes had to be broken down before time-series graphs could be brought into use for revealing regularities in economic events by the century's end.

Key-words : Time Graphs – History of Statistics – Causation in History – 19th Century British Economics.

Résumé : *La partition de l'histoire : l'introduction de l'analyse graphique dans l'économie britannique du XIX^{ème} siècle*

L'introduction de graphiques temporels dans la pensée économique britannique du XIX^{ème} siècle a été permise par une nouvelle initialisation du temps historique, qui se présente désormais sous la forme d'événements comparables, mesurables, et standardisés. Pourtant, les économistes classiques anglais du début du XIX^{ème} siècle percevaient l'histoire de manière très différente, comme un ensemble d'événements hétérogènes et complexes, les statistiques présentant des faits non reliés entre eux. Ces deux idées ont dû être abandonnées pour que les graphiques temporels soient utilisés à la fin du siècle afin de mettre en évidence des régularités à l'œuvre dans les phénomènes économiques.

Mots-clés : *Graphiques temporels – Histoire de la statistique – Causalité en histoire – Pensée économique anglaise au XIX^{ème} siècle.*

Introduction

The second half of the nineteenth century saw the introduction of a wealth of new tools and instruments for the analysis of economic phenomena : the calculus, index-numbers, diagrams and graphs. Not all of these new tools were universally acclaimed by economists, but it can hardly be disputed that an economic text from, say, 1920 looks very different from a text of a century earlier. The aim of this paper is to examine the introduction of what is visually the most spectacular new tool – graphs – into British economics.

Early use of graphs to display economic data can be found at the end of the 18th century in Germany¹, and by William Playfair in Britain and France in the same period. But these remained exceptions, especially in Britain, for « Englishmen lost sight of William Playfair », to paraphrase one of the later pioneers of the use of graphs in economics, William Stanley Jevons. While graphs became regularly used in the natural sciences from the 1830s onwards, they were still looked upon with distrust by political economists and statisticians, and we see a real explosion of their use only after the 1880s. The Jubilee-issue of the *Journal of the Royal Statistical Society* (formerly the London Statistical Society) of 1885 contained substantive contributions on the graphical method, written by the British economist Alfred Marshall and the French statistician Émile Levasseur. In the *Palgrave* of 1894-1896, John Neville Keynes advocated its usage for inductive arguments in economics and A.W. Flux analysed certain examples. Bowley gave the method a central place in one of the first textbooks in statistical methods of 1901. With Jevons and Bowley, graphs came into their own both as a technique to reveal economic phenomena and as materials upon which to base explanations.

Why there was such a gap between Playfair's introduction of graphs into political economy and Jevons's full employment of such techniques has been something of a mystery². We suggest it has much to do with the attitudes of 19th century British economists in the classical tradition towards both history and statistics. On the one hand, for most of the century, British political economists held statistics in disdain, a disdain evident in their rejection of political arithmetic and so statistical data. In contrast they had a stronger regard for the particularity of events and for history. For political economists in the classical tradition, from Smith to Mill and beyond, economic actions and behaviour, and so their scientific explanation, were located in the motivations and propensities of individuals, understood by introspection and common sense reasoning followed by deduction. History figured as the canvas in which these actions were played out and so the time and space in which the laws of economics might, perhaps, be evidenced. But these laws would rarely be observed directly because of the many other contributing causes which melded together to produce particularity in each historical event. Statistical data on such events would thus reveal nothing but the particularities of history. And even if the laws were occasionally revealed, they would not give access to the motivations which underlay them. For example, Malthus's ideas about economic motivation could not be drawn

¹ Cf. NIKOLOW, 2001.

² This may have been part of a general reduction in the use of graphs in mid-century Britain, apart from work in tides, but we do not address this issue here. For a recent history of the development of graphs in the nineteenth century, cf. HANKINS, 1999.

out of a set of statistics, and his laws of population could not, he claimed, be seen in the history of a country because so many other factors were at work.

So, we argue, before graphs could reveal economic phenomena and feature in economic explanations, British economists had to rethink their position with regard to both history and statistics : specifically, historical *events* had to be repackaged as *data*. This change in understanding would have transgressed the traditional boundaries between the moral and natural sciences in the early part of the century, but became unproblematic by the end. A complicating factor is that in so far as time-series of social, or moral, realm data were considered by statisticians (as well as political economists), they too understood these data as the outcomes of complex historical events. These boundaries broke down during the century as economists strove for an apparently unified method of inquiry for the natural and the social sciences and as statisticians in Britain abandoned their self-imposed injunction merely to report facts and moved to using data to make explanations. In the process, multiple causes, which economists and statisticians had understood as *contributing causes* in the construction of particular historical events came to be seen as *disturbing causes* to be stripped away for explanatory power. This enabled more straightforward comparisons between economics and the natural sciences and was associated with a statistical analysis of graphic data. These last steps were only taken from Jevons onwards.

Thus the introduction of graphs can not be separated from debates on the « true » method of political economy that occurred in Britain throughout the 19th century. Their introduction involved not just a clarification of the role of statistics, but a reinterpretation of the nature of economic events in historical terms. We argue that this interpretative move involved two elements : the standardisation of historical events and what we call the « timing of history », a phrase we discuss in the first following section. We continue with the early rejection of political arithmetic as relevant to political economy by Dugald Stewart and we shortly contrast Stewart's views with William Playfair's early use of time-series graphs. Stewart's classification of the sciences sets the stage for the mid 19th century debates on the method of political economy, in particular between John Stuart Mill and William Whewell, and to the motivations that lay behind the formation of statistical societies in Britain in mid century. All ingredients are then in place to understand how the pioneer of the graphical method in political economy, William Stanley Jevons, initiated the use of graphs in his economic research. We then examine how the graphical method took hold in economics, turning in particular to Marshall's exposition of the graphical method at the Jubilee meeting of the Royal Statistical Society.

I – Timing history

To understand what we mean by the timing of history, first imagine a simple time-series graph picturing a century of data of corn-prices. Nowadays, such a graph functions unproblematically both as a graphic representation of evidence and as material for economic explanation. But, just as the Law of (individual) Errors had to be reinterpreted as a pattern of natural variation, and relabelled as the « normal

distribution », for it to function in biometric explanations³, so political economists had to understand a set of data in time not as representing a series of individual or particular historical events, but as showing a pattern of comparable economic activity through time, a pattern which could form the basis for economic explanations.

To suggest the full magnitude of what is involved in our claim that the introduction of graphs involved the « timing of history » and the standardisation of events, and thus to problematize what might now seem historically self-evident, let us look at the first time history was charted on a horizontal axis : Joseph Priestley's *Chart of Biography* (1765) (see figure 1).

Priestley rendered the life of famous historical persons by a « longer or shorter » horizontal line parallel to the horizontal axis to indicate the length of someone's life in a spatial representation. The possibility of this may seem obvious, but it is important to note that Priestley needed four pages of written text to convince his readers of the possibility of depicting the length of someone's life by a horizontal line⁴.

When making such a chart, Priestley omitted all concerns about the accomplishments of the lives imaged, and the only elements that remain are their age in terms of years, and the overlapping of their lives (a not inconsiderable aspect). When thinking about the historical importance of Mozart, or Schubert, for the development of music, we do not think about their age, but about their accomplishments. What does it serve our understanding of their greatness to picture their lives in the way Priestley suggests⁵? The reason they are historically important cannot be figured from the graph, only from other sources.

³ Cf. PORTER, 1986.

⁴ In his *Analysis of the Phenomena of the Human Mind* (1829) James Mill equally made a lengthy argument to convince the reader that time could be represented by a straight line, an argument that was extensively criticised much later by the French philosopher Bergson (1889), who distinguished between time as perceived in our memory (historical time) and natural, or physical, time.

⁵ Similarly, it is perhaps one of Marcel Proust's major tricks that at all stages of his *À la recherche du temps perdu* (note the title !) the age of Marcel is completely unspecified and impossible for the reader to figure out because the perspective change between the book's protagonist Marcel and the narrator, Marcel Proust, is completely fluid.

Priestley drew on a longer tradition of demarcation of historical time, in which BC time had been separated from AD time, and in which historical periods and centuries had been recognised. His chart was the first attempt to match historical time with equal chunks on the horizontal axis⁶, but it lacks that second critical element we associate with time-series graphs, namely a meaningful vertical axis upon which we can place our events and compare them in terms of relative magnitude and judge their relative importance. Thus, history is not imaged in the graph, only time. Priestley's chart took time for history. Our time-series graphs of the present day assume that life is already evaluated in standardised terms and numbered so that such a graph entails that we can rank a Livy over a Catullus or a Cicero over a Brutus (on the right hand side of Priestley's chart).

