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PROMOTING STATISTICAL METHODS TO ENGINEERS AND ECONOMISTS: WALTER ANDREW SHEWHART AND STATISTICAL QUALITY CONTROL

BY JULIEN GRADOZ

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Promoting Statistical Methods to Engineers and Economists: Walter Andrew Shewhart and Statistical Quality Control

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<u>Abstract</u>. Walter Andrew Shewhart is regarded as the founder of Statistical Quality Control (SQC), an approach to production inspection based on the application of statistical theory. He developed SQC in the 1920s while working at Bell Telephone Laboratories. During this period, he was tasked with training Bell System engineers in SQC. Concurrently, he addressed broader audiences through numerous publications and lectures worldwide. In this context, he notably played an active role in the early activities of the Econometric Society, where he promoted SQC and, more broadly, the use of statistical methods among its members. This article examines how Shewhart envisioned the relationships between economists and engineers during the interwar period, his role as a promoter of statistical methods among both groups, and the reasons behind the Econometric Society's interest in him—a figure positioned at the intersection of mathematical statistics and production organization within one of the largest American firms of the era.

JEL codes. B23, C44, L15, M11

<u>Keywords</u>. Walter Andrew Shewhart, statistical quality control, economists, engineers, Econometric Society.

Walter Andrew Shewhart (1891-1967) is widely regarded as the founder of Statistical Quality Control (SQC), which has been defined as "the science and art of making the most economic use of material and human resources for the production of goods to satisfy human wants" (Mahalanobis 1948: 51). Originally trained in experimental physics, Shewhart pursued his career at the Bell Telephone Laboratories, the industrial laboratories in charge of R&D for the "Bell System" (Hoddeson 1980: 422). His main task at the beginning of his career was to rethink the Bell System's inspection method. It is in this context that he developed SQC, an approach to inspection that heavily relies on mathematical statistics, a discipline undergoing significant

development during this period. Given the effectiveness of the initial applications of SQC, Shewhart was tasked with training the Bell System's engineers in SQC during a period in which most engineers lacked knowledge of statistical methods. He was also encouraged by the Bell System to promote SQC more broadly and to further develop it, as it was the case for several of his colleagues with their respective research, such as Thornton Carle Fry with differential equations (1929). At that time, the Bell System was promoting the research produced within its laboratories, as evidenced by publications in "The Bell Telephone Laboratories Book Series" by the scientific publisher D. Van Nostrand Company and the creation of *The Bell System Technical Journal* in 1922. While Shewhart did publish in this book series and journal (1926; 1930; 1931), he more broadly contributed to a wide range of journals, addressing diverse audiences, held editorial responsibilities for several mathematical statistics journals, delivered numerous lectures in the United States and abroad, and contributed to the founding of several scholarly societies.

While Shewhart's work has received attention from historians of management thought and statistical thought (e.g., Bayart 2005; Best et Neuhauser 2006; Xie et Mukherjee 2017; Bradford et Miranti 2021), it has received little attention from historians of economic thought. A notable exception is Judy Klein (2000), who dedicated an article to how several economists and statisticians contributed to the implementation and deepening of SQC for the US government in the war industry during World War II. Klein briefly discusses Shewhart's contributions and highlights how this encounter with SQC during World War II influenced several developments in decision theory, statistical theory, and game theory after 1945.

In this article, we focus on the interwar period (more precisely between 1924 and 1939), during which Shewhart developed and actively promoted SQC. We shed light on Shewhart's close connections with several economists and statisticians who showed a keen interest in the emerging field of econometrics—a shared interest of Shewhart's. He notably participated in the activities of the Econometric Society during its early years of existence. He was one of the sixteen scholars who attended the founding meeting of the Econometric Society in 1930, alongside Ragnar Frisch, Charles Roos, and Harold Hotelling. He also published two articles in the first volume of *Econometrica* in 1933 and presented his work multiple times at the Econometric Society conferences. Thanks to the archives of the Indian Statistical Institute, we have access to the typescripts of his presentations, which have not been analyzed until now. These typescripts provide insight into the "supply side" of this story, that is, why Shewhart was involved in the activities of the Econometric Society. He notably explains that "the object of

the industry is to set up economic ways and means of satisfying human wants" (1931a: vii), which, in his view, requires an increased use of the "scientific method" in organizing production. According to him, engineers should draw upon "laws" from physics, biology, mechanics, or economics to organize production. However, Shewhart, who was actively involved in the scientific life of his time, knew that most of these disciplines were undergoing significant transformations, moving from a focus on "deterministic" to "statistical" laws. SQC itself adopts a statistical rather than deterministic approach to the problems it addresses. This is why it was necessary to train Bell System engineers in statistical methods, as they increasingly encountered statistical approaches when borrowing knowledge from various disciplines. At the time of the Econometric Society's creation, the statistical approach to economic problems was still in its infancy, and one of the Society's goals was precisely to develop this approach. More generally, the Econometric Society advocated for a more "scientific" approach to studying economic problems, seeking to align itself with the natural sciences (as mentioned in its constitution). Shewhart therefore became involved in the Econometric Society to encourage this initiative, hoping that economists would produce more (deterministic and statistical) economic laws that engineers could use in organizing production. Shewhart viewed economists as providers of knowledge for engineers and encouraged them to align with the engineers he had trained, namely to take a greater interest in statistical methods. Studying Shewhart's participation in the Econometric Society therefore sheds new light on how relationships between economists and engineers were conceived during the interwar period, which has recently been the subject of a significant literature in the history of economic thought (see the supplement to History of Political Economy edited by Pedro Garcia Duarte and Yann Giraud 2020). Regarding the "demand" side—that is, why the Econometric Society invited Shewhart to its founding meeting, invited him several times as a keynote speaker at its conferences, and commissioned him to publish in *Econometrica*—two main reasons can be identified. The first is that Shewhart was an important figure in mathematical statistics at that time, and the Econometric Society sought specifically to promote the study of economic problems using this type of approach. Gaining Shewhart's support was therefore essential for legitimizing the Econometric Society's initiative. In this sense, Shewhart belongs to the category of "Econometricians' Statisticians," as studied by John Aldrich (2010)-statisticians who supported the birth of econometrics and who were approached by the Econometric Society, although Shewhart himself is not covered by Aldrich. The second reason relates to the fact that the Econometric Society, in its early days, was highly interested in the business world. In fact, when examining the content of the early volumes of Econometrica or the titles of the

presentations at the Society's conferences, we notice the strong presence of contributions related to firms' organization. This can be explained by the fact that several key members of the Econometric Society's organizing committee at the time were involved, or had been involved, in the business world, such as Irving Fisher, Alfred Cowles III, or Charles Frederick Roos. It was also a period when the theory of the firm was experiencing renewed interest among economists, partly related to questions about imperfect competition. In this context, having the opportunity to interact with the inventor of SQC, a method that served as the basis for the reorganization of the production process at one of the largest American companies at the time, was of paramount interest to the Econometric Society. In this sense, Shewhart belongs to the category of businesspersons who supported the development of econometrics as studied by Thomas Stapleford (2017), although Shewhart himself is not covered by Stapleford. Studying the career of Shewhart and his promotion of statistical methods among engineers and economists during the interwar period therefore provides a better understanding of the context surrounding the creation and institutionalization of the Econometric Society, contributing to a growing body of literature on the subject (e.g., Bjerkholt 2017; Louro, Cruz-e-Silva, and Almeida 2024).

The first section revisits the development of SQC and presents its fundamental principles. It highlights Shewhart's role in promoting this method and more generally the use of statistical methods by engineers. The second section focuses on his article "The Rôle of Statistical Method in Economic Standardization" (1933a), the third article published in *Econometrica*. In this article, Shewhart argues that the establishment of production standards is fundamentally an economic problem, and that the best way to address it is by using statistical theory. Through this article, he generally invites economists, much like engineers, to adopt statistical methods, which will, in turn, benefit industries aiming to organize production in the most economical way to meet human wants. The third section examines Shewhart's involvement in the activities of the Econometric Society during its early years.

