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# *Scientific Management: Application in Bethlehem Steel and Criticism*

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***Abstract:*** During the Second Industrial Revolution, in response to the growing need for efficient management systems caused by the rapid expansion of industrial organisations, Frederick Taylor devised a management theory known as 'Scientific Management' to enhance the factory's production process. The purpose of the article is to examine and evaluate the implementation of the Scientific Management theory, with a particular focus on its application in Bethlehem Steel. The research examines the experimental design implemented by Taylor, as well as the data on productivity and salary improvement resulting from the implementation of Scientific Management. The findings indicate that Taylor's efforts were successful in enhancing the productivity of certain workers in the factory. Also, the criticisms directed towards Scientific Management should play a significant role. Upon assessing the credibility of Taylor's report and scrutinising the pessimistic attitude of the workers, it becomes evident that Scientific Management possesses notable constraints when implemented to enhance the operation of an enormous manufacturing firm.

***Keywords:*** Scientific Management, Frederick Taylor, productivity improvement, workforce motivation

## 1. Introduction

The Second Industrial Revolution, which occurred from 1870 to 1914, witnessed a significant transformation in the organisation of production due to technological advancements. One notable development was the substantial expansion of economies of scale and throughput in certain industries [1]. Economies of scale often require some changes within the production, so several management theories have been offered to assist organisations in maintaining profit growth within this macro phenomenon. Production management plays a crucial role in this context due to the potential challenges that may arise in relation to factors such as location, layout, quality control, and scheduling of the production process throughout the growth and expansion of enterprises [2].

Scientific management, or “Taylorism”, is a management theory created by Frederick Winslow Taylor that focuses on the production process. Based on common experiences, managers of manufacturing organisations have usually tried to find and recruit skilled and professional workforces to improve the production process. However, Taylor provided a statement from a different perspective, which focused on systematic management and defined management as a genuine scientific discipline, which concludes well-defined laws, rules and principles as its fundamental basis [3].

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Taylor made efforts to enhance the motivational aspect of employees' working attitudes, aiming to cultivate a more positive work environment. Motivation plays a pivotal role in determining the performance of an organisation, while simultaneously giving rise to various challenges in this domain. For example, it has been seen that several proficient and seasoned individuals possess the capability to attain exceptionally elevated levels of performance, nevertheless opt to exhibit subpar performance instead [4]. The prevalence of passivity and slackness was seen in the workplace. According to Taylor , this issue was mostly attributed to the old wage model, which entails a fixed compensation for a specific amount of effort [3]. In order to address this issue, a proposed solution was the implementation of a differential piece rate system, wherein workers who demonstrate high levels of efficiency would receive additional and extra high compensation. Moreover, Taylor's research also examined the uniformity of the production process as a crucial factor. There existed abundant permutations of the constituent elements employed to accomplish identical tasks, with a significant proportion of these being derived from prior experiential knowledge. In order to enhance the operational procedures, Taylor employed elementary time study to ascertain the utmost efficiency. Subsequently, a sequence of measures was implemented, including the standardisation of production equipment, the establishment of routing and scheduling protocols, and the implementation of the most improved and scientific training for the employees [5]. The aforementioned concepts may be regarded as the fundamental concepts of Scientific Management. In addition, the specific methodologies for determining optimal efficiency and configuring components may vary among industries and organisations. The primary focus of evaluating the theory's impact on companies and labourers should be the effects it has on enhancing production process performance.

This research aims to examine the implementation of the Scientific Management theory during the Second Industrial Revolution, at the time of its inception. Taylor formulated his theory by drawing upon his personal experiences working in several factories, with Bethlehem Steel serving as a representative example [6]. Therefore, analysing the performance changes of Bethlehem Steel could produce valuable insights. Moreover, the workforce assumes a significant role within the framework of Taylorism, therefore an investigation of the impact on them is necessary as well. Taylor's time at Bethlehem Steel serves as a typical illustration of the experimentation and implementation of an innovative management theory. Therefore, this study also aims to uncover insights that can benefit modern managers.

