



Ford Whitman Harris's economical lot size model



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ABSTRACT

Here we celebrate the centennial of Ford Whitman Harris's model for determining economical lot sizes, which was published in the A.W. Shaw Company's magazine *Factory, The Magazine of Management* in February 1913. The square-root formula derived by Harris has become one of the most cited and applied results in production and operations management. We examine the circumstances under which this result was derived, and explore the probable causes for the later obscurity of Harris's paper, which was forgotten for many years.

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In 1913 Ford W. Harris published a paper with the title “How many parts to make at once” (Harris, 1913). This paper addresses the problem of finding the most economical quantity to be made of each lot of a product so as to meet a demand that continues over time at a constant rate. His derivation of the square-root formula for this quantity is a foundation result in operations research and the theory of inventory management, which is commonly known as the “economic order quantity” (EOQ) formula. It has appeared in countless articles and texts over the past 100 years. A reprint of Harris's original 1913 paper accompanies this paper.

The fundamental issue in Harris's model is the balancing of two cost components: the cost of carrying inventory, which increases with the lot size, and the average set-up cost per unit, which declines with larger lots. This tradeoff is depicted in the “Manufacturing quantities curves” of Fig. 1 in Harris's paper. These curves also have appeared countless times in other publications during the past 100 years.

Harris's foundation paper was lost from sight for many years and was finally rediscovered 75 years later (Erlenkotter, 1989, 1990a). After an additional 25 years, there are still questions about the circumstances underlying the origin of the EOQ model and the reasons behind its disconnection from its origin. Although there seems to be no way to settle all these questions definitively, there is enough evidence available for some intelligent discussion here.

1. Harris and the origination of the EOQ model

Certainly there is nothing in Harris's early life that would lead one to expect that he might produce such an original and fundamental result. He was born in 1877 and grew up in the

Portland, Maine area, where he received a high school education. After high school he worked for four years as an engineering apprentice and draftsman for two Portland employers, the Belknap Motor Company and the Maine Electric Company. In 1900 he moved to Pittsburgh, Pennsylvania, where he became a draftsman and engineer for Heyl and Patterson. During the period from 1904 to 1912 Harris was employed as an engineer for the Westinghouse Electric and Manufacturing Company in East Pittsburgh (Erlenkotter, 1990a).

In 1912 Harris left Westinghouse and moved to Los Angeles, California (Leonard, 1922). Family sources suggest several reasons for this move. One of his wife's sisters was ill with consumption (tuberculosis), and the Mellon family had decided that the Southern California environment would be more favorable to her health. After his years in Maine and Pittsburgh, Harris had grown tired of cold weather and snow and looked forward to a warmer climate (Smith, 1988). He also may have wanted to expand his horizons beyond the confines of Westinghouse. Tutoring and self-study had educated him in electrical engineering, and he had patented a number of inventions in the electrical field. However, these patents had all been assigned to Westinghouse as his employer. Patents continued to be granted in his name and assigned to Westinghouse as late as 1916 (Erlenkotter, 1990a).

So, at the age of 35 Harris was faced with the need to retool his career. His daughter believed that he had an agreement with Westinghouse that barred competitive employment, and this blocked him from further inventions of an electrical nature (Smith, 1988). He had little in the way of formal educational credentials. But he did have an engineering background and experience in a major industrial corporation. It appears, then, that he began writing and publishing work on industrial management topics in 1913 to help establish his credentials in this broader field.

The first such paper was the one on the EOQ formula (Harris, 1913), which appeared in *Factory, The Magazine of Management* in its February 1913 issue. *Factory*, which was published by the A.W.

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Fig. 1. Ford W. Harris and his wife Eugenia, enjoying the California outdoors.

Shaw Company of Chicago, had an intended audience of “the manager in manufacturing”, with 10,000 readers in 1913. What better media outlet could there have been for Harris’s writings in this area? A dozen more of his articles were published in *Factory* over the next five years.

The A.W. Shaw Company’s flagship publication was *System, The Magazine of Business*, which was renamed *Business Week* after it was acquired by McGraw–Hill in 1928. Harris contributed an article on the “make or buy” problem to *System* in 1914. In 1915 Shaw published *The Library of Factory Management* in six volumes, which presented a remarkable view of the field of factory management at the time of the First World War (Erlenkotter, 1990b). It was oriented towards an audience of practitioners, and its initial notice promised the “hard-fisted ideas that pay”. The *Library* was drawn mainly from the two Shaw periodicals *Factory* and *System*, and three chapters were based on articles by Harris. One of these covered his EOQ model (Harris, 1915).