1 Statistical Quality Control and the Promotion of Statistical Methods to Engineers

Walter Andrew Shewhart was born in 1891 in Illinois. He studied physics at the University of Illinois at Urbana-Champaign and later at UC Berkeley, where he completed his Ph.D. in 1917 with a dissertation titled *A Study of the Accelerated Motion of Small Drops Through a Viscous*

Medium. In 1918, he joined the engineering department of the Western Electric Company. This department became Bell Telephone Laboratories in 1925, corresponding to the industrial laboratories in charge of the R&D for the "Bell System". He worked there until his retirement in 1956. His initial work involved designing soundproof headsets for aviators, which allowed him to become familiar with the issues related to the organization of production. From 1924 onwards, Shewhart was tasked with rethinking the inspection methods used by the Bell System. At that time, companies typically inspected every piece at the different stages of production, which was very costly. Other firms relied on the inspection of samples, notably when inspection involved destroying the product (Shewhart 1931b: 12). However, these samples were often not constructed according to a thorough understanding of statistical theory, and therefore failed to provide relevant insights about the entire production (Bayart 2006: 89). Drawing on his largely self-taught knowledge of statistical theory, which was often the case at the time (Deming, 1967: 49), Shewhart proposed SQC as an alternative approach to inspection.¹ SQC uses statistical theory to establish sampling plans at the different stages of production and interpret the sources of variations between samples. SQC notably allows the identification of variations that stem from "non-assignable" causes (considered as random variations) and those that stem from "assignable" causes (such as a machine defect).² To illustrate this idea, Shewhart uses an example from ballistics, also noted by Klein (2000: 31).

Suppose a person were to fire one hundred rounds at a target. We know what probably would happen—the individual would not hit the bull's-eye every time. Possibly some of the shots would fall within the first ring, others, within the second ring, and, in general, the shots would be distributed somewhat uniformly about the center of the target. We have a more or less definite picture of some of the possible reasons why the individual would not hit the bull's-eye every time, but we probably cannot assign the reasons or causes for his missing the bull's-eye in any particular instance—the causes of missing are non-assignable. Suppose, however, that the individual tended to shoot to

¹ While Shewhart is generally considered the inventor of SQC, Klein (2000: 30) mentions several scholars who developed similar ideas in the early 20th century. We can also mention the work of Malcolm Churchill Rorty (Stapleford 2020).

² "For example, random fluctuations in such factors as humidity, temperature, grade of raw material, and wear and tear on machines may introduce resultant differences between units in respect to any one characteristic. Similarly, physiological and psychological conditions of the personnel involved in the manufacturing, assembling, testing, and inspecting operations may furnish other causes which produce differences between the units. Thus, granting that it is impossible to eliminate all such causes, just as it is impossible to eliminate all causes of error in making a physical measurement, the manufacturer tries to eliminate those causes which produce irregular, cyclic, or secular trends in any one characteristic of the product just as in the physical laboratory the experimenter tries to eliminate such causes when making physical measurements" (Shewhart 1925: 1).

the right of the bull's-eye. Naturally we would conclude that there was some discoverable cause for this general tendency, e.g., we would feel that the observed effect could be assigned to some particular cause (Shewhart 1926: 593).

A uniform distribution of impacts around the center of a target would be considered as stemming from non-assignable causes, and therefore considered as random variations. In contrast, a distribution centered to the right of the target would be attributed to a problem with an assignable cause (such as a sight defect). A "controlled" product is defined as one "which does not vary from one period to another by more than an amount which may be accounted for by a system of chance or non-assignable causes producing variations independent of time" (*ibid.*). The target example was quite common. For instance, it appeared during the same period in the theory of price indexes (e.g., Mitchell 1921; Fisher 1922). It illustrates a basic principle of statistical theory, which is central to SQC. More generally, Leonard Henry Caleb Tippett (1967: 594), another key figure in SQC, argued that Shewhart's main contribution during his career was not the results he developed in mathematical statistics (1931c; 1931d; 1946), but rather the dissemination of key statistical principles among engineers. This was notably reflected in the numerous training sessions provided by Shewhart to engineers within the Bell System, with some of the materials available in the archives of the Indian Statistical Institute. His most famous book, Economic Control of Quality of Manufactured Product (1931a), is a compilation of the "Out-of-Hour Courses in Bell Telephone Laboratories" (1931a: vii). Reading this book provides insight into the efforts made by Shewhart to popularize statistical methods and make them accessible to engineers in the context of implementing SQC. Shewhart also created tools that facilitated the practical application of these methods at a time when most engineers had limited knowledge of them. This is notably the case with quality control charts, which are closely associated with Shewhart's name today.

The control chart was essentially the normal curve rotated at a right angle, allowing the abscissa to function as a timeline. Two parallel limit lines each set at three standard deviations (three-sigma) from the central arithmetic mean line, derived by averaging several years' data. This area encompassed 99.98 percent of the possible observations included under a normal curve. Because of the longitudinal nature of these values, Shewhart reasoned that they encompassed the population of items produced under conditions of statistical control. As such, their rates of error were thought to be random, resulting only from chance. Observations lying beyond the six-sigma boundary were presumed to deviate too much from the mean to satisfy conditions of control. These

latter outliers were, by definition, uncontrolled jobs having a high probability of embedding assignable causes of error. The outliers, however, contained useful information that could be studied to strengthen production processes (Bradford and Miranti 2021: 201).

In addition to providing a method for distinguishing assignable causes from non-assignable causes of variations, another important aspect of SQC is the use of statistical theory, notably sampling theory, to identify consumer expectations regarding the product. This allows producers to adjust the production process and inspection methods according to these expectations. For instance, if consumers cannot detect a variation ΔX of the size of a nail (or do not care about this variation), it is not necessary to invest resources in reducing the variability of the nail's length below this amount. Moreover, producers must consider that consumers' expectations may evolve, for instance, due to rising living standards, which can make consumers more demanding or sensitive to specific characteristics. Discovering consumers' expectations does not mean meeting them. In fact, it may be too costly or impossible. Therefore, producers face economic trade-offs: a trade-off between the cost of inspecting more pieces and the cost of recalling defective pieces, or between the cost of gaining a better understanding of consumers' expectations and the cost of offering a product that does not align with those expectations. SQC offers solutions to these trade-offs, grounded in statistical theory. The definition of SQC proposed in the introduction therefore becomes clearer: "the science and art of making the most economic use of material and human resources for the production of goods to satisfy human wants" (Mahalanobis 1948: 51). SQC is the application of a "science of economizing" (Klein 2000: 28) to the production process, grounded in statistical theory, and is therefore inseparable from economic reasoning.³ Shewhart's most famous book is titled Economic Control of Quality of Manufactured Product (1931a), which explicitly refers to this economic dimension. In the special issue of Industrial Quality Control dedicated to Shewhart upon his death, he is described as someone "whose pioneering efforts in joining the forces of

³ As Thomas Stapleford points out, it is no coincidence that the Bell System played a leading role in placing economic considerations at the center of production organization: "The strongest early overlaps between the practice of engineering and that of economics in the United States came in the late nineteenth century through large civil engineering projects that required engineers to think carefully about fixed costs, operating costs, and future revenues as part of their design decisions—indeed, in some cases as the crucial factors. Railways were the first example of what eventually would be called 'engineering economics' (Lesser 1969), but similar design problems existed in electrical power and new communications systems such as telegraphs and telephones: companies had to invest substantial capital into extensive technological systems that would be fixed in specific geographic locations. One critical component of those calculations involved market analysis: because these systems represented long-term investments that could not easily be relocated, companies faced intense pressure to identify both current and future demand for service in various areas" (2020: 62).

statistics, engineering, and economics opened the door to the science of statistical quality control" (IQC Editorial Board 1967: 69). Likewise, Judy Klein notes:

Shewhart considered his vision to be as much about economics as it was about statistics, and the main stimulus to SQC in the Bell system had been the need to reduce inspection costs (2000: 34).

Shewhart outlined the principles of SQC in numerous internal documents, communications, and publications. He notably published several articles in the Bell System Technical Journal, a journal in which only researchers of the Bell System could publish, and which served to promote the research done within the Bell System. Notable examples include "Quality Control Charts" (1926) and "Economic Quality Control of Manufactured Product" (1930), which summarizes the content of his book Economic Control of Quality of Manufactured Product (1931a). Another significant work is his book Statistical Method from the Viewpoint of Quality Control (1939), which compiles a series of lectures he delivered at the US Department of Agriculture (see Rutherford 2011), published with the assistance of William Edwards Deming, another key figure in SQC. In his writings, Shewhart urged engineers to become familiar with statistical methods. According to him, to organize production as efficiently as possible, engineers must draw upon "laws" from different disciplines, whether physics, chemistry, or mechanics. During the interwar period, these disciplines were increasingly adopting a statistical approach to the problems they studied, meaning that the laws they proposed were more and more "statistical" rather than "deterministic". This profound shift required engineers to develop greater competence in statistics, a goal to which Shewhart dedicated himself throughout his career, first within the Bell System, and later to broader audiences. As a matter of fact, beyond his writings, Shewhart actively promoted SQC, and more broadly, statistical theory, to diverse audiences, taking advantage of the great freedom granted by the Bell System, in a context of promoting the scientific work produced within the company (for more information on Bell System's scientific policy at that time, see Reich 2002). He delivered numerous lectures both in the United States and abroad, including a visit to the United Kingdom in 1932, three extended trips to India at the invitation of Prasanta Chandra Mahalanobis, and one visit to Japan (where William Edwards Deming, who considers Shewhart his mentor, would later have a considerable influence). Starting in 1943, he also co-edited the Wiley & Sons series on mathematical statistics with Samuel Stanley Wilks. Additionally, he served on various committees and contributed to the founding of several scholarly societies. He was a member of the American Society for Testing Materials, served as president of the American Statistical Association in

1945, and was twice president of the Institute of Mathematical Statistics, in 1937 and 1944. In 1948, the American Society for Quality Control, which he helped to establish, created the Shewhart Medal, of which he was the first recipient. Shewhart retired in 1956 and passed away in 1967.