## 2. Application: Taylor's Experiments

Bethlehem Steel Corporation emerged as a modestly-sized steel manufacturing enterprise during its formative years in the 1870s, establishing its headquarters in a specific geographical area. According to Warren, Pennsylvania exhibits a typical steel yield. Prior to the Second Industrial Revolution, the steel yield in Pennsylvania did not possess any discernible advantages compared to other regions of the United States [7]. However, the production of pig iron in Western Pennsylvania experienced a significant increase from 387 thousand gross tonnes in 1872 to 4435 thousand gross tonnes in 1898, reflecting the rapid rise of Bethlehem Steel [7]. Consequently, the implementation of a management theory may be necessary in order to effectively address the problem arising from economies of scale. Taylor participated in this particular situation and made efforts to demonstrate the effectiveness of his theory.

### 2.1. Differential Piece Rate

Initially, Taylor endeavoured to align his theory of differential piece rate. To evaluate the efficacy of theoretical procedures, it is advisable to select a manufacturing unit with low productivity, as this would yield a readily comparable outcome. According to Nelson, Taylor implemented his theory

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within the plant yard of the Bethlehem facility, which was characterised by a workforce with the lowest wages and lowest level of efficiency [6]. Taylor made the decision to implement a differential piece rate system for the workers. In order to determine the optimal production and efficiency of the workers, Taylor collaborated with his assistant James Gillespie and the supervisor of Bethlehem. According to Nelson, a group of 10 highly efficient workers was chosen and their production records were used to establish a reasonably precise maximum level of output. As a result of the implementation of the differential piece rate system, workers who demonstrate exceptional performance would be entitled to an additional 46% of their regular compensation. This could be the first application of Taylorism in Bethlehem Steel.

The use of differential piece rate by Taylor yielded notable enhancements to the production process, as emphasised by himself in his publication, The Principle of Scientific Management [3]. In his book, Schmidt can be characterised as an energetic worker who achieved high levels of productivity after the application of the theory. His experience can be viewed as a representative and favourable example of the outcomes that arise from the implementation of a differential piece rate system. Taylor provided motivation for him to enhance his level of effort by offering assurance of a substantially higher wage. As a result, Schmidt experienced a notable boost in his daily output, which rose from 12 tonnes to perhaps 47 or 48 tonnes. Correspondingly, his income also saw a large rise to 1.85 dollars per day, surpassing the standard wage level of 1.15 dollars in Bethlehem. In the specific case at hand, there was a notable increase in the productivity of a production unit (labourer), which held undeniable importance for the whole production process. According to Flynn and Amanatullah, if the presence of a co-actor who possesses a greater level of performance-based status is able to elicit increased ambition levels for a focal actor, then this may result in an improvement in the performance of the focal actor [8]. Consequently, it is plausible that the presence of a cooperative individual may have the capacity to enhance the productivity of other workers through their influence. Moreover, this might be interpreted as a reaction to the recognition that heightened productivity can result in enhanced remuneration, motivated by their drive to maximise their advantages. Considering the circumstances from a broader temporal standpoint, it is conceivable that the firm may derive advantages from the augmentation in production. This is due to the likelihood that the expansion in productivity will sufficiently offset the augmented costs linked to personnel. As an illustration, Schmidt experienced a 62% increase in compensation, while his output witnessed a fourfold increase [3].