In order to make time-series graphs, history had to be thought of in terms of numerical data – information on events which could be considered similar enough for valid comparison and which were measurable so that their numbers could be plotted in a Cartesian grid – rather than understood as a series of particular events, always different and so incomparable. The introduction of graphs in social research is thus inextricably connected with the process of its quantification.

Graphs are also inextricably linked with changing ideas about strategies of explanation in social research. For as long as political economy was seen as a sub-branch of history, as it was in late 18th century Britain, it is not obvious that such graphs could be relevant for explanatory purposes. Historical explanations were concerned with events like the Napoleonic Wars (1800-1815), that is events that are complex and heterogeneous. There is nothing that indicates that such events in history have just the right format so that they can be divided into equal bits on the horizontal time-axis, as well as comparable bits on the vertical-axis, which – to be sure – assumes they are homogeneous in some respect.

The distinction between data and events, then, is related to the distinction between time and history in explanatory work. Time seems not the relevant factor when thinking about Napoleon's place in history. History is the narrative linking events like wars, their causes, outcomes, and how these involved and affected the motives for action of those involved. Each particular event is considered complex, and to be explained by striving for a complete rendering of all contributing causes that account for its internal complexity. At least this is how history was long seen and it brought Dugald Stewart, an important late 18th century commentator on such matters, to the distinction between facts of history and facts of nature. Time comes in when examining how distance, force and velocity relate to one another, not when examining historical events : that is for the interplay of institutions, people, their motives and actions.

⁶ And a successful one. Priestley's chart went through several reprints. The accompanying introductory text, explaining the possibility of depicting the length of someone's life by a horizontal line, disappeared after the first edition. The convention of a horizontal axis for time was not so well established even by the Jubilee volume of 1885 that Marshall could not argue, quite seriously, for a vertical time axis. We discuss this later.

II – Dugald Stewart : history and political economy as induction by reflection

At the turn of the eighteenth century the distinction between the sciences of nature and history, including political economy, was made most forcefully in Britain by the professor of moral philosophy at Edinburgh, Dugald Stewart. A student of the Scottish « Common Sense » philosopher Thomas Reid, Stewart was a pivotal figure in canonising the nineteenth century view of the Scottish Enlightenment's contribution to the sciences as mainly consisting in their invention of political economy and history, an image that is defended to this day⁷. For Stewart, political economy inextricably belonged to the science of history, indeed, it was its most advanced branch.

Stewart defended the distinction between the sciences of nature and of history in his *General View of the Progress of Metaphysical, Ethical, and Political Philosophy, Since the Revival of Letters in Europe*, of 1824⁸. Contrasting his views with earlier classifications of the sciences, by Bacon, Locke, and the famous one by d'Alembert in his foreword to the equally famous *Encyclopédie*, Stewart used the two « diametrically opposite » fields of « observation » and « reflection » to distinguish between the sciences of mind and of matter. Stewart emphasised that this division of the sciences did most justice to common sense usage : « the word *Physicks*, in particular, which, in our language, long and constant use has restricted to the phenomena of Matter, cannot fail to strike every ear as *anomalously*, and therefore *illogically*, applied, when extended to those of Thought and Consciousness »⁹. Stewart criticised Turgot who included « under the name of Physics... even History ». In contrast, Stewart noted approvingly, Descartes had « perceived the necessity, in studying the laws of Mind, of abstracting entirely from the analogies of Matter » (167).

History formed part of the sciences of the mind, as political economy did also by implication. In contrast with the natural sciences, history involved the constant use of memory. Its aim was « to treasure up particular facts » as opposed to the establishment of « general conclusions » (15). The « word History » should be understood « to comprehend all our knowledge of particular facts and particular events » (19). This did not mean there were no general laws governing these « particular events ». Indeed, Stewart singled out the work of political economists as having contributed much to their discovery. But these laws were found not by the way of the natural philosopher – by observation with the eye, but by the way of the philosopher of the mind – by internal reflection with the mind. Stewart gave the example of Adam Smith to elucidate how economists explain. Political economists appealed to « the maxims upon which men act in private life ». Thus, Smith « indulged in theory » by simply exposing the « common sense which guides

⁷ Cf. WOOD, 2000 for an overview and further references.

⁸ The first part of Stewart's essay was first published 1815, the second, in French, in 1821. The full essay, together with John Playfair's (the elder brother of William and professor of mathematics at Edinburgh) two essays on the progress of the mathematical and natural sciences, was first printed in 1824 as preliminary dissertation to the supplement of the 4th, and then 5th, and 6th editions of the *Encyclopaedia Britannica*.

⁹ STEWART, [1824] 1975, 26.

mankind in their private concern »¹⁰. A « particular event » was explained when it was shown how individuals acting on their motives and passions brought the event about.

Stewart equated this explanatory strategy with induction. The inductions of the political economists were not to be identified with the false inductions of the political arithmeticians, or « statistical collectors ». Stewart shared Adam Smith's low opinion of political arithmetic and transposed this to statistics. Statistics, in his view identical to the « collection of facts », gave only delusory information. « The facts accumulated by the statistical collector are merely *particular results*, which other men have seldom an opportunity of verifying or of disproving ; and which, to those who consider them in an insulated state, can never afford any important information »¹¹. Even when a fact was « accurately » observed and described by the statistician, it did not give us « the combination of circumstances whereby the effect is modified ». The « particular results » of the political arithmetician do not add up to something « important ». That is, statistical data are senseless units when searching for an explanation of historical events. They don't indicate motives for action. It were therefore wiser, in Stewart view, to have recourse to political economy as a check on the « extravagancies of political arithmetic », instead of the other way round¹².

III – William Playfair : mapping history in graphs

Stewart's criticism of political arithmetic shows that historical explanations in his view were only to be gathered from knowledge of all the contributing causes to an essentially complex event. To consider part of such an event, that is a « fact » in an « insulated state », as helpful for explanatory purposes was not even considered by Stewart, let alone to *construct* an event or phenomenon (e.g. a seasonal fluctuation) by connecting different insulated facts as it is typically done in a time-series graph. A graph typically does away with the presentation of a « particular result » in an « insulated state », but brings out the general course of these particular results. Stewart's criticism, then, seems ill-suited with regard to the power of graphs. It does show, however, that a transformation was needed in how to think about historical events before graphical means of representation could be brought to bear upon the subject. Instead of investigating all contributing causes to an observed complex event

¹⁰ STEWART, [1792] 1994, 2, 235.

¹¹ *Ibid.*, 331.

¹² *Ibid.*, 331-332. Stewart offered another intriguing reason to distrust statistical studies. In his eyes, these invariably offered the wrong policy advice. Where political economists rightly argued for the importance of free trade to improve the wealth of nations, statisticians « invariably encourag[ed] a predilection for restraints and checks, and all the other technical combinations of an antiquated and scholastic policy » (*Works*, 1994 3, 334). When statistical inquiry took off in Victorian England, this was, of course, no longer so. Indeed, Tooke and Newmarch, two of their more pronounced exponents highly welcomed the benefits of free-trade, which Newmarch compared in importance to the discovery of a new continent. Theodore PORTER (1986, 5-6) emphasises how statistics as the « calculus of nature » was embraced by nineteenth century liberalism. The relation of statistics to political economy seems to have been easier on the continent. On political economists and statisticians in Germany in the early 19th century, cf. NIKOLOV, 1999 and 2001. On the reception of statistics in France, cf. MÉNARD, 1980 and JOVANOVIĆ, 2002.

or to a sequence of separate events, historical explanation should be considered as dealing with comparable and recurring events in time.

It was in these terms that William Playfair, a contemporary of Stewart, explained his innovative use of graphs to display economic data. William Playfair designed an elaborate book of plates which he called the *Commercial and Political Atlas*. First edited in 1786, the work went through three extended and revised editions. Most of the plates concerned time-series graphs of the prices of corn, weekly wages, export surpluses or deficits.

Playfair got to his graphs from various sources. He credits extensively his much elder brother John Playfair, who after the untimely death of their father somewhat took his place in the family. According to William Playfair, his brother taught him that « whatever can be expressed in numbers, may be represented in lines »¹³. Between 1778 and 1781 he worked as a draughtsman for James Watt. In this period Watt used graphic devices to check the variation of water pressure in the steam engine¹⁴. He was also familiar with Priestley's historical schema shown above and he may well have meant Priestley's successful charts when he wrote that geometry « had long before been applied to chronology with great success », while he himself « was actually the first who applied [geometry] to matters of finance » (1796, iv). Playfair thus took insights from the humanities, mathematics, and engineering in constructing his charts, and also credited geography as we shall see.