Despite Shewhart's active promotion of SQC from the 1920s onwards, Mahalanobis (1948: 54) noted that its adoption was slow. This was partly due to the reluctance of inspectors in many firms, who viewed SQC as a threat to their jobs and salaries (Bradford and Miranti 2021: 202). It wasn't until World War II, with the associated war industry, that SQC became more widely implemented (Bayart 2005). Judy Klein (2000) dedicated an article to the role of SQC during World War II. She highlights how several economists and statisticians, including Harold Hotelling, Abraham Wald, and Milton Friedman, were approached by the US government to implement and deepen SQC in the war industry. She demonstrates that this experience influenced post-war economic and statistical theory, for example, through the development of optimal stopping theory (e.g., Wald 1947). However, Klein's article does not explore the familiarity of these economists and statisticians with SQC before World War II. For instance, Hotelling was well-acquainted with Shewhart's work as early as the 1930s, and they frequently interacted during the interwar period. Hotelling notably wrote a review of Shewhart's book, Economic Control of Quality of Manufactured Product (Hotelling 1932b). In 1938, both Hotelling and Shewhart joined the editorial board of the Annals of Mathematical Statistics, where they met regularly (Stigler 1996). Hotelling's correspondence also highlights their closeness and the respect Hotelling had for Shewhart.⁴ For instance, in a letter dated January 23, 1931, responding to Frederick Cecil Mills's proposal to join Columbia University, Hotelling suggests consulting Shewhart to assess the value of his work in statistics.⁵ Similarly, in a letter to Burton Howard Camp dated March 13, 1937, he strongly recommends Shewhart as a keynote speaker for a conference.⁶ As we will highlight in the third section, Hotelling and Shewhart also frequently interacted within the Econometric Society during the interwar period. Focusing on this period therefore enriches the analysis proposed by Klein, showing that most of these economists and statisticians took an early interest in Shewhart's work at the Bell System.

⁴ This correspondence was made available to us by Marion Gaspard, Antoine Missemer, and Thomas Mueller, to whom we extend our warmest thanks. Marion Gaspard and Antoine Missemer were able to digitize part of Hotelling's archives thanks to funding from ESHET for the project "Bifurcations in Natural Resource Economics." ⁵ Hotelling Papers, Box #1, Folder 'Mills, Frederick C.', Rare Book and Manuscript Library, Columbia University. Digitised version by Marion Gaspard & Antoine Missemer, June 2017.

⁶ *Ibid.*, Folder 'Camp, Burton H.'

2 Promoting Statistical Methods to Economists: The Case of Standardization

According to Shewhart, among the disciplines from which engineers must draw "laws" to organize production, economics is one of them. As a matter of fact, if "the object of the industry is to set up economic ways and means of satisfying human wants" (Shewhart 1931a: vii), economics has a central role to play⁷. However, Shewhart believed that economics was lagging behind physics or chemistry in its use of statistical methods, and he therefore encouraged economists to adopt them, as he did with engineers. To this end, he notably published two articles in the first volume of Econometrica in 1933. The first article, titled "The Rôle of Statistical Method in Economic Standardization" (1933a), was the third article published in the journal (after an article by Joseph Aloïs Schumpeter and an article by René François Joseph Roy). The second article, titled "Annual Survey of Statistical Technique Developments in Sampling Theory" (1933b), appeared in the third issue. This article was part of a series commissioned by the editors, providing a literature review on topics of interest to readers of the journal.8 It focuses on recent developments in sampling theory, a field Shewhart was wellversed in due to its close links with SQC. We focus on the first article, in which Shewhart argues that the establishment of production standards is fundamentally an economic problem, and that the best way to address it is by using statistical methods. Through this article, he generally invites economists to adopt statistical methods, which will, in turn, benefit industries aiming to organize production in the most economical way to meet human wants.

This is a short article (thirteen pages). Shewhart presents it as an abridged version of a lecture given at the University of London in May 1932. He was invited to this university by Egon Sharpe Pearson, son of the British statistician Karl Pearson, to deliver a series of lectures to statisticians and industry representatives (Pearson 1936). Tippett (1967: 593) judges that Shewhart's visit had a considerable impact on British industrial policy, as it highlighted the importance of considering standardization seriously (see also Klein 2000: 35). Similarly, in a letter dated June 24, 1954, British statistician Ronald Aylmer Fisher, then president of the Royal Statistical Society, informed Shewhart of his election as an honorary member, emphasizing: "I

⁷ Amy Sue Bix (2020) details the gradual introduction of economics and management courses into engineering curricula starting in the 1930s, which, according to her, notably influenced the writing of Paul Anthony Samuelson's textbook *Economics* (1948).

⁸ Other articles in the series include for instance one by Alvin Harvey Hansen and Herbert Tout (1933) on business cycle theory or one by Jakob Marschak (1933) on statistical information.

hope you will take this election as a tribute to the esteem in which your work is held in this country."⁹ At the third conference of the Econometric Society in January 1932 in New Orleans, Shewhart gave a presentation titled "Economic Standards of Quality." Thanks to the archives of the Indian Statistical Institute, the typescript of this presentation is available (Shewhart 1931b). We will also use this typescript as a complement to the article to clarify several aspects of this article and highlight several differences.

Shewhart begins his article by noting that "standards" aim to determine when two things can be considered the same. According to him, two approaches to this problem can be distinguished. First, two things can be considered the same when there is an agreement that they are perfectly substitutable in terms of their uses. A vacuum cleaner can therefore be considered the same as a broom, despite their differing characteristics, if the standard is based on the ability to pick up dust. Second, two things can be considered the same when there is an agreement on the measurements to be applied to them, these measurements are taken, and the results are compared against agreed-upon tolerances. Shewhart uses the following example. Consider nitems, with actual lengths $(X'_1, ..., X'_n)$. The measured lengths are $(X_1, ..., X_n)$. By defining a "standard length" and agreeing on a tolerated deviation, one can determine if these n items meet the "standard length" and can be considered the same according to the standard, provided that the standard pertains solely to length. As Shewhart emphasizes, the actual lengths $(X'_1, ..., X'_n)$ are necessarily unknown, so it is impossible to assert that n items are of the same length. One can only infer this based on (X_1, \dots, X_n) , within a given metrological convention and under an agreement on the tolerated deviations between measurements. To put it differently, we cannot assert that two things are the same, only that they are considered the same.

After defining standards, Shewhart defines standards of quality as "standards by which the consumer may judge the quality of a product, and which in themselves represent the goal of the producer" (1933a: 23). This definition is not clear, because it is not accompanied by a definition of "quality." However, an analysis of the various occurrences of the word "quality" in his article allows us to define this term. After the presentation of the example of length, Shewhart emphasizes:

This example shows that we cannot expect the specification of a standard to outline a way of determining whether or not a thing *is* of standard quality. This is true even when

⁹ The letter can be found here:

https://digital.library.adelaide.edu.au/dspace/handle/2440/67997?mode=full.

what we mean by quality is limited to a few measurable characteristics, for we always have to allow for errors of observation. To the question, *Is* a given thing of standard quality? there can be no positive answer, yes or no (1933a: 25).