## 2.2. Standardisation

Besides differential piece rate, Taylor made attempts to establish a fundamental principle about the law of heavy labouring. This endeavour might be seen as an endeavour to introduce a standardised approach to the loading of pig-iron [9]. Upon discovering a correlation between various elements and the fatigue experienced by workers, he would be capable of proposing a more optimised routine and timetable for the production process. During his investigation, his attention was directed towards several aspects that could potentially impact the fatigue experienced by labourers. Consequently, Taylor took into account the energy expenditure, quantified as the workload was considered as the primary determinant. Therefore, Taylor subsequently asserted that the allocation of recuperative time is necessary in order to prevent engaging in work while experiencing exhaustion, since this may lead to diminished productivity [9]. The result reached by Taylor can be seen as an instruction to restructure and optimise the routine and scheduling of the production process.

Nevertheless, it has been determined that Taylor's allegation is not accurate. Instead of the amount of energy that is consumed, the key factor that should be considered when determining the amount of labour that a worker can do should be the worker's talents and endurance, as stated in the report that was written by Gillespie and Wolle [9]. For the explanation, Taylor made a few errors during the

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process of doing his research. He employed workloads as an approach to quantifying the level of energy expended, yet failed to account for the differences between individuals, which was a bit biased due to insufficient variables. However, despite the fact that Taylor was unable to identify a specific factor that was responsible for the tired effect, he did make an effort to identify several components that would promote the standardisation of the production process. As a result, the managerial practices exhibited by Taylor were in alignment with his theoretical processes.

## 3. Criticism

Since the theoretical framework of Scientific Management was first conceived, it has been subject to criticism. In spite of the fact that Taylor had significantly enhanced its visibility through promotion, its effectiveness was doubted, and some even feared that it would have a detrimental effect on the organisation's performance over the long term. When these objections are taken into consideration, the issues about the labourers who played a significant role in the development of Taylor's theory may become a primary focus.

### 3.1. Effectiveness of the Results

The significant critique should focus on the development of productivity in manufacturing organisations, which is the primary goal of Taylor and may also be viewed as the effectiveness of scientific management. Taylor's "Principle of Scientific Management" highlighted "Schmidt"'s productivity increase when Scientific Management was implemented [3]. However, he failed to provide any other analogous instances to back up his assertions. As Taylor mentioned, he used rough talk to motivate Schmidt who was not an educated mechanic, or an intelligent labourer [3]. This indicated that a similar method might not be appropriate for other employees. Furthermore, it was ascertained that "Schmidt" is a pseudonym stated by Taylor, and the dialogue between Taylor and this individual was deemed to be fictional [9]. However, although Taylor offers a thorough account of the story in his book, the anecdote's effectiveness as evidence supporting the increase in production resulting from Scientific Management was rather limited.

In addition to that, when assessing the efficacy of an experiment, it is crucial to evaluate the elements of comparison. In Taylor's application, he opted to select a production plant that had a low level of productivity as the test subject in order to demonstrate his exceedingly expected improvement. On the other hand, the productivity of the workers at the manufacturing yard that he selected was extremely poor, and according to Gershon, they only completed between a third and a fourth of the amount of work that similar workers at other manufacturing facilities did [10]. In this particular instance, the initial low productivity of workers and the output of other plants could be considered to be different points of reference. Despite the fact that Taylor improved the yard's productivity by a significant amount, the outcome was not particularly outstanding in comparison to that of other industrial units. To conclude, the implementation of Scientific Management could potentially motivate the workers in the yard to enhance their productivity in order to achieve the standard level. However, this only indicates that the theory is applicable to a production process with untapped potential, but it does not guarantee significant improvements in production plants with average output. Thus, Scientific Management might not be considered as an effective theory according to Taylor's experiment's details.

### 3.2. Labourers' Dissatisfaction

The adoption of Scientific Management significantly altered the daily work routine of workers. One notable alteration is the increased workload imposed on the workers, with higher production expectations. In The Principle of Scientific Management, it is said that Taylor discovered that just a

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few people possessed the necessary physical fitness to handle the task he had designed, while the majority were unable to reach such a high level of productivity [3]. Taylor's limited consideration of wages as the sole element influencing workforce motivation was the reason for this. Yurtseven & Halici identified low earnings and salaries, poor working conditions, low-status positions, and demanding tasks as prevalent factors that contribute to issues in service sector businesses [11]. Furthermore, there is a bias among the employees that disregards the job as a significant obligation or a potentially rewarding profession. Taylor ignored various elements that impact the views of labourers, apart from their wages. Schmidt was highly motivated in this instance due to his great aspiration for an increased salary, even with the additional workload it required. Due to their consideration of multiple factors, the other chosen employees were not sufficiently tempted by the higher earnings and so would not be content with the additional workload demanded by the business.