In explaining the advantages of his charts, Playfair wrote persuasively about their role in comprehension, expression and memory :

- As the eye is the best judge of proportion, being more accurate and quicker than any other of our organs, it follows, that where-ever *relative quantities*, a gradual increase or decrease of any revenue, receipt or expenditure of money, or other value, are to be stated, this mode of representing it is peculiarly applicable, as it gives a simple, accurate, and permanent idea ; it produces form and shape to a number of separate ideas, which are otherwise abstract and unconnected ; for in a numerical table there are as many distinct ideas given, and to be remembered, as there are sums. The order and progression, therefore, of those sums, are also to be recollected by another effort of memory, while this [the chart] unites proportion, progression, and amount, all under one simple impression of vision, and consequently one act of memory (1796, v-vi).

- Memory does not serve as a storage of events, as it was considered by Dugald Stewart. Instead, it acts as an instrument of recognition, of insight in the « production » of a *new* event : the movement of a homogeneous entity, money, through time.

In the matter of the axes, Playfair's graphs made a critical innovation over that of Priestley by calibrating the vertical axis. Here we can be struck by the simplicity of his explanation, but we might be equally struck by the fact that Playfair had to give it at all : « This method has struck several persons as being fallacious, because geometrical measurement has not any relation to money or to time ; yet here it is made to represent both. » Imagine, Playfair argued, that each night a man makes a pile of the guineas he has made from trade that day, so that in one operation « time, proportion, and amount, would all be physically combined ». But still, this has to be

¹³ COSTIGAN-EAVES, MACDONALD-ROSS, 1990, quoting Playfair.

¹⁴ COSTIGAN-EAVES, MACDONALD-ROSS, 1990, 324.

shown, and here he looked to geography, which he took to be the obvious source for ideas on how to represent the wealth or trade of a nation state in spatial terms by the use of scales : « Lineal arithmetic then, it may be averred, is nothing more than those piles of guineas represented on paper, and on a small scale, in which an inch, perhaps, represents the thickness of five millions of guineas, as in geography it does the breadth of a river, or any other extent of country »¹⁵. Money, a homogeneous quantity, is taken as the obvious token for wealth, which is not obviously as homogeneous and quantitative. Money formed his vertical calibrations and allowed him to show relative amounts. Playfair's lineal arithmetic of graphs scaled economic life in monetary terms and in time units¹⁶.

But these decisions about scales were not straightforward. Perhaps Playfair's most famous graph, showing a rise of the price of wheat against a rise of the wage of a « good mechanic », was misleading in that it suggested the prices of wheat to have risen much faster than the weekly wage, while the argument Playfair made was just the opposite (see figure 2).

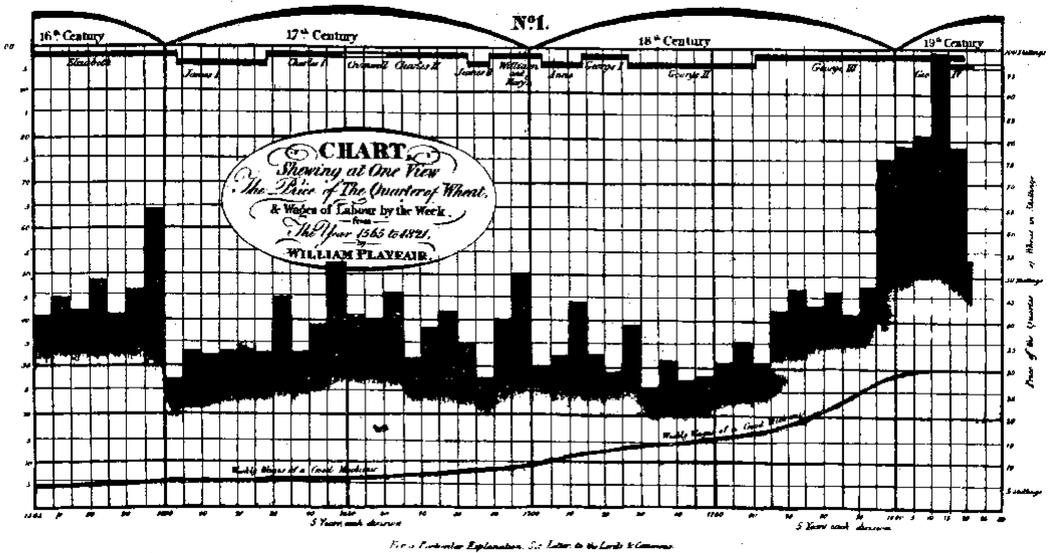


Figure 2. Diagram from William Playfair's Letter on Our Agricultural Distress (1821), showing the price of wheat (the vertical bars) and the weekly wage of a « good mechanic » (in the line beneath)

Work had to be done therefore to get at a meaningful comparison of different curves in the Cartesian grid. That is, the different time-series had to be made comparable so as to get at a meaningful result. The scaling of the vertical axis, as well as the manner of plotting the data, were matters of careful consideration, rather than something that flowed from the nature of the subject or had been established by conventions elsewhere.

¹⁵ All quotes, PLAYFAIR, 1796, vi-vii.

¹⁶ To take money as token for wealth was not obvious. His contemporary August Crome, for example, took population as the relevant scale for his « maps » measuring the « strength of states » (see NIKOLOV, 2001).

Recent accounts of Playfair's graphs have emphasised their convenience from a rhetorical and cognitive point of view. As will be clear from the above, these elements are also to be found in Playfair's original texts. He praised the usefulness of his graphs, but he also wrote that his graphs make statistics less « dry » and more « alluring » to the general public. Klein¹⁷ also notes Playfair's « complete mastery of the graph as an instrument of persuasion ». Nevertheless, it was clear to Playfair that to grasp the meaning of his graphs was easier for those acquainted with the spatial depiction of information. Thus, mathematicians and geographers would be far better able to read his graphs than those not educated in these subjects. Neither the rhetoric of graphs, nor their cognitive power was historically obvious nor conventional in the late 18th and early 19th centuries.

Facility in reading graphs thus spills over to another, and more important subject : how they function as aids in understanding. As Klein¹⁸ notes « Playfair asserted that his « mode of painting » could isolate and capture the essence of permanent causes ». He made an explicit statement in this direction with respect to the following graph depicting the revenue of France and England, and England's surplus revenue (see figure 3) where he wrote that « another observation to be made on the French revenue is, that its increase and that of England going so nearly alike, proves that some *common* cause operates on both » (1796, 12). Playfair did not specify how to think of this common cause, neither why it would be a cause in the first place. As elsewhere he pointed to where a cause might be operating, but not what such a cause might be. Yet, his remark makes clear that Playfair designed his graphs to do more than making statistics fashionable to the public. His graphs did not merely give a convenient representation of data facilitating understanding. They go from graphical representation to graphical investigation, but usually of a limited kind. Playfair's charts were designed to reveal how history lead through time to a particular historical event, rather than to reveal the laws of history.

¹⁷ KLEIN, 1995, 118.

¹⁸ KLEIN, 2001, 112.

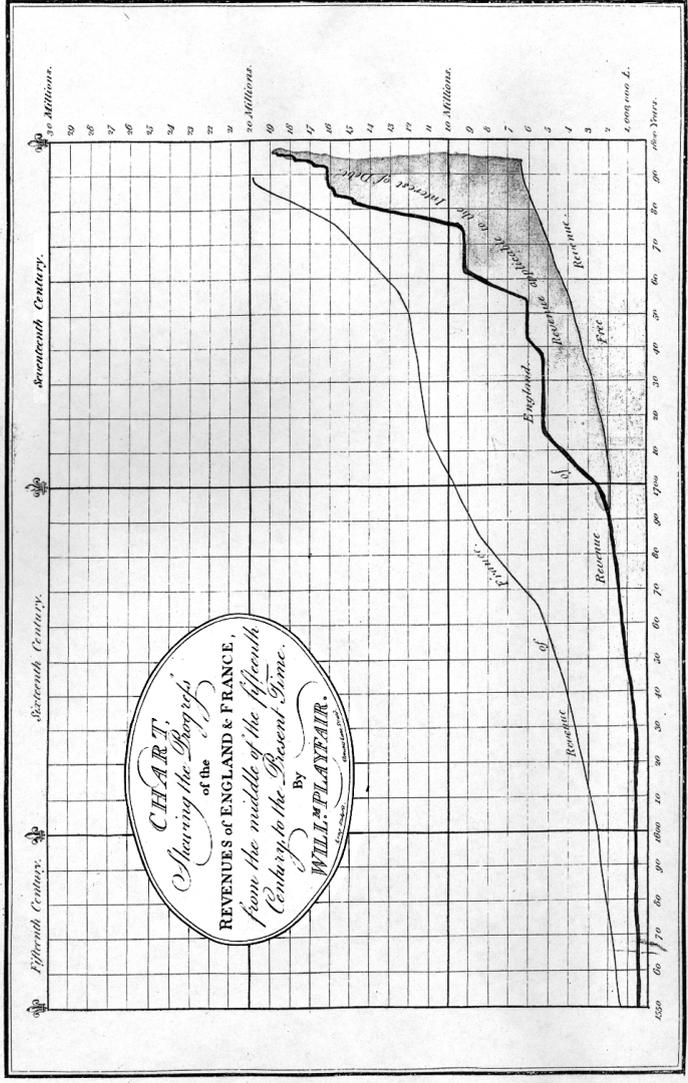


Plate I.