By suggesting that quality can be reduced to a few measurable characteristics, Shewhart refers to quality as a set of product characteristics. This idea is reinforced by the fact that Shewhart repeatedly mentions "quality characteristics," that is, the characteristics included in quality. Shewhart is much more explicit in his typescript, where he defines the quality of a thing as "those characteristics which make it what it is" (Shewhart 1931b). He is even more explicit in an earlier article, where he writes: "Quality is some function of those characteristics *X*, *Y*, *Z*, required to define a thing" (Shewhart 1926: 593). For instance, quality can correspond to the set (*length, width, height*). By measuring these three characteristics, one obtains a "measured quality," which is not the real quality, as demonstrated with the example of length. A product is considered to be of "standard quality" when its measured characteristics fall within the ranges (*standard length* +/- *tolerated deviation, standard width* +/- *tolerated deviation, standard* that specifies the ranges within which the measured characteristics defining quality must fall for a thing to be considered of "standard quality." Two questions arise: 1) how are the characteristics defining "quality" selected? 2) how are the tolerated deviations defined?

To answer these two questions, Shewhart employs SQC, which corresponds to the other occurrences of the word "quality" in his article. A large portion of his article is then devoted to presenting the principles of SQC to a non-specialist audience. Regarding the first question, SQC suggests establishing a sampling plan of consumers to identify their expectations of the product, although Shewhart is not explicit about the methods for constructing this sampling plan. The characteristics defining quality therefore correspond to those that matter to consumers. As he writes: "In the last analysis, the consumer is interested in the wantableness of the quality of a thing [...] This constitutes a goal for the action of the producer" (Shewhart 1936a: 2). Part of the answer to the second question also involves establishing a sampling plan of consumers. Shewhart emphasizes, "in determining sizes and tolerated deviations, one of the statistical factors of interest is the distribution of the minimum detectable increment ΔX in a given characteristic for a homogeneous group of people" (1933a: 30). As a matter of fact, it is important to know whether consumers can distinguish between nails of two different lengths in order to determine the tolerated deviations in the standard of quality for nails. This is why

quality of a product, and which in themselves represent the goal of the producer." Standards that focus on characteristics that do not matter to consumers would not allow them to evaluate the product. Similarly, standards that focus on imperceptible variations in characteristics would not be of interest to consumers. It is noteworthy that similar questions existed in agricultural economics at that time. As a matter of fact, the issue of standards and their informational content was central at that moment (Delcey and Noblet 2024). Several agricultural economists even proposed using statistical theory to identify the characteristics of agricultural products that matter to consumers (e.g., Waugh 1928), but these works are not discussed by Shewhart. Variations in characteristics perceived by consumers represent only one of the dimensions for establishing the tolerated deviations in a standard of quality. It is also necessary to consider measurement errors as well as the fundamental variability of certain product characteristics. Regarding measurement errors, Shewhart offers an analogy with physics:

Let us consider the objective charge X' on an electron. It is generally assumed that this is a constant. A series of measurements of this charge, however, do not show constancy when taken even by an outstanding physicist like Millikan.¹⁰ In fact our only approach to the assumed objective reality is statistical. All we can say is that the average of a number *n* of measurements appears to approach a statistical limit (Shewhart 1933a: 27).

Even when the measured characteristic is assumed to take the same value for all observations, there are measurement errors, which result in variability in the measured values. It is therefore necessary to identify the variability that has assignable causes (such as the inspector being intoxicated) and the variability that has non-assignable causes. Moreover, most of the time, a characteristic cannot be considered as taking the same value for all observations. For example, even if we try to produce nails of the same length, they are never exactly the same length. As Shewhart points out in his typescript, "it is not humanly possible to make things identically alike" (1931b: 6). Likewise, it is necessary to identify the variability with assignable causes and the variability with non-assignable causes. The effective correction of a part of this variability will depend on the expected economic outcomes. Shewhart defines *economic* standards of quality as "those where, under the given conditions in respect to the development of science and the development of human wants, there is a balance between the economic value to the consumer of any possible modification in the quality standard and the cost of such

¹⁰ Robert Andrews Millikan was an American physicist known for the "oil drop experiment," which allows the measurement of the charge of an electron and earned him the Nobel Prize in Physics in 1923. In his thesis, Shewhart extended the reflections and borrowed some methods from Millikan (Bradford and Miranti 2021).

modification" (1933a: 23). In his typescript, they are defined more simply as "those arrived at after due consideration to the economic consequences of the choice" (1931b: 3) and he notes that "standardization is inherently an economic problem" (*ibid*.). It is the responsibility of economists to study the issue of standardization and Shewhart highlights that this economic problem must be studied from a statistical perspective, as standardization requires accounting for measurement errors and the fundamental variability of the characteristics being measured. Economists must therefore develop greater competence in the use of statistical methods to study the issue of standardization and, through their work, assist engineers in organizing production.¹¹ Shewhart is much more explicit in the final section of his article.

The final section of the article, which serves as a conclusion, is titled "Econometrics and Industrial Standardization." Shewhart highlights in a footnote that this section was added in September 1932. This suggests that it was not included in his lecture at the University of London in May 1932. However, the main elements of this conclusion are found in his 1931 typescript, making it likely that this conclusion was presented to participants at the January 1932 conference of the Econometric Society. After recalling the definition of an economic standard of quality, Shewhart mentions a conception of science "in which there is not so much a struggle between men, or companies, or nations, for a limited store, where one's gain must be another's loss, as there is cooperation in an effort to raise the standards of living of all by making use of the results of progress in pure science" (1933a: 35). In his typescript, he introduces a similar quote from John Joseph Carty, Chief Engineer of the American Telephone and Telegraph.¹² Shewhart fully appropriates this quote in the published article, without using quotation marks. From this specific conception of science, he assigns the following role to econometrics, represented here by the Econometric Society:

It is obvious that in this effort there is need for the development of a quantitative economic theory which will take into account not only demand and supply but also

¹¹ This represents the perspective of an engineer addressing economists. Interestingly, at the same time, some economists believed that it was the engineers who should assist the economists. Amy Sue Bix, for example, highlights a quote from economist Don Lescohier (1933), published in the *Journal of Engineering Education* the same year as Shewhart's article, stating that "the engineer needed to assist economists, political scientists, bankers, and business and labor leaders in analyzing the complexities of business cycles" (2020: 41).

¹² The quotation of Carty is: "According to the vision of Science, life must no longer be regarded as a struggle among men for a limited store where one man's gain or one nation's gain must be another's loss. Under the banner of scientific research we are asked to join with our fellow men, working together in controlling and utilizing the boundless forces of nature" (Engineering Foundation 1929). We were unable to access the book, but this quote is also mentioned in the announcement of its release published in the journal of the American Institute of Electrical Engineers (AIEE Editorial Board 1929). This quote aligns quite well with the self-perception engineers had of themselves following the Great Depression, which was sometimes attributed to technological unemployment, for which engineers were accused of being responsible (Bix, 2020: 44).

quality. By nature the engineer is one who likes to set a goal and then try to attain it. But to do this, it is necessary for him to have available quantitative equations of economic theory in the same sense that he has such equations in the natural sciences hence the significance of scientific economics, as supported by the Econometric Society, to the industrial leaders charged with making use of physical laws and properties in satisfying human wants (*ibid*.).

Shewhart therefore assigns to econometrics the role of discovering economic "laws" that can be used by engineers to meet human wants at the lowest cost. Econometrics is equated with "scientific economics," and its approach is likened to that of the natural sciences. It is important to recall that the natural sciences are mentioned as an ideal to be achieved by economics in the constitution of the Econometric Society (Roos 1933a: 106), and Shewhart participated in drafting the final version of this constitution (see the next section). Shewhart's reasoning can be reconstructed as follows: An engineer needs "laws" to organize production. Naturally, one first thinks of physical and chemical laws. However, "at the same time, he must know as much as possible about consumer demand and its fluctuations, just as he must know about processes that govern the cost of raw materials both present and future, and the conditions controlling the labor market" (Shewhart 1931b: 9). According to him, "scientific economics" can only emerge through an increased use of the "scientific method" by economists (see also Jackson 1935). Since most sciences at that time were characterized by a growing use of statistical methods, it is therefore necessary for economists to become familiar with these methods¹³, just as engineers had previously become familiar with them through the contributions of Shewhart.¹⁴ According to this view, he writes:

¹³ Ronald Aylmer Fisher said something similar: "Statistical methods are essential to social studies, and it is principally by the aid of such methods that these studies may be raised to the rank of sciences. This particular dependence of social studies upon statistical methods has led to the painful misapprehension that statistics is to be regarded as a branch of economics, whereas in truth economists have much to learn from their scientific contemporaries, not only in general scientific method, but in particular in statistical practice"(Fisher 1925: 2; quoted by Aldrich 2010).