2. Harris’s EOQ contribution obscured

How, then, did Harris’s EOQ contribution end up lost from view and unrecognized for so many years? Initially it would have appeared that its publication in the popular magazine *Factory*, followed by republication in the widely distributed and practitioner-oriented *Library of Factory Management*, would have ensured its continued visibility. As mentioned, *Factory* had a target audience of 10,000 manufacturing managers. The *Library* was in its third printing by August 1916, and the volumes were issued again separately in 1921 in the *Shaw Factory Management Series*.

But, as I have documented elsewhere, his original 1913 paper seems to have been forgotten, and the 1915 *Library of Factory Management* version was misreferenced for decades in such a way that it was almost impossible to locate (Erlenkotter, 1989, 1990a). Once the erroneous citation was embedded in the literature, those who did reference his chapter merely repeated it and did not make the effort to seek out and access the original.

There were several causes contributing to this obscurity. First, the publishers of *Factory* actively encouraged destruction of the magazine! Readers were advised to tear out articles and file them by topic for future use. Perhaps this was useful in the short run, but it was fatal to long-term preservation. Second, the practitioner

audience was mainly interested in immediate results, and had little or no interest in the origin or history of ideas. The field of management, which was just beginning to develop, lacked academic and intellectual roots.

Moreover, as management did develop as a discipline, various groups drew boundaries and tended to exclude contributions made by outsiders. Taylor’s “Scientific Management” movement had its own agenda, and disciples within this cult could be savage towards outsiders. The roots of the eventual field of industrial engineering were in the Management Division of the American Society of Mechanical Engineers (ASME), for which L.P. Alford was the long-time gate-keeper. Elsewhere I have documented how Alford ignored early work on EOQ models that did not originate within his own circle, and how others appropriated this model for themselves without recognition of prior contributions (Erlenkotter, 1990a).

A.W. Shaw, who published Harris’s EOQ work, was closely affiliated with the Harvard Business School during its early years and was the first there to use actual business cases in teaching. He financed the establishment of the School’s Bureau of Business Research in 1911, and the A.W. Shaw Company was the first publisher of the *Harvard Business Review*. However, establishment of the case method at the school took it on a path away from formally codified knowledge such as the EOQ formula.

A final consideration here is Harris’s diversion of his efforts to other directions. He had no academic credentials or connections that would have supported promotion of his ideas beyond his published writings. Los Angeles in 1913 was not a very fertile environment for managerial or engineering pursuits since the city had yet to develop a manufacturing base. Also, a two-year economic recession began in this year. In September 1914 Harris wrote of making patent office drawings for a local attorney “during a stringency in [his] personal finances” (Harris, 1914). He also commented that

A patent lawyer should be about eight-tenths engineer or inventor and two-tenths lawyer. If he has the mechanical gifts he can pick up the law, but unless he has a constructive imagination and the mechanical sense he will never get it by studying law books.

So, even though he had never attended college, Harris decided to become a patent lawyer. He sought employment in a law firm and began reading the law in addition to his regular work. The evolution of his career is clearly documented in Los Angeles city directories. In 1913 he is listed as an electrical engineer; in 1914 as a consulting engineer with the law firm of Townsend and Graham; in 1915 as a member of the law firm of Townsend, Graham and Harris; and from 1916 through the end of the decade as a member of the law firm of Graham and Harris. He was admitted to practice before the U.S. Patent Office in 1914 and became a member of the California Bar in 1916. About this time his published writings shifted from managerial to legal topics. Harris was admitted to practice before the U.S. Supreme Court in 1922, and opened his own patent law office in Los Angeles in 1923. He was founding president of the Los Angeles Patent Law Association in 1934.

In April 1943 Harris commented that

... I made a precarious living as an engineer for a considerable period before I broke down the fence into what I thought was a greener pasture (Harris, 1943).

The “greener pasture”, however, was far removed from his EOQ model!

In this connection, I would note that Harris’s family had no knowledge that he had any involvement with the EOQ formula. In 1989 his grandson Laird W. Smith wrote me and said that

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