Figure 3. Diagram from William Playfair's *A Real Statement of the Finances and Resources of Great Britain (1796)*, showing the progress of the revenues of England and France from 1550-1795. Reading from the top, the diagram shows the revenue of France, the revenue of England, and the free revenue of England. The shaded area gives that part of England's revenue necessary for the payment of foreign debt.

Mapping history in graphs captured an underlying vision of what was to be explained and what served as an explanation that, we have seen, was not generally agreed upon at the time. At least as important for our history is that these were graphs of things already numbered, already measured, already in the form of what we now understand as statistical data, whereas for most events in history, as for most aspects of political economy, such events were not already numbered. At the time of Playfair and Stewart we do well to remember that statistics was the collection of facts about the nation state, but this by no means implied that such facts were numerically expressed, and thus available for political or lineal arithmetic.

IV – Mill versus Whewell on the method of political economy

Stewart's classification of the sciences was far more important for the development of thinking on the method of political economy in Britain than Playfair's spectacular *Atlas*. Stewart's position on the method of history, political economy, and statistics invited two fundamentally opposite reactions, both to be found in the first half of the nineteenth century in the persons of John Stuart Mill and William Whewell. Two of the towering persons of their age, whose respective opinions loom large over the British intellectual community in the nineteenth century, Mill and Whewell exhibit the split between theoretical and statistical investigations that is characteristic to the economics of their day.

In contrast with Stewart, Mill took great pains to point out that the route of reflection followed in the social or moral sciences, was, in fact, no other than the ordinary route of « observation and experiment » followed in the natural sciences. Mill's position was essentially a vindication of Ricardian economics. By limiting – it is well known – the science of political economy to the study of only three motives of which the effects on human actions could reasonably well be judged from every one's own experience, political economists were able to infer to tendencies which stood on the same footing as the laws of the natural sciences established by observation and controlled experiments. But even though these tendencies held with the same certainty as the laws of the « most demonstrative parts of physics »¹⁹, these tendencies could seldom be observed in practice.

For political economy Mill thus ingeniously resolved the problem of dealing with complex historical events that he had been struggling with for years by reducing them to three simple causes via the route of introspection. By reducing the number of causes, Mill hoped to safeguard the deductive method for the science of political economy²⁰. But for history, he refused to disentangle these complex historical events into more simple data, thus safeguarding their essentially complex nature. While Mill considered all other causes as *disturbing* causes in the case of political economy, these disturbing causes were considered as *contributing* causes in the case of historical events²¹. And, by distinguishing between the *science* and the *art* of political

¹⁹ MILL, [1836] 1967.

²⁰ On Mill's early struggles with history, see especially DE MARCHI, 2002 (forthcoming).

²¹ Mill's and Jevons's views on the notion of disturbing causes are best outlined in PEART, 1995. A recent account of the distinction between contributing and disturbing causes in relation to the different explanatory strategies of econometrics and mathematical economics is given in MORGAN, 2000, where she interprets these as modern versions, respectively, of Mill's historical and deductive methods in economics.

economy, Mill relegated to the wise judgement of the statesman the task of translating the simple tendency laws of political economy to their historical appearance. Hence, statistical data could give support to the truth of tendency laws, but they could never refute them ²².

One of the most prominent scientists of 19th century Britain to take issue with Mill's stance on the values of statistical inquiry was William Whewell. Whewell most strongly contested Mill's « hope of the efficacy of Deduction, rather than Induction, in promoting the future progress of Science » ²³. Even granting the somewhat different status of political economy, and the moral sciences in general, Whewell emphasised that political economy could not evade the tedious path followed by the natural sciences to become genuinely scientific : « many of the principles which regulate the material wealth of states, are obtained, if not exclusively, at least most clearly and securely, by induction from large surveys of facts » ²⁴.

In his *Philosophy of the Inductive Sciences* Whewell credited the « method of curves » with the potential to reveal a dependency relation between the data on two variables ²⁵. The kind of relationships he had in mind were those which could be understood in terms of a mathematical relation between the order of magnitudes of two things and their changes. The two examples he first discussed were the relationship between the tides and time and that between corn prices and time. In such cases, the graphic method was more helpful than tables of numbers for « order and regularity are more readily and clearly recognised, when thus exhibited to the eye in a picture, than they are when presented to the mind in any other manner » ²⁶. The graphic method enabled the scientist to detect simple laws by seeing the patterns relating quantities and their changes. The induction relied on the power of the eye :

« If, for example, we thus arrange as ordinates [along the vertical axis] the prices of corn in each year for a series of years, we shall see the order, rapidity, and amount of the increase and decrease of price, far more clearly than in any other manner. And if there were any recurrence of increase and decrease at stated intervals of years, we should in this manner perceive it... And these resemblances and contrasts, when discovered, are the images of laws of phenomena ; which are made manifest at once by this artifice, although the mind could not easily catch the indications of their existence, if they were not thus reflected to her in the clear mirror of space.

Thus when we have a series of good observations, and know the argument upon which their change of magnitude depends, the Method of Curves enables us to ascertain, almost at a glance, the law of change ; and by further attention, may be made to give us a formula with great accuracy » (397-398).

²² In *Logic* (1843), Mill proposed a science of history based on his proposed science of ethology. Mill clearly played with the idea of doing justice to all contributing causes of historical events, thus explaining, for example « national character », where such a notion in the case of the more limited *economic* behaviour of individuals and nations was considered irrelevant. Mill never really embarked on the project, however, even though his empirical studies in economics show a clear awareness of the influence of what he considered disturbing causes for the abstract science of economics in concrete cases. For an exposition of Mill's awareness, cf. HOLLANDER, PEART, 1999.

²³ WHEWELL, [1860] 1971, 282.

²⁴ *Ibid.*, 285.

²⁵ Whewell's *Philosophy of the Inductive Sciences* first appeared 1840. We have used a reprint of the 1847 edition.

²⁶ WHEWELL, [1847] 1967, 396.

Success with the method depends both on knowing the factor upon which our variable of interest depends and on there not being many laws which affect our variable at the same time. Whewell's explanation of the first of these difficulties is most instructive for our discussion of time and history, for he treats his examples of the tide and corn prices as equivalent, so we can understand his view of time in the former and use it to comment on the latter. First, time is not on the horizontal axis as a matter of convention, but as the variable upon which the vertically expressed element depends (or, in mathematicians' terms, the « argument ».) But what counts as time is not obvious. It is clear that the « stated intervals » of recurrences of « increase and decrease » will only come out once the proper time-unit is chosen. In the question of tides, Whewell is careful to point out that knowing the correct argument means knowing the correct form of time unit. Tides vary not with solar time but with lunar time, and only by using this correctly measured unit for the axis, will the first law of tides, the time of high water, be fully revealed. Other aspects of tidal variation depend on other time varying aspects of the moon's characteristics²⁷. He does not discuss different time units for his corn price example beyond the use of calendar years, but we can immediately make the link from his tide-moon discussion to the standard time unit regularities of economics (long term, cyclical, seasonal and so forth) which later became commonplace in graphic methods of time series for economic data.

In the tides, as in corn prices, time is not presented as the cause of variations, but time provides the measure upon which the variability depends and so whose correct choice enables the pattern of variation, and so the law(s) of nature to be revealed. There is no distinction here between mathematical dependency, scientific laws and laws in the social realm. In addition, correctly chosen time happens to be the realm for both examples, but these were considered to be no different in Whewell's treatment from a functional relationship between two non-time elements.

For Whewell, in clear contrast with Stewart, induction had nothing to do with internal reflection, and everything to do with external reflection, the reflection of observations made over time in « the clear mirror of space » of the graph. And, in contrast with Mill's views on political economy, it was not introspection, but observation and analysis of the observations with the same tools used by astronomers and other scientists, which gave rise to the discovery of laws and regularities. For this aim, statistics was indispensable, while statistics for Mill had been of only secondary concern. Explanations in political economy – in Mill's account – abstracted from the complex events of history by focussing on just three motives of action to make a deductively tractable branch of science. For Mill, the facts gathered by statisticians did not turn that field into the sort of inductive inquiry suggested by Playfair's graphs and explicitly advocated by Whewell.