¹⁴ "If industry had for its consideration a program outlining in a comprehensive way what might be accomplished through the extension of the applications of the scientific method—already being applied so extensively in industrial research—to the economic problems which in the last analysis must be solved if we are to attain all of the potential benefits of industrial research of the present kind, it seems reasonable to believe that such a program would be given careful consideration. Perhaps the Econometric Society, being an international one interested as it is in the promotion of studies that aim at a unification of the theoretical-quantitative and the empirical-quantitative approach to economic problems through the application of rigorous thinking similar to that which has come to dominate the natural sciences, may be the logical body to formulate such a program through committee action" (Shewhart 1931b: 17).

It would seem that only to the extent that we may hope to get more economics in engineering and engineering in economics and to the extent that we may get more mathematics, statistics, and scientific method in both, may we hope to progress toward stabilized economic standards of quality that will give to the consuming public maximum satisfaction at minimum cost in strict accord with the latest developments in industrial science (Shewhart 1931b: 15).

3 Walter Andrew Shewhart and the Econometric Society

Beyond his writings in *Econometrica*, Shewhart was regularly approached by the Econometric Society during its early years, and he frequently participated in its activities. The article "The Rôle of Statistical Method in Economic Standardization" helped shed light on the "supply side" of this story—the reasons why Shewhart accepted these invitations. Participating provided a way for him to support an initiative that promoted a "scientific" approach to economic problems he believed would be useful to engineers. But what about the "demand side"—the reasons why the Econometric Society invited Shewhart to participate in its founding meeting, publish in its journal, and serve as a keynote speaker at several of its conferences?

The history of the creation of the Econometric Society is detailed by Olav Bjerkholt (2017). We focus here on the aspects related to Shewhart. On November 29, 1930, Irving Fisher, Ragnar Frisch, and Charles Frederick Roos sent eighty-three invitations for a meeting in Cleveland on December 29, 1930, with the aim of establishing the Econometric Society. The invitation was accompanied by a draft constitution for this "international society for the advancement of economic theory in its relation to statistics and mathematics" (Roos 1933a: 106)¹⁵, whose main objective would be "to promote studies that aim at a unification of the theoretical-quantitative and the empirical-quantitative approach to economic problems and that are penetrated by constructive and rigorous thinking similar to that which has come to dominate in the natural sciences" (*ibid.*). Walter Andrew Shewhart was among the recipients of the invitation.¹⁶ The date and location were chosen because around forty scholarly societies were meeting in Cleveland at that time (Rorty 1930), increasing the likelihood that the invitees could attend. The American Economic Association, the Farm Economics Association, and Section K of the

¹⁵ This draft constitution is reproduced in Bjerkholt (2017).

¹⁶ https://www.econometricsociety.org/uploads/historical/OriginalAnnouncement29%2011%2030.pdf

American Association for the Advancement of Science were present. The annual conference of the American Statistical Association was also held there, during which Shewhart gave two presentations (Rorty 1930). In the program announcement published in the *Journal of the American Statistical Association*, Malcolm Churchill Rorty, who also attended the founding meeting of the Econometric Society (though he was not initially on the invitation list),¹⁷ noted "the recent rapid spread of statistical technique in all branches of science" (*ibid.*: 329) and called for a clarification of what constitutes the specificity of the members of this association, of which he was president in 1930. He notably identified a distinctive feature of its members:

A direct interest in certain statistical applications which are of particular interest to the members of the Association, or which are not being adequately fostered by other organizations. For example, there fall in this category statistical applications in commerce and industry; general financial, investment, and production statistics, particularly as related to business trends; etc. (*ibid*.)

The Econometric Society therefore appears as an initiative that could address the gap identified by Rorty. Sixteen people attended this meeting, including Walter Andrew Shewhart (Roos 1933b: 72). The other participants were Ragnar Frisch, Harold Hotelling, Karl Menger, Frederick Cecil Mills, William Fielding Ogburn, Oystein Ore, James Harvey Rogers, Charles Frederick Roos, Malcolm Churchill Rorty, Joseph Schumpeter, Henry Schultz, Carl Snyder, Ingvar Wedervang, Norbert Wiener, and Edwin Bidwell Wilson (*ibid*.).¹⁸ At the end of the meeting, the Econometric Society was established, with Irving Fisher elected as its first president. As noted by Roos (1933b: 71), all participants in the meeting actively contributed to revising the society's constitution, including Shewhart.

In 1931, Alfred Cowles III, a businessman and heir to a family that owned various media outlets, and who had owned a company offering financial forecasts until before the Great Depression, reached out to Irving Fisher on the advice of Harold Thayer Davis¹⁹ to offer financial support for the development of the Econometric Society (Christ 1983: 5). Through Davis and Thornton

¹⁷ Bjerkholt explains Rorty's presence by noting that he attended the sessions of the American Statistical Association during which several participants of the meeting were presenting their work, which likely led to his invitation (2017: 191). Additionally, Stapleford (2017) highlighted Rorty's strong interest in economics.

¹⁸ Louçã and Terlica write about this meeting: "Despite their heterogeneity, this small number of economists, sociologists, and mathematicians, some of them neoclassical, others institutionalists, reunited to lay the foundation of one of the societies that would reshape economics" (2011: 63). Shewhart does not belong to any of these categories. He can be considered either an engineer or a statistician.

¹⁹ The meeting between Cowles and Davis is detailed by Grier (2005). Davis was one of the first associate editors of *Econometrica*.

Carle Fry, who worked at Bell Telephone Laboratories, Cowles III met with several persons in New York to discuss this initiative, including Walter Andrew Shewhart and Harold Hotelling (*ibid.*). We do not have the explanation why Shewhart was invited to meet Cowles III, but we can conjecture that it was due to Shewhart's close relationship with Thornton Carle Fry²⁰ and his knowledge regarding the potential to apply economic research findings to the business world. After debates within the Econometric Society about the acceptability of this support (Bjerkholt 2017), and its subsequent acceptance, Cowles's support notably led to the creation of *Econometrica* in 1932, with the first issue published in January 1933. The minutes of the conversation between Shewhart and Cowles III are not available. However, we might speculate on its content based on this passage from Shewhart's 1931 typescript which was presented at the Econometric Society conference in January 1932:

What happens when American industrial leaders feel the need for good engineering data of a physico-chemical nature? The answer is: they bring into existence more than 1600 industrial research laboratories, equip them with scientifically trained men who know how to get and to interpret good data even though it costs them roughly \$155,000,000 a year to do so. What would happen if industry subsidized economic research as it has other kinds; if it brought together scientifically trained authorities capable of getting and analyzing good economic data as a basis for minimizing the cost of production? (Shewhart 1931b: 11)

The Econometric Society organized numerous conferences during its early years, and Shewhart participated in several of them. As previously mentioned, in January 1932, in New Orleans, he presented "Economic Standards of Quality," which would later become his article in *Econometrica*, in the same session as Harold Hotelling, who presented his famous article on Edgeworth's paradox (1932a). There were only eight presentations at this conference, which was due to the limited resources of the Econometric Society at the time, a gap that Cowles III helped to fill (Christ 1983: 5). Shewhart was discussed by Hotelling (Fisher 1933), and he discussed Joseph Mayer's article "Pseudo-Scientific Method in Economics" (1933), also published in the first volume of *Econometrica*. This conference was organized jointly with Section K of the American Association for the Advancement of Science. In December 1932, in Atlantic City, during another conference organized jointly with Section K of the American Association for the Advancement of Science, Shewhart, as an invited speaker, presented an

²⁰ Fry is described as a "close friend" of Shewhart (Alger 1967: 111).

article titled "Probability as a Basis for Action" (Shewhart 1932) in a session organized with the American Mathematical Society. This presentation focused on the epistemological foundations of the study of action and was once again discussed by Hotelling (Richardson 1933). This provided Shewhart with another opportunity to promote statistical methods to the members of the Econometric Society. In December 1938, in Detroit, Shewhart presented a paper titled "Importance of some Statistical Characteristics of a Standard of Quality" (Shewhart 1938) in the session "Problems in Industrial Replacement and Standards of Quality," chaired by Robert Burgess of the Western Electric Company, a colleague of Shewhart (Leavens 1939). This title, reminiscent of the 1933 article, once again addresses the issue of standardization, the economic nature of this problem, and the reasons why it must be approached using statistical methods. Harold Hotelling was also present at this conference, illustrating that Hotelling and Shewhart regularly interacted within the Econometric Society during the interwar period. Shewhart also chaired sessions at the conferences of January 1936²¹ and December 1941 (Leavens 1942). Through Hotelling's correspondence, we learn that Shewhart actively participated in the elaboration of the program for several conferences of the Econometric Society, even if he did not present his own work. This was the case for the 1933 and 1937 conferences.²² Additionally, he participated in the Cowles summer conference of 1936 as an invited speaker,²³ giving a talk titled "Use of Laws of Chance in Industrial Development" (Shewhart 1936b), which included passages from his Econometrica article discussed in the previous section. In his article devoted to the Cowles summer conferences, Robert Dimand notes, firstly, that "the presence of mathematically sophisticated researchers from industrial research or insurance such as Lotka, Hayes, and Shewhart at the 1936 conference was not repeated at the subsequent Cowles summer conferences" (2021: 785), and secondly, that "the Bell Labs connection inaugurated by Shewhart was continued by Thornton Fry, giving two talks in 1937, and by Robert Burgess, statistician at Western Electric, speaking in 1939 and 1940"

²¹ The program of the conference is available in Hotelling's archives (Hotelling Papers, Box #13, Folder 'Econometric Society (1)', Rare Book and Manuscript Library, Columbia University. Digitised version by Marion Gaspard & Antoine Missemer, June 2017).