In addition to this, an important percentage of workers were resistant to working under the differential piece rate because they were opposed to change and refused to work in accordance with orders [6]. Possibly, they failed to recognise the potential advantages that Scientific Management could offer them, or they simply prefer the original fixed salary arrangement as it aligns better with their requirements. Such concerns have led to a rise in resistance towards change. In addition, certain employees were dismissed due to their stubbornness. Despite the fact that Taylor was able to successfully enhance the salaries of employees such as Schmidt, a strategy that was opposed by a large number of workers and resulted in unemployment could not be deemed a very appropriate method to improve such a production process.

Another significant concern that the labourers took into account was the potential monotony introduced by Scientific Management. According to Taylor's hypothesis, the workers are expected to complete their output by adhering to the standardised process in order to get optimal efficiency. Consequently, the workers were required to perform repetitive activities like to a machine, without the chance to provide any modifications. Johansson found that the repetitious nature of the task can adversely impact workers' health and job satisfaction [12]. Hence, the discontentment of workers is expected to progressively escalate in the scenario of standardised labour. In general, the workers' resistance to change and acceptance of scientific management could potentially diminish the theory's ability to bring about a sustainable boost in productivity.

## 4. Conclusion

Taylor's Scientific Management theory is a prominent example of the several management theories that have been established to accommodate the external environment. This idea centres on enhancing the efficiency of industrial production. Taylor prepared a synopsis of the ideas derived from his own firsthand encounters, with the intention of enhancing efficacy through the stimulation of work drive and the reduction of wastefulness. Taylor conducted various tests to demonstrate the effectiveness of his idea, taking advantage of the abundant opportunities available to him during his career at Bethlehem Steel. Taylor sought to enhance the production process under specified conditions, and he achieved success by identifying an example of workers whose productivity notably increased due to his efforts. Although he did not discover a faultless standardisation concept in the pig-iron yard, his mode of thinking was truly remarkable.

However, Taylorism failed to achieve popular adoption due to the limitations it imposed. Taylor's self-provided description was lacking in truthfulness. Furthermore, the adverse impacts it had on the workers which led to the objection by them were an additional aspect that contributed to the decision to reject it. Consequently, there is a belief that Taylorism may not be sufficiently effective in achieving success for a manufacturing company of such scale.

The arduous process of Taylor's application offers valuable insights for modern corporate managers seeking to establish an innovative management system. According to the findings of this

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study, in order to demonstrate that a management theory is effective, it is necessary to conduct experiments that have been carefully planned and take into account a variety of elements that are relevant to the investigation. By gaining the experience of Taylor's application, modern managers can assess a broader spectrum of factors that are frequently disregarded, enabling the construction of a more comprehensive and suitable experiment. However, it is important to acknowledge certain deficiencies in this research that should be considered for enhancement. Initially, the sources utilised were limited as they primarily consisted of historical records, which are subject to the significant disparity in context between past eras and the present. Additionally, certain data, such as the workload and income fluctuation of Schmidt, were deliberately highlighted, but the same sort of data of other employees working in the same facility, which might be considered a good example of comparable aspects, was never taken into consideration. Given this information, it is plausible that the rationales and the final outcome of the study may be influenced by a certain level of subjectivity. In future research endeavours similar to this, it is crucial to incorporate a broader range of sources and external variables such as temporal fluctuations, to attain more discerning and unbiased conclusions.

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