²⁷ For a history of tidology, cf. CARTWRIGHT, 1999. Whewell made pathbreaking contributions to the construction of cotidal maps. Many of Whewell's phrases in tidology are still in use, like « age of the tide » and « luni-tidal interval ». Whewell read a paper on a mechanical graphical tide-recorder, constructed by T.G. Bunt to the Royal Society of London 1837. Cf. WHEWELL, 1838.

V – Jevons's stretching of statistics from tables of numbers to the graphical method of explanation

To search for causes had become, by mid-century, the monopoly of political economy, to search for facts, the monopoly of statistics. Jevons made it his lifelong task to combat this division of labour between political economy and statistics for he believed it had detrimental consequences for both sides. In line with Whewell's inductivist methodology, he aimed to install political economy on a « truly scientific » basis, using statistics for this purpose. But, at the time Jevons embarked on his statistical studies in economics, in the early 1860s, statistics was still concerned with fact gathering and, in economics, Mill's distinction between the *science* and *art* of political economy still reigned supreme.

In those times, in line with the goal and purpose formulated for the famous section F (that is the statistics and political economy section) of the BAAS (British Association for the Advancement of Science), and even more pointedly for the Statistical Society of London, statistical inquiry was restricted to data-gathering, preferably in tabular form. The logo of the Statistical Society (selected by Charles Babbage), a loosely bounded sheaf of wheat with the words *Aliis Exterendum* – to be threshed out by others, precisely expressed this aim. This limit to statistical inquiry did not conflict with the increasing need felt for statistical facts (as had been recognised by McCulloch in the early 1820s and, of course, by Thomas Tooke, see Hilts 1978).

Economists concerned at that time with the *art* of political economy treated individual statistical facts themselves as complex events that were in need of explanation. That is, a statistical fact – even when presented numerically – was itself a complex event that was occasioned by a multiplicity of causes. The common explanatory strategy was to trace all these causes and search for the main cause, or causes, a strategy that recently has been happily compared with Mill's so-called Method of Residues²⁸.

For economists practising the abstract *science* of political economy, Mill's deductive claims to certainty were considered invariantly true. In correspondence with Quetelet, Nassau Senior even went so far to claim that he did « not consider the truths of political economy » to depend on « Statistical facts »²⁹. John Elliot Cairnes's eloquently written lectures on the « character and logical method of political economy »³⁰ summarised the prevailing opinion on the relation of statistics to political economy that « for the ultimate truths of economic science we are independent of this inductive process, having the direct proof afforded by our own senses and consciousness »³¹. This « curious separation between abstract theory and empirical work »³² thus found general support among political economists of the day³³.

²⁸ HOOVER, DOWELL 2001.

²⁹ CULLEN, 1975, 84.

³⁰ CAIRNES, 1857.

³¹ *Ibid.*, 78.

³² BLAUG, 1976, 185.

³³ Even though debate has been recently opened up to what extent Mill subscribed to his own methodological views in his practical economic writing (HOLLANDER, PEART, 1999).

These demarcation disputes were anathema to Jevons who crossed both of these divides. In his 1870 opening address as president of Section F of the BAAS at Liverpool, Jevons strongly denied statistics was solely the collection of numerical data in tabular form, and he went on to argue that for a « scientific treatment », facts should be « analysed, arranged and explained by inductive or deductive processes », just as was done « in other branches of science »³⁴. Jevons was clearly stretching the meaning of statistics to include « deductive processes » here. But in stretching it in this direction, he also crossed the other divide, namely Mill's separation of the art and science of political economy, of history versus deduction.

One of these other methods of analysis and arrangement that Jevons was thinking of in his address was the use of graphs. Indeed, as Jevons later noted, once numerical variation was there, the « curvilinear method » was introduced³⁵. This method was « the natural complement » to the tabular method. Examples abound of the use of the graphic method in Jevons's published and unpublished work. His experiments on the exertion of muscular force, first published in *Nature*³⁶, and positively referred to in the *Theory* as well as the *Principles* are one example. More important for our story are those examples where Jevons's decisive step was that he no longer considered the individual data as themselves historical events, but as representing, when taken together, a functional or dependency relation between two things. Just as Whewell had explained in his *Philosophy of the Inductive Sciences*, the graphic method served not only to get at observations that were more true than the data themselves (by washing out errors of observation) but also to reveal the relations between things by making a connection between their observations.

His « explanation » of the King Davenant Price Quantity table of corn is a good example to elucidate the different explanatory strategies of Jevons and those who considered data themselves as representing complex historical events (see table 1).

Changes in	
Quantity of Corn	Price
1.0	1.0
0.9	1.3
0.8	1.8
0.7	2.6
0.6	3.8
0.5	5.5

Table 1. Jevons's rendering of the King Davenant price quantity table of corn

Jevons used this table in the *Theory of Political Economy* to construct a continuous relation between prices and shortages in supply. The choice of the example was not incidental. It was discussed in Whewell³⁷, Tooke's *History of*

³⁴ JEVONS, 1870, 309.

³⁵ In a commentary on a paper by William Guy on tabular analysis (JEVONS, 1879, 657). We owe this reference to Jevons's comments to Judy Klein.

³⁶ JEVONS, 1870.

³⁷ WHEWELL, 1830.

Prices³⁸ and Cairnes³⁹, among others, and played an important role in arguments at the time for and against the possibility of mathematising economics⁴⁰.

Cairnes's views were the most outspoken against mathematising economics. Cairnes compared the reaction of the demand for luxuries and necessities to supply shortages and was only willing to admit that prices would react differently in both cases. But those who attempted to « go beyond this general statement » and had attempted to derive an exact numerical relation between shortages of supply and price-rises in concrete cases, asked too much from their data « expressed in a tabulated form ». The « causes » and the « circumstances » being too diverse to place « reliance... on the accuracy of such calculations » and the « dispositions of people... can never, like the forces of physical nature, be brought within the limits of a formulated statement »⁴¹. The circumstances Cairnes referred to were all the other causes contributing to the observed changes in prices, and these obviated anything more than loose qualitative statements. According to Cairnes, an explanation in economics was reached once the « fact to be explained » had been traced back to the « ultimate axioms of Political Economy – that is to say, to the mental and physical principles from which its doctrines are derived »⁴². Cairnes clearly did not consider the form of the relation expressed by the ensemble of numbers in the table relevant to their explanation.

In contrast with Cairnes, functional form and relations were important for Jevons. He extensively discussed the use of the graphical method to establish functional relations in his *Principles of Science*⁴³ and it is more than likely that he made private use of this method to obtain an idea of the function that would be the best compromise between the data of the table and the theoretical notions he wanted the function to incorporate. Jevons's estimation of the relation between price and quantity changes of corn was :

$$p = \frac{5}{6\left(x - \frac{1}{8}\right)^2} \quad ^{44}$$

A different example of such a private use of the graphical method, possibly relating to price-quantity data, is reproduced below (figure 4).

³⁸ TOOKE, 1838.

³⁹ CAIRNES, 1857.

⁴⁰ Cf. CREEDY, 1986 for an overview, cf. also ALDRICH, 1987 ; WHITE, 1989 ; KIM, 1995.

⁴¹ CAIRNES, 1857, 86-88.

⁴² *Ibid.*, 91.

⁴³ JEVONS, [1874] 1958.

⁴⁴ STIGLER (1994) provides a definitive solution to the « puzzle » how Jevons estimated this equation. For an extensive analysis of Jevons's use of the King Davenant Price Quantity Table in relation to the *Theory of Political Economy*, cf. MAAS, 2001, 188-191.