²² Letter dated June 12, 1933, from Shewhart to Hotelling (Hotelling Papers, Box #34, Folder 'Chap.1 (4)', Rare Book and Manuscript Library, Columbia University. Digitised version by Marion Gaspard & Antoine Missemer, June 2017) and letter dated January 20, 1937, from Roos to Hotelling (Hotelling Papers, Box #1, Folder 'Camp, Burton H.', Rare Book and Manuscript Library, Columbia University. Digitised version by Marion Gaspard & Antoine Missemer, June 2017).

²³ "The Cowles Commission for Research in Economics held six month-long summer research conferences in Colorado Springs from 1935 to 1940 that, together with the closely-related meetings of the Econometric Society, created a forum for mathematically-inclined economic theorists and economic statisticians to interact and present their research for constructive criticism by a sympathetic audience, at a time when only a small minority of the economics discipline was receptive to such research" (Dimand 2021: 777).

(Dimand 2021: 790). While Shewhart may have been the first member of Bell Telephone Laboratories to speak at the Cowles summer conferences, we have noted earlier that Cowles III had known Thornton Carle Fry at least since 1931. It is therefore difficult to affirm that Shewhart "inaugurated" the Bell Laboratories connection. Moreover, Fry was an invited speaker at the International Congress of Mathematicians in 1924, which is considered one of the highest distinctions in mathematics. Contrary to what Dimand asserts, Fry can therefore be considered a "mathematically sophisticated researcher". Shewhart was listed in *Econometrica* as a member of the Econometric Society from 1934 to 1964. In 1948, he was elected a Fellow of the Econometric Society (Cowles 1949). In a tribute to Shewhart, Paul Smith Olmstead of Bell Telephone Laboratories recounted how Shewhart convinced him to join several scholarly societies, including the Econometric Society, as "each was presented to me as being necessary for the clearer understanding first of what was happening in Inspection Engineering and then of what needed to be done to advance the cause of quality control" (1967: 118).

Two main reasons explain these repeated invitations from the Econometric Society to Shewhart during its early years, beyond the good personal relationships Shewhart had with several members of the Econometric Society (notably Hotelling). The first is that Shewhart was an important figure in mathematical statistics during the interwar period, and the Econometric Society sought to promote the study of economic problems using this approach. Gaining Shewhart's support was therefore essential for legitimizing the Econometric Society's initiative, in the same manner as it was important to gain support from Ronald Aylmer Fisher, Samuel Stanley Wilks, Georges Darmois, Jerzy Neyman, Egon Sharpe Person or Edwin Bidwell Wilson. Several of them were also invited to publish in *Econometrica* at the same time as Shewhart (e.g., Darmois 1934; Fisher 1935; Wilks 1935) or to participate in the Econometric Society's conferences (e.g., Darmois in September 1931, April 1933 and July 1934; Wilson in January 1932 and October 1934, Neyman in October 1937 and April 1939, Wilks in January 1933). Shewhart can therefore be associated with the "Econometricians' Statisticians" as studied by John Aldrich (2010)-statisticians who supported the birth of econometrics and who were approached by the Econometric Society during its early years of existence, although Shewhart himself is not covered by Aldrich.

The second reason relates to the fact that the Econometric Society, in its early years, was interested in industrial issues and notably in the planning methods used by engineers within large companies. This could be explained by the fact that several key members of the Econometric Society's organizing committee between 1933 and 1939 were involved, or had

been involved, in the business world, such as Irving Fisher, Alfred Cowles III, or Charles Frederick Roos. This interest could also be explained by the renewed interest of economists for the theory of the firm in the context of the publication of several seminal works on imperfect competition (Hotelling 1929; Zeuthen 1930; Chamberlin 1933; Robinson 1933).²⁴ For instance, in a letter dated January 5, 1936, Ragnar Frisch, editor of Econometrica, invited Edward Hastings Chamberlin to write a literature review on the theory of monopolistic competition as part of the series we previously mentioned, which Chamberlin declined.²⁵ However, Chamberlin participated in a session on "imperfect competition" during the December 1933 conference of the Econometric Society, Frederik Zeuthen attended five times the conferences between 1934 and 1937, and Hotelling was a member of the organizing committee of the Econometric Society. This interest is also reflected in the articles published in Econometrica and in the presentations at the Econometric Society's conferences. We can mention the presentation "Quantitative Factors in the Distribution of the Value Product of Industry" by Malcolm Churchill Rorty in December 1931, who was working for the American Telephone and Telegraph (see Stapleford 2020), the session "Some Fundamental Problems of Mutual Interest to Scientific Economists and Engineers" of the June 1933 conference or the establishment in 1933 of "The Econometrica Committee on Source Material for Quantitative Production Studies", which focused on determining the methods for collecting useful data on firm production that could be mobilized by economists in empirical studies. Shewhart, as a member of the Bell System and having participated in the reorganization of production at this company, which was one of the largest in the United States at the time, was therefore a particularly valuable interlocutor for the Econometric Society. In this sense, Shewhart can be associated with the businesspersons who supported the development of econometrics and who were approached by the Econometric Society during its early years of existence, as studied by Thomas Stapleford (2017), although Shewhart himself is not covered by Stapleford.

Shewhart therefore found himself at a specific intersection between mathematical statistics and the organization of production, an intersection that made him a key figure for the Econometric Society at the time of its creation. This story is reminiscent of the case of Malcolm Churchill Rorty (1875-1937), who worked as an engineer at American Telephone & Telegraph (AT&T),

²⁴ Thomas Stapleford (2020) highlights a similar pattern in the case of Malcolm Churchill Rorty (working for the American Telephone & Telegraph) and the NBER, where the NBER was highly interested by the issue of business cycles, which relied heavily on forecasting—something Rorty was helping to develop within AT&T.

²⁵ Duke Economists' Papers Archive, Edward H. Chamberlin papers, 1896-2017, Box 1, Folder "Frisch, Ragnar 1936-1937".

eventually becoming the company's chief statistician, and who was one of the key figures in the creation of the NBER and who also participated in the creation of the Econometric Society. His career bears many similarities to that of Shewhart, notably through his involvement in several scholarly societies, and Thomas Stapleford (2020) has dedicated an article to Rorty's interest in economics, which he saw as the logical continuation of his engineering "practice" in the 1920s, a similar pattern observed in Shewhart's career. The specificity of Shewhart highlighted in this article lies in his role in popularizing statistical methods among engineers and economists.

4 Conclusion

Walter Andrew Shewhart is a central figure in quality management, and his name is closely associated with the development of Statistical Quality Control. As such, he has been the subject of several studies by historians of management and statistical thought. However, he has been largely overlooked by historians of economic thought. As a result, there has been a lack of research on the connections between Statistical Quality Control and economics, as well as on the relationships between Shewhart and economists or statisticians interested in econometrics. This article focused on the interwar period to shed light on these two questions. In particular, it has shown that Shewhart supported the development of econometrics and viewed it as a way to bring economists, engineers, and statisticians closer together.

In the introduction to the special issue on "Economics and Engineering: Institutions, Practices, and Cultures", Pedro Duarte and Yann Giraud highlight that in the literature devoted to the relations between economics and engineering, "what is more often left aside is the actual interaction between economists and engineers. How did the latter react to economists' appropriation of their tools, and were they themselves interested in taking into account economic knowledge as part of their professional activities?" (2020: 13). In the case of Shewhart, we have shown that he actively promoted SQC to economists, encouraging them to adopt statistical methods he also promoted to engineers, so that engineers could leverage the economic knowledge derived from this adoption to organize production.

References

- AIEE Editorial Board. 1929. "New Volume of Research Narratives Available." *Journal of the AIEE* 48, no. 9: 715–715.
- Aldrich, John. 2010. "The Econometricians' Statisticians, 1895-1945." *History of Political Economy* 42, no. 1: 111–54. https://doi.org/10.1215/00182702-2009-064.

- Alger, Philip. 1967. "Tribute to Walter A. Shewhart." *Industrial Quality Control* 24, no. 2: 111–111.
- BAMS Editorial Board. 1932. "Notes." *Bulletin of the American Mathematical Society* 38, no. 5: 336–42.
- Bayart, Denis. 2005. "Walter Andrew Shewhart, Economic Control of Quality of Manufactured Product (1931)." In Landmark Writings in Western Mathematics 1640-1940, edited by Ivor Grattan-Guinness, Roger Cooke, Leo Corry, Pierre Crépel, and Niccolo Guicciardini, 926–35. Amsterdam: Elsevier. https://doi.org/10.1016/B978-044450871-3/50153-4.
- Bayart, Denis. 2006. "The Fact-Theory Dialogue in an Industrial Context: The Case of Statistical Quality Control." *European Management Review* 3, no. 2: 87–99. https://doi.org/10.1057/palgrave.emr.1500055.
- Best, Mark, and Duncan Neuhauser. 2006. "Walter A. Shewhart, 1924, and the Hawthorne Factory." *BMJ Quality & Safety* 15, no. 2: 142–43. https://doi.org/10.1136/qshc.2006.018093.
- Bix, Amy Sue. 2020. "The Wider Context of Samuelson's MIT Textbook—Depression-Era Discussions about the Value of Economics Education for American Engineers." In *Economics and Engineering: Institutions, Practices, and Cultures*, edited by Pedro Garcia Duarte and Yann Giraud. *History of Political Economy* 52 (supplement): 31– 58. <u>https://doi.org/10.1215/00182702-8717924</u>.
- Bjerkholt, Olav. 1999. "Ragnar Frisch and the Foundation of the Econometric Society and *Econometrica*." In *Econometrics and Economic Theory in the 20th Century. The Ragnar Frisch Centennial Symposium*, edited by Steinar Strøm, 26–57. Cambridge: Cambridge University Press. https://doi.org/10.1017/CCOL521633230.002.
- Bjerkholt, Olav. 2017. "On the Founding of the Econometric Society." *Journal of the History* of Economic Thought 39, no. 2: 175–98.
 - https://doi.org/10.1017/S105383721600002X.
- Bradford, Phillip G., and Paul J. Miranti. 2021. "Information in an Industrial Culture: Walter A. Shewhart and the Evolution of the Control Chart, 1917-1954." *Information & Culture* 54, no. 2: 179–219. <u>https://doi.org/10.7560/IC54203</u>.
- Chamberlin, Edward Hastings. 1933. *The Theory of Monopolistic Competition. A Re-Orientation of the Theory of Value*. Cambridge: Harvard University Press.
- Christ, Carl Finley. 1983. "The Founding of the Econometric Society and *Econometrica*." *Econometrica* 51, no. 1: 3–6.
- Cowles III, Alfred. 1949. "Report of the Council for 1948." Econometrica 17, no. 1: 79-79.
- Cowles III, Alfred. 1960. "Ragnar Frisch and the Founding of the Econometric Society." *Econometrica* 28, no. 2: 173–74. <u>https://doi.org/10.2307/1907715</u>.
- Darmois, Georges. 1934. "Développements récents de la technique statistique." *Econometrica* 2, no. 3: 238–48.
- David, Paul Allan. 1985. "Clio and the Economics of QWERTY." *The American Economic Review* 75, no. 2: 332–37.
- Delcey, Thomas, and Guillaume Noblet. 2024. "The Making of Informational Efficiency: Information Policy and Theory in Interwar Agricultural Economics." *History of Political Economy* 56, no. 4: 685–711. <u>https://doi.org/10.1215/00182702-11242749</u>.
- Deming, William Edwards. 1967. "Walter A. Shewhart, 1891-1967." *The American Statistician* 21, no. 2: 39–40.
- Dimand, Robert. 2021. "The Cowles Summer Research Conferences on Economics and Statistics 1935-1940: Building a Community for Mathematical Economics and Econometrics." *Revue d'économie politique* 131, no. 5: 777–801. https://doi.org/10.3917/redp.315.0059.

- Duarte, Pedro Garcia, and Yann Giraud. 2020. "Introduction: From 'Economics as Engineering' to 'Economics and Engineering." In *Economics and Engineering: Institutions, Practices, and Cultures*, edited by Pedro Garcia Duarte and Yann Giraud. *History of Political Economy* 52 (supplement): 10–27. https://doi.org/10.1215/00182702-8717898.
- Engineering Foundation. 1929. Popular Research Narratives: Stories of Research, Invention or Discovery, Directly from the "Men Who Did It" Pithily Told in Language for Laymen, Young and Old. Volume 3. New York: Williams & Wilkins company.
- Fisher, Irving. 1922. The Making of Index Numbers. A Study of Their Varieties, Tests, and Reliability. Boston: Houghton Mifflin.
- Fisher, Irving. 1933. "Report of the Meeting." Econometrica 1, no. 1: 92–93.
- Fisher, Ronald Aylmer. 1925. Statistical Methods for Research Workers. Edinburgh: Oliver & Boyd.
- Fisher, Ronald Aylmer. 1935. "The Mathematical Distributions Used in the Common Tests of Significance." *Econometrica* 3, no. 4: 343–365. <u>https://doi.org/10.2307/1905628</u>.
- Fry, Thornton Carl. 1929. *Elementary Differential Equations*. New York: D. Van Nostrand Company, Inc.
- Grier, David Alan. 2005. When Computers Were Human. Princeton: Princeton University Press.
- Hansen, Alvin Harvey, and Herbert Tout. 1933. "Annual Survey of Business Cycle Theory: Investment and Saving in Business Cycle Theory." *Econometrica* 1, no. 2: 119–47. <u>https://doi.org/10.2307/1907087</u>.
- Hoddeson, Lillian Hartmann. 1980. "The Entry of the Quantum Theory of Solids into the Bell Telephone Laboratories, 1925-40: A Case-Study of the Industrial Application of Fundamental Science." *Minerva* 18, no. 3: 422–47.
- Hotelling, Harold. 1929. "Stability in Competition." *The Economic Journal* 39, no. 153: 41–57.
- Hotelling, Harold. 1932a. "Edgeworth's Taxation Paradox and the Nature of Demand and Supply Functions." *Journal of Political Economy* 40, no. 5: 577–616. https://doi.org/10.1086/254387.
- Hotelling, Harold. 1932b. "Reviewed Work: Economic Control of Quality of Manufactured Product by W. A. Shewhart." *Journal of the American Statistical Association* 27, no. 178: 215–17. https://doi.org/10.2307/2277676.
- IQC Editorial Board. 1967. "In Memoriam." Industrial Quality Control 24, no. 2: 69-69.
- Jackson, Dugald. 1935. "Objectives of Engineering Education." *Journal of Engineering Education*, no. 26: 60–85.
- Karlin, John Elias. 1967. "Tribute to Walter A. Shewhart." *Industrial Quality Control* 24, no. 2: 116–116.
- Klein, Judy. 2000. "Economics for a Client: The Case of Statistical Quality Control and Sequential Analysis." In *Economic Techniques and Practical Problems*, edited by Roger E. Backhouse and Jeff Biddle. *History of Political Economy* 32 (supplement): 25–70. https://doi.org/10.1215/00182702-32-Suppl_1-25.
- Leavens, Dickson Hammond. 1939. "Report of the Detroit Meeting, December 27-30, 1938." *Econometrica* 7, no. 2: 167–90.
- Leavens, Dickson Hammond. 1942. "Report of the New York Meeting, December 27-30, 1941, and of the Dallas Meeting, December 29-30, 1941." *Econometrica* 10, no. 2: 169–91.
- Lescohier, Don. 1933. "The Place of the Social Sciences in the Training of Engineers." *Journal of Engineering Education*, no. 24: 414–21.