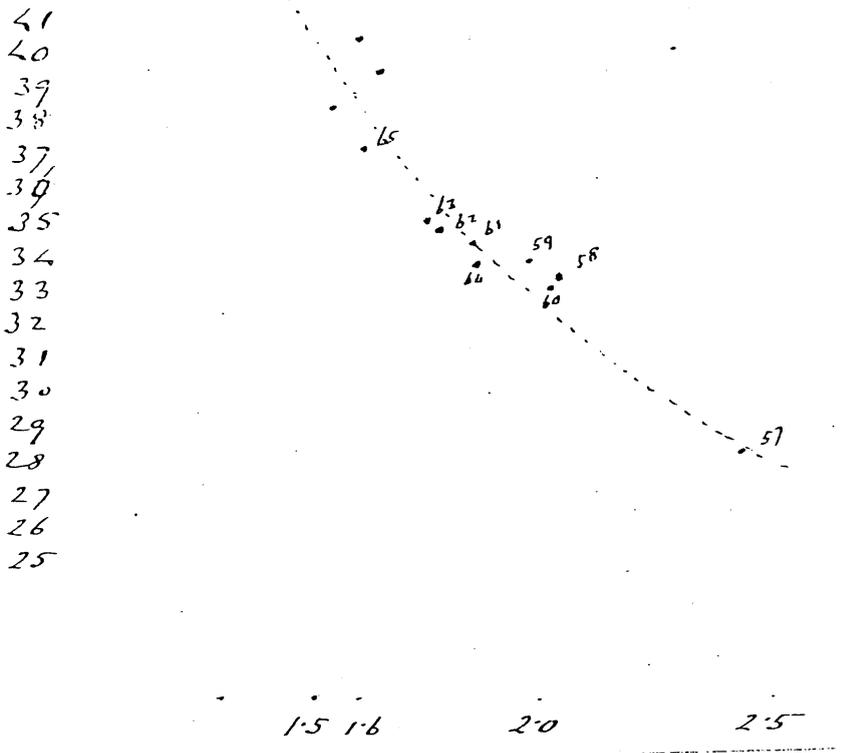


Figure 4. Jevons's drawing of an alleged price law graph. Jevons Archives, Manchester, JA 6/48/49. The vertical and horizontal axis most likely state quantities and prices respectively. Reproduced by courtesy of the Director and Librarian, the John Rylands University Library of Manchester.

By rendering the data of the King-Davenant price quantity table into mathematical form and into graphic form and calculating the functional relation, Jevons argued, numerical insight could be gained into how changes in prices and variations in supply were linked. Even though Jevons was fully aware of the many problems, he did not consider them prohibitive. Rather, the important point was to treat the separate pairs of observations as comparable and equally contributory – standardized inputs – for specifying one functional relation.

VI – Jevons's standardizing and timing of events

Already in the early 1860s, Jevons had advocated – without success – the use of time series graphs for economic analysis, as we know from his unfortunate attempt to interest William Newmarch in his so-called *Statistical Atlas* project, a comprehensive design of economic time-series diagrams to be used for analytical and policy

purposes. But in some of his most innovative statistical studies of the 1860s, graphs were only introduced later in the reprinted and extended versions of these works.

An example is his successful study of the Autumnal pressure in the money market, in which Jevons argued against explanations of the high withdrawals of coin from the Bank of England in October 1865 from a variety of accidentally contributing causes. By contrast, Jevons focussed on the « annual tide » in the money market. Seasonal variations had been an important theme for the explanation of economic fluctuations in Thomas Tooke's *History of Prices*. There were clear and important reasons, Jevons argued, to distinguish a regular and recurring drain in the money market from an « irregular » drain and consequent fall in the reserves of the Bank of England. In the first case the Bank could take appropriate measures admitting, for example, a lowering of reserves below normal, while the second case might be in need of another reaction. « It is a matter of skill and discretion to *allow for the normal changes*. It is the abnormal changes which are alone threatening or worthy of very much attention »⁴⁵.

Thinking in terms of an annual tide enabled Jevons to consider yearly variations as a sufficiently comparable event that repeats itself over the years. In line with this, Jevons averaged out quarterly variations over the period under consideration (1845-1861) to get at the normal pattern of seasonal variation. Jevons's discussion clearly reminds us of Whewell's emphasis on the possibility of discovering « laws of phenomena » from the « recurrence of increase and decrease at stated intervals of the year »⁴⁶ that we discussed earlier. Jevons concluded there was in fact nothing abnormal in the perceived extreme fall in money reserves in October 1865. Panic reactions to the phenomenon might be avoided by understanding its normal and regular occurrence and acting in accordance with this.

Jevons sought the explanation of the Autumnal drain in « a concurrence of causes » of which he mainly considered the wage payments in coin of landworkers through August and September, which, with a lag, affected the Bank of England. This, combined with regular payment of dividends, created the drain of coin. But he explicitly refrained from a « complete explanation of all these variations, pointing out how much is due to each particular cause », an explanation that « could only be found on a wide basis of statistics, which do not exist »⁴⁷. Instead, Jevons contented himself with pointing out the « precise character and amount of the fluctuation in order that we may rightly appreciate the degree of disturbance they [these causes] will usually occasion in the money market »⁴⁸. The emphasis in Jevons's study then was on comparability and regularity of events, rather than the explanation of all contributing causes.

In the original study Jevons stuck to the traditional way of presenting, namely in tabular form. It is only in the extended version that was printed in 1884 in *Investigations in Currency and Finance* that Jevons added graphs to « illustrate » the results of his tables and to suggest (rather than pursue) a further test of his original results by means of them (see figure 5).

⁴⁵ JEVONS, 1884, 181.

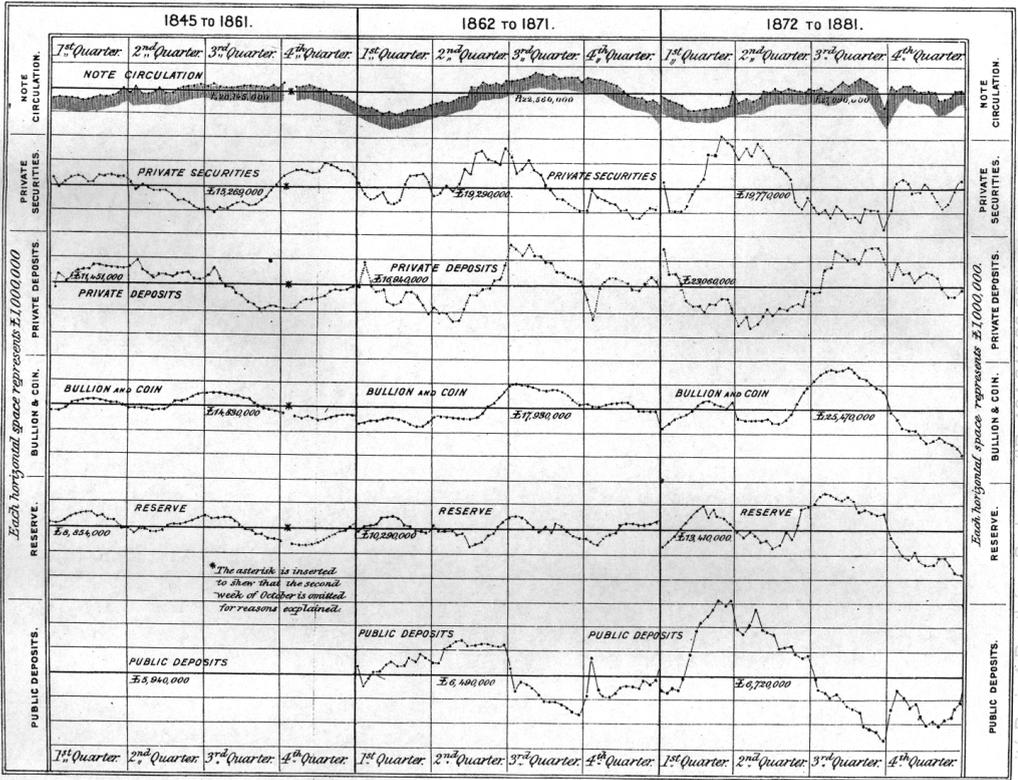
⁴⁶ WHEWELL, [1847] 1967, 397.

⁴⁷ JEVONS, 1884, 172.

⁴⁸ *Ibid.*

COMMERCIAL FLUCTUATIONS.

Divergence of the Bank of England Accounts from their Average condition after Elimination of the Quarterly Variation.



To face p. 173.

Figure 5. Jevons's diagram (reduced) showing the divergence of the accounts of the Bank of England from their average values after elimination of quarterly variations.

Reading from the top, the diagram shows notes in circulation, private securities, private deposits, bullion and coin, reserves, and public deposits respectively. From *On the Frequent Autumnal Pressure in the Money Market, and the Action of the Bank of England*, reprinted in *JEVONS (1884)*, between 192-193.

Graphs were more important to Jevons's arguments to two of his better known studies, the first his successful study in the fall of the value of gold, the second his highly unsuccessful studies into the relation between sunspots and commercial fluctuations. Comments on the gold-studies understandably have focussed on Jevons's innovative use of index-numbers to thresh out a causal relation between the Australian and Californian gold-discoveries and the depreciation of gold⁴⁹. In the study itself, as in his correspondence with Cairnes on this issue, Jevons used his graph as evidence that a causal relation between the discoveries and the value of gold could be found, thus arguing against those who considered that price-changes had to be explained by doing justice to all contributing causes⁵⁰.

⁴⁹ For a recent analysis of Jevons's approach to index-numbers in his goldstudy, cf. MAAS, 2001.

⁵⁰ JEVONS, 1884, 48, cf. also letter of 3 June 1863 to CAIRNES, in BLACK, KÖNEKAMP, 3, 22-23.