- Louçã, Francisco, and Sofia Terlica. 2011. "The Fellowship of Econometrics: Selection and Diverging Views in the Province of Mathematical Economics, from the 1930s to the 1950s." In *Histories on Econometrics*, edited by Marcel Boumans, Ariane Dupont-Kieffer and Duo Qin. *History of Political Economy* 43 (supplement): 57–85. https://doi.org/10.1215/00182702-1158799.
- Louro, Rosana, Victor Cruz-e-Silva, and Felipe Almeida. 2024. "François Divisia in Between Rational Economics and the Establishment of the Econometric Society." *The European Journal of the History of Economic Thought*, forthcoming. https://doi.org/10.1080/09672567.2024.2384887.
- Mahalanobis, Prasanta Chandra. 1948. "Walter A. Shewhart and Statistical Quality Control in India." *Sankhyā: The Indian Journal of Statistics* 9, no. 1: 51–60.
- Marschak, Jakob. 1933. "Annual Survey of Statistical Information: The Branches of National Spending." *Econometrica* 1, no. 4: 373–86. https://doi.org/10.2307/1907329.
- Mayer, Joseph. 1933. "Pseudo-Scientific Method in Economics." *Econometrica* 1, no. 4: 418–28. https://doi.org/10.2307/1907334.
- Mitchell, Wesley Clair. 1921. "The Making and Using of Index Numbers." In *Index Numbers* of Wholesale Prices in the United States and Foreign Countries, edited by Bureau of Labor Statistics, 7–114. Washington: US Government Printing Office.
- Olmstead, Paul Smith. 1967. "Tribute to Walter A. Shewhart." *Industrial Quality Control* 24, no. 2: 118–118.
- Pearson, Egon Sharpe. 1936. "Statistical Method and Industry in Great Britain." Journal of the American Statistical Association 31, no. 194: 361–66. <u>https://doi.org/10.2307/2278563</u>.
- Reich, Leonard Sidney. 2002. *The Making of American Industrial Research. Science and Business at GE and Bell, 1876-1926.* Cambridge: Cambridge University Press.
- Richardson, Roland George Dwight. 1933. "The Annual Meeting in Atlantic City and Princeton." *Bulletin of the American Mathematical Society* 39, no. 3: 161–70.
- Robinson, Joan. 1933. The Economics of Imperfect Competition. London: MacMillan.
- Roos, Charles. 1933a. "Constitution of the Econometric Society." *Econometrica* 1, no. 1: 106–8.
- Roos, Charles. 1933b. "The Organization of the Econometric Society in Cleveland, Ohio, December, 1930." *Econometrica* 1, no. 1: 71–72.
- Rorty, Malcolm Churchill. 1930. "The Program for the 1930 Annual Meeting." *Journal of the American Statistical Association* 25, no. 171: 328–32. https://doi.org/10.2307/2278197.
- Rutherford, Malcolm. 2011. "The USDA Graduate School: Government Training in Statistics and Economics, 1921-1945." *Journal of the History of Economic Thought* 33, no. 4: 419–47. https://doi.org/10.1017/S1053837211000265.
- Samuelson, Paul Anthony. 1948. Economics. New York: McGraw-Hill.
- Shewhart, Walter Andrew. 1925. "The Application of Statistics as an Aid in Maintaining Quality of a Manufactured Product." *Journal of the American Statistical Association* 20, no. 152: 546–48. https://doi.org/10.2307/2277170.
- Shewhart, Walter Andrew. 1926. "Quality Control Charts." *The Bell System Technical Journal* 5, no. 4: 593–603. https://doi.org/10.1002/j.1538-7305.1926.tb00125.x.
- Shewhart, Walter Andrew. 1930. "Economic Quality Control of Manufactured Product." *The Bell System Technical Journal* 9, no. 2: 364–89. <u>https://doi.org/10.1002/j.1538-</u> <u>7305.1930.tb00373.x</u>.
- Shewhart, Walter Andrew. 1931a. *Economic Control of Quality of Manufactured Product*. London: MacMillan.

- Shewhart, Walter Andrew. 1931b. "Economic Standards of Quality." Draft of Paper Prepared at the Request of Program Committee of the Econometric Society and to be Presented at the Annual Meeting of this Society at New Orleans, January 1, 1932. Bell Telephone Laboratories. http://library.isical.ac.in:8080/xmlui/handle/10263/6518.
- Shewhart, Walter Andrew. 1931c. "Applications of Statistical Method in Engineering." Journal of the American Statistical Association 26, no. 173: 214–21. https://doi.org/10.1080/01621459.1931.10503195.
- Shewhart, Walter Andrew. 1931d. "Statistical Method from an Engineering Viewpoint." *Journal of the American Statistical Association* 26, no. 175: 262–69.
- Shewhart, Walter Andrew. 1932. "Probability as a Basis for Action." Paper Presented at the Joint Meeting of the American Mathematical Society and Section K of the American Association for the Advancement of Science at Atlantic City, December 27, 1932. Bell Telephone Laboratories. http://library.isical.ac.in:8080/jspui/handle/10263/6524.
- Shewhart, Walter Andrew. 1933a. "The Rôle of Statistical Method in Economic Standardization." *Econometrica* 1, no. 1: 23–35. https://doi.org/10.2307/1912228.
- Shewhart, Walter Andrew. 1933b. "Annual Survey of Statistical Technique Developments in Sampling Theory." *Econometrica* 1, no. 3: 225–37. https://doi.org/10.2307/1907037.
- Shewhart, Walter Andrew. 1936a. "Significant Differences in Quality." Paper Presented at Bell Telephone Laboratories. http://library.isical.ac.in:8080/xmlui/handle/10263/6570.
- Shewhart, Walter Andrew. 1936b. "Use of Laws of Chance in Industrial Development." Paper Prepared for Presentation at Public Gathering Under the Auspices of Colorado College, Colorado Springs, Colorado, July 23, 1936. Bell Telephone Laboratories. http://library.isical.ac.in:8080/xmlui/handle/10263/6575.
- Shewhart, Walter Andrew. 1938. "Importance of Some Statistical Characteristics of a Standard of Quality." Paper presented at Christmas Meeting of the Econometric Society in Detroit, December, 1938. Bell Telephone Laboratories. http://library.isical.ac.in:8080/xmlui/handle/10263/6521.
- Shewhart, Walter Andrew. 1939. *Statistical Method from the Viewpoint of Quality Control.* Washington: The US Department of Agriculture.
- Shewhart, Walter Andrew. 1946. "The Advancing Statistical Front." *Journal of the American Statistical Association* 41, no. 233: 1–15.
 - https://doi.org/10.1080/01621459.1946.10500754.
- Stapleford, Thomas. 2017. "Business and the Making of American Econometrics, 1910-1940." *History of Political Economy* 49, no. 2: 233–65. <u>https://doi.org/10.1215/00182702-3876469</u>.
- Stapleford, Thomas. 2020. "Engineering the 'Statistical Control of Business': Malcolm Rorty, Telephone Engineering, and American Economics, 1900–1930." In *Economics and Engineering: Institutions, Practices, and Cultures*, edited by Pedro Garcia Duarte and Yann Giraud. *History of Political Economy* 52 (supplement): 59–84. https://doi.org/10.1215/00182702-8717924.
- Stigler, Stephen Mack. 1996. "The History of Statistics in 1933." *Statistical Science* 11, no. 3: 244–52. https://doi.org/10.1214/ss/1032280216.
- Tippett, Leonard Henry Caleb. 1967. "Walter A. Shewhart." *Journal of the Royal Statistical Society. Series A (General)* 130, no. 4: 593–94. https://doi.org/10.1111/j.2397-2327.1967.tb02376.x.
- Wald, Abraham. 1947. "Foundations of a General Theory of Sequential Decision Functions." *Econometrica* 15, no. 4: 279–313. https://doi.org/10.2307/1905331.
- Waugh, Frederick Vail. 1928. "Quality Factors Influencing Vegetable Prices." Journal of Farm Economics 10, no. 2: 185–96. <u>https://doi.org/10.2307/1230278</u>.

- Wilks, Samuel Stanley. 1935. "On the Independence of *k* Sets of Normally Distributed Statistical Variables." *Econometrica* 3, no. 3: 309–326. https://doi.org/10.2307/1905324.
- Xie, Min, and Amitava Mukherjee. 2017. "'Advances in the Theory and Application of Statistical Process Control'—Celebrate the Quasquicentennial (125th) Birth Anniversary of the Father of Statistical Quality Control—Dr. Walter Andrew Shewhart." *Quality Technology & Quantitative Management* 14, no. 4: 341–42. <u>https://doi.org/10.1080/16843703.2017.1304033</u>.
- Zeuthen, Frederick. 1930. Problems of Monopoly and Economic Warfare. London: Routledge.