In his sunspot studies⁵¹, Jevons attempted to single out a dependency relation between the solar period and trade cycles in the manner suggested by Whewell by using the method of curves. Time was used as the ruler against which the two elements' relation would emerge. An example of his use of graphs to match the solar period with trade cycles can be found in his unpublished paper on the influence of the solar period on the economy, read to the Section F in 1875. Jevons started the paper with the observation that « it is a well-known principle of mechanics that the effects of a periodically varying cause are themselves periodic, and usually go through their phases in periods of time equal to those of the cause »⁵². It thus was a matter of prime importance to show that the time-unit of the solar period and that of commercial fluctuations matched each other close enough to infer to a causal relationship between sunspots and commercial fluctuations.

These trade cycle graphs, constructed to illustrate their periodic nature, met with great suspicion compared to the good reception given to those of his study of the autumnal pressure in the money market. In the latter case, a year presents itself as the natural unit to sort out seasonal variations, where seasons are to be found in the yearly cycle of the affairs of men and money. In the case of longer commercial fluctuations, Jevons sought to prove that the sunspot cycle was the natural unit for economic activity and thus to validate a certain periodicity in the trade cycle was to provide for a causal inference back to the sunspot cycle. In one example, Jevons reworked a graph from Milburn's *Oriental Commerce* by taking 3-year moving averages and making a log chart to make the « strongly-marked decennial variation [thought to characterise the sunspot cycle], (...) more apparent »⁵³. It is noteworthy that even a contemporary sympathiser in the analytical use of statistics, Anthony Beaujon (1853-1890), remarked that this was an example of « manipulation »⁵⁴. In another example, published in 1882, shortly before his death, Jevons made even stronger causal claims⁵⁵. He graphed the sunspot cycle (represented by Wolf's numbers) against commercial crises (represented by the prices of corn at Delhi). From this graph (shown here as figure 6), Jevons not only claimed support for the sunspot-commercial cycle « relation between cause and effect which [he] had inferred to exist »⁵⁶ but went on to infer the existence of a missing sunspot maximum in the years between 1790 and 1804⁵⁷ ! In this case, the choice of time-unit met with a suspicion that was not to be allayed compared to his study of the Autumnal pressure in the money market.

⁵¹ The sunspot studies have been much analysed – cf. particularly MORGAN, 1990 and PEART, 1996. Also MIROWSKI, 1984.

⁵² JEVONS, 1884, 194.

⁵³ *Ibid.*, 218. The date of publication of Milburn's treatise, 1813, in the same period as Playfair's work, may be noted.

⁵⁴ A margin marking on JEVONS (1884, 212), University of Amsterdam, Central Library, call mark 539 B 21. On Beaujon, cf. STAMHUIS, 1989.

⁵⁵ In 'The Solar-Commercial Cycle', published in *Nature*, 26, 226-228, 6 July 1882. This short article is reprinted in BLACK, KÖNEKAMP, 1972-1981, 7, 108-112.

⁵⁶ BLACK, KÖNEKAMP, 1972-1981, 7, 108.

⁵⁷ His inferences were supported by both a re-estimation of the sunspot cycle and the finding of a small maximum in sunspots around 1797.

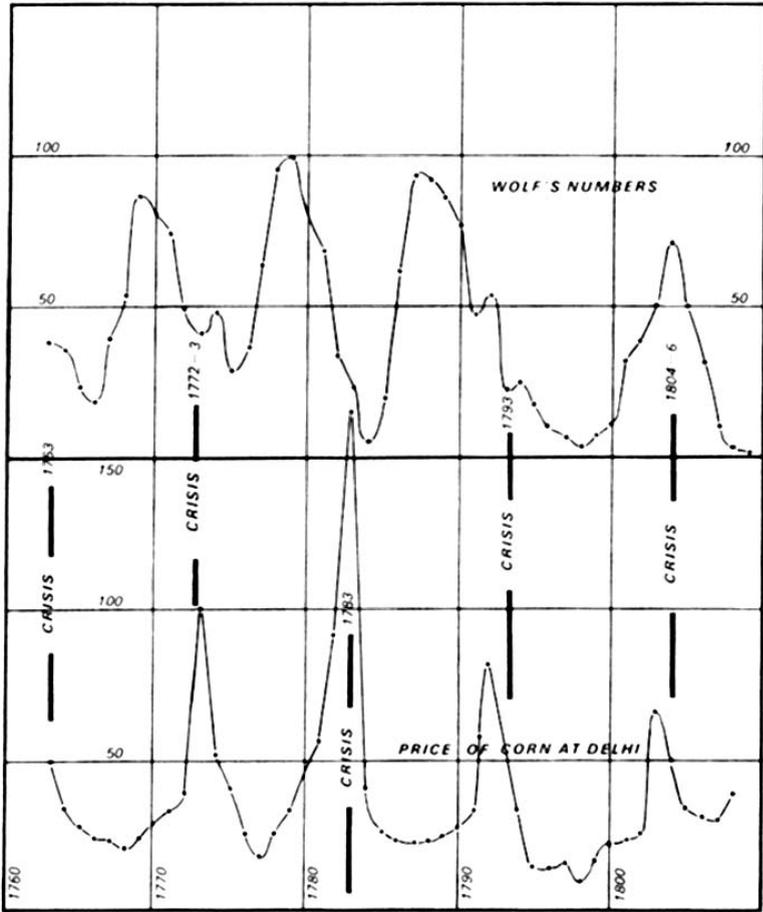


Figure 6. Jevons's diagram showing fluctuations in the sunspot-activity (represented by Wolf's numbers) and fluctuations in commercial activity (represented by the prices of corn at Delhi). Time is depicted on the horizontal axis. Jevons did not provide a description of what exactly is stated on the vertical axis. From *The Solar-Commercial Cycle* (1882). Reproduced in BLACK, KÖNEKAMP, 1972-1981, 7, 112

These examples show how the choice of the right time-unit became of prime importance in making causal inferences and how graphs could figure in this. Whereas the seasonality in the money market graphs gave conviction to the argument, Jevons's ingenious reasoning about the sunspots did not convince his contemporaries, though here the problem did not seem to reside in the use of graphs so much as in the details of the particular causal chain being discussed. Jevons's claim that there was an « [almost perfect] coincidence of commercial crises in Western Europe with high corn prices in Dehli »⁵⁸ was not considered a persuasive causal link, quite independently of whether sunspots influenced weather conditions in India or not.

⁵⁸ BLACK, KÖNEKAMP, 1972-1981, 7, 108.

VII – Time series graphs take hold in economics

We noted that in the early 1860s Jevons had started working on his so-called « statistical atlas » – a title most likely chosen to link with Playfair's *Commercial and Political Atlas*. But we noted that his attempts at that time to get William Newmarch, then editor of the *Statistical Journal* and president of the Statistical Society of London interested in the project turned out unsuccessful. From his diary we read that « Newmarch looked at my diagrams without interest and almost without a word, so I soon left him »⁵⁹. In a letter to his relative Richard Hutton, who helped him publish two of his diagrams at Jevons's cost, Jevons wrote : « My diagrams not only shew the minutest details given in the tables, but also supersede the taking of averages, since the eye or mind of itself notices the *general course* of a set of numbers »⁶⁰. It is well known that Jevons was extremely careful in plotting the data, and his choice of grid enables one to read the original figures with fair precision from the graphs, but, for Newmarch this virtue must have been a vice⁶¹. Why not state the data in their more precise numerical (tabular) form from the very start ? The more so, since Jevons based his graphs on the data collected by Tooke and Newmarch themselves.

For Newmarch, Jevons's colourful plottings were only suggestive of more than could be obtained in them, and therefore suspect. While statisticians like Newmarch focussed primarily on the explanation of the individual numbers in the tables, taking them as reporting heterogeneous historical events, Jevons by contrast took these data as homogeneous and so comparable. By the use of the method of curves, the graphic method, on these data, a series of like events through time would emerge, and so a general phenomenon – the trade cycle – could be constructed and perhaps reveal its economic laws.

Newmarch's lack of interest when Jevons entered the office with his enormous plates of statistics is consistent with the views of statisticians of mid-century but contrasts with the positive reception given to Marshall's proposal for a statistical atlas of even greater ambition, as reported at the Jubilee meeting of the Royal Statistical Society in 1885. By this time, and no doubt largely due to the important and persuasive work by Jevons in those intervening years, the graphic method had apparently become sufficiently firmly established to be the subject of two major papers by Marshall and Levasseur, reported in the Jubilee issue of the *Journal of the Royal Statistical Society*. Levasseur's paper was full of diagrams, charts, maps stereograms (3-dimensional drawings) and every kind of visual method of representing statistical data that you can think of. Strangely enough, there was very little on the type of graphic method as discussed here, namely time-series graphs. Marshall however made up for this.

In a complete reversal of the early 19th century views of political economists about history and statistics, Marshall argued that all the causes of historical events were best

⁵⁹ *Ibid.*, 1, 181, entry of 8. December 1861.

⁶⁰ *Ibid.*, 2, 450, letter to Richard Hutton, September 1, 1862.

⁶¹ Another aspect that might explain Newmarch's dismissive attitude is the comprehensive character of Jevons's undertaking. If Jevons showed Newmarch not only his plates, but also the general plan of the work, one can understand Newmarch's hesitations. Jevons planned encompassing graphs for all four branches that formed the basis of the Statistical Society. Imagine your own reaction to a student entering your office with similar plans in view !

observed and revealed through the use of statistics shown in graphic form. « Historical curves » as he termed time-series graphs were primarily useful for determining causes :

« We often speak of observing that certain causes produce a certain result. But what we really do is to observe that the result happened at a certain time and that the causes were in existence at that or some earlier time ; and then by a process of, perhaps unconscious, reasoning we infer that the result is rightly to be attributed to the causes in question... But history has not done its work unless it suggests not merely some, but all the causes, or at least all the chief causes which occurred at such a time that they may probably have as a part in bringing about the result »⁶².

Unlike Whewell, who worried about disentangling several different relations in his graphs according to their different time dependencies, Marshall's focus was on tracing the relevant historical causes operating through time. History was not the aim, causal explanation was.

It seems that Marshall took up Playfair's project to compare and connect graphs, for Marshall was confident that the analysis of causes could be done by using many graphs together. He argued for a book, or many books, on each page of which were charted a group of curves. Unlike Playfair's horizontal time, each page would have the same vertical time scale so that the eye could leaf through the pages and compare, with considerable ease, different subject matters for the same point in time. His choice of vertical time scale may well be explained by the fact that if Marshall was thinking of moving from statistical numbers in tables to showing the same information in charts, the natural transposition is to make time vertical⁶³ (remember that Whewell's choice for the vertical was based on mathematical conventions about where to put the dependent variable, leaving time, on which the variable of interest depended, on the horizontal). Certainly his claim, that reading and comparing their movements over many pages would be easier than in tables, makes sense, since we in any case read from left to right rather than vertically. Whatever the reason, his claim was that this would enable the scientist to see the timing of historical changes and reveal multiple causes.

The sheaf of corn – the Royal Statistical Society's logo – was used by Marshall as an analogy to buttress his argument in an unusual rhetorical flourish : a sheaf with only a few stalks is not very stable ; a sheaf with many stalks is soundly grounded. This implied not only lots of graphs for one country, but an international comparative project, for the Jubilee meeting was in part met to consider the work of the International Statistical Institute.

Marshall's use of the Society's logo differs however markedly from their original mid-century intentions. While the Society had considered individual statistical facts as being loosely held together in a wheatsheaf, Marshall's reference to the individual stalks was no longer to isolated numerical facts, but to isolated graphs. And, in fact, the logo itself had been changed over these years. The words *Aliis Exterendum* had been removed, the rope binding together the stalks had become tighter, and the wheatsheaf itself made a much less disorderly impression. Even in its logo, the Society's distinction between theorizing and data-collection no longer held. Marshall

⁶² MARSHALL, 1885, 252.

⁶³ We might interpret Clément Juglar's « table-graphs » of 1889 in the same light – as a « natural » move to turn tables into graphs. Cf. MORGAN, 1990, chapter 1, for an example.

understood his graphs to contain all the evidence for causal relations and historical explanations and his suggestion to bind these all together was an expression of a hope to get at encompassing explanations of economic events through time.

We can also trace some of the earlier approaches to history in Marshall's remarks however. While Jevons had somewhat easily side-stepped the problem of interfering causes that had motivated John Stuart Mill to his deductive approach to economics in the first place, Marshall's use of the Society's logo entailed a return to the idea of economic explanations in terms of contributing causes. But these causes were no longer to be gathered by way of introspection. They were to be derived from comparisons of the graphs. Thus the sort of historical events Marshall considered were constructed in the ways envisaged by Whewell and Jevons. Although for Marshall, events remained in some sense individual, they were comparable events constructed from homogenised data connected through time ; they were no longer heterogeneous independent events in history.

The particularity of certain key events was often noted on the graphs of the late 19th century, including some of those by Jevons. For example, major trade crises, wars and other big events were generally written over the relevant point of the graph. Such marking out of especial cases was not intended to suggest non-comparability of the reported data, but to denote an especially strong cause at work or a particular disturbing event, and thus to explain some local derangement of the regular patterns revealed in the data. These notations of particularity only disappeared with the development of more formal methods of analysis of the graphs. Here the critical figure in British political economy is Arthur Lyon Bowley, whose statistical textbook of 1901 laid out specific methods of analysis for time-series graphs.

Bowley's methods, and those of other statisticians working on socio-economic data around the turn of the century, were designed to disentangle both the various different time unit variations (Whewell's problem) *and* to identify the different causal connections between two or more graphed time-series (Marshall's problem). Marshall had toyed with a further problem – namely assessing the strength of these causes, but these only found answers with the development of statistical methods of correlation and regression (by the same turn of the century group of statisticians). This further development took the analysis away from the graphic sphere and their statistical processes of calculation effectively did more to erase history from economics in the 20th century than the development of times series graphs had done in the 19th century⁶⁴.

Conclusions : logical and historical time

Our account of the introduction of graphs into 19th century British economics argues that to depict historical time in a graph, historical time had to be preceded by the timing of history. That is to say that historical events had to be fundamentally reconceptualized before history could be graphed. This timing of history means at

⁶⁴ The construction of causal arguments from graphs in the late 19th century and the switch from graphs to correlation and regression in economics around the turn of the century are both treated in much greater depth in Morgan 1997 who also gives a full account of Bowley's work in these respects. Cf. also MORGAN, 1990, chapter 2.

least two things : the choice of historical events which are homogeneous and comparable (the vertical axis) and the choice of a relevant time-unit, so that history can be imaged through time (the horizontal axis). To understand that there is a choice of time-unit in economics requires an awareness of what the relevant time unit is that governs, or at least maps, economic activities of various kinds. To understand that there is a choice of comparable and homogeneous historical events requires rethinking both the nature of economic events and the treatment of their causes. Thus, the development from early 19th century political economy to late 19th century economics in Britain is marked by the change, for example, from historical descriptions outlining the complex and multiple causes of the wealth of the nation to the use of graphs of trade cycles to explain the monetary path of the economy through time. The usual problems and questions about such a graph : the problem of an unchanging definition of wealth, of the correct index for measuring income, and so forth, were not discussed in this paper. We did not go into such problems and questions, because they follow the steps that are usually taken for granted, namely that there was an unbroken continuity in how historical events were conceptualized in economics, as there is continuity assumed in what might count as an explanation for them.

It is precisely these steps which we have sought to problematize in this paper. As we have seen, early century political economics rejected statistics as being relevant to causal explanation and accepted history as being relevant for discussion of causes, but only in terms of a full-scale, case study, complexity. Late 19th century economists used time-series graphs involving statistics as the realm of explanation for historical and scientific events conceived as comparable and time dated. But, at a certain point in the mid 19th century, represented so cleanly in Whewell's work, scientific and historical events were both depicted in the same way in graphic representations and were both interpreted in terms of functional dependency. Out of this one kind of graph and dependency grew two different kinds of graphs : time-series graphs and causal dependency graphs. Time-series graphs take the time pattern to be important, whether the dependency be measured by the ordinary ruler of historical or calendar time, or some other time-unit ruler. Causal relation graphs abstract from time patterns and consequently the dependency between the graphed elements cuts free of the timing of history. In effect, our account shows how Judy Klein's « logical » and « historical » time were at one time linked in the graphic mode and, by suggesting how they separated, provides an historical rationale to Klein's recently argued analytical distinction ⁶⁵.

To image historical time in graphs, then, is to think differently about both the nature of historical events and about explanations in history and marks a change in British political economists' views towards history and statistics. History, in being timed and standardized, had its explanatory range within economics tamed ; statistics, when allowed to develop beyond tables of numbers, filled the explanatory void.

⁶⁵ Cf. KLEIN, 1995 and 1997. Logical time, if we read her correctly, is unrelated to the « real » course of time. We can move back and forward on a curve in logical time which violates the « irreversible paths of change in temporal processes ». Hence, logical time is ultimately related to « static analysis » in economics, and not to the plotting of actual or imaginary data changing over time. Historical time, by contrast, involves irreversible patterns of change, whether these relate to actual data or to mental abstractions « drawn to follow a path of a variable over time » (KLEIN, 1995, 98-99).

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