Citing Taylor: Tracing Taylorism's Technical and Sociotechnical Duality through Latent Semantic Analysis

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The body of scholarly works that cite F. W. Taylor's book, The Principles of Scientific Management *is examined. Latent Semantic Analysis, a method that statistically estimates the semantic and conceptual content in textual data, is used to analyze 5,057 titles and 671 abstracts of citing sources. Management concepts and practices, research topics and application contexts, as well as two high-level perspectives of Taylorism are quantitatively extracted as principal components of word usage patterns. The results chart the intellectual territory that was influenced by Taylor's ideas and, through a technical/sociotechnical duality, suggest their continuing relevance through their post-industrial evolution.*

Among many other –isms, the 20th century brought about the advent of Taylorism. Hailed as the triumph of science over traditional management practices by many, denounced as inhuman obsessive technocracy by some, the ideas introduced by Frederick Winslow Taylor (1911) had an undisputable impact on our industrial, organizational, occupational, educational, economic, and sociopolitical world. Soon after publication of *The Principles of Scientific Management* in 1911, Taylor's ideas were received enthusiastically by the business world. Harvard modeled its first MBA curriculum on scientific management, and Taylor was invited by Harvard to lecture annually (Crawford 2009, p. 39). On the occasion of the 100th anniversary of the publishing of *The Principles of Scientific Management*, the work praised by Peter Drucker (1954, p. 280) as the "most powerful as well as the most lasting contribution America has made to Western thought since the Federalist Papers," a reevaluation of Taylor's legacy is in order.

The Principles of Scientific Management and Its Impact on Scholarly Work and Managerial Practice

Efforts in taking stock of Taylor's contribution started soon after his death in 1915. Feiss (1924) credited Taylor with steering management toward a great profession "involving both *science* as applied to the handling of all materials and methods, and *art* as applied to the handling of all its human relations." Locke (1982) examined the validity of Taylor's ideas on time study, standardization, goal setting, money as a motivator, scientific selection, and rest pauses, and finds such ideas fundamentally correct and generally accepted.

The application of Taylor's ideas into management practices was not met without resistance. Health care trade unions argued that "health care cannot be treated like a business" and that "a top-down approach to health care reform will not deliver effective outcomes" (OECD, 2004). Are such reactions justified? Boddewyn (1961) points out that Taylor's polemists often held superficial notions about parts of his system, quoted him out of context, and read or understood his work and his "philosophy of human labor" very little.

Yet, other scholars were not so critical of the contemporary applicability of Taylor's ideas. Investigating whether Taylor's ideas on improving national inefficiency through scientific management are still applicable today, Schachter (2007) found Taylor's spirit still alive in the halls of government and proposed a new look at public sector efficiency that took into account political considerations as intangible costs and benefits and were compatible with the Taylorist approach. Martin (1995, p. 38) found continuity between scientific management and modern TQM and concluded that the fundamental issues of meeting the needs of internal and external customers were fairly similar, therefore Taylor "would be pleased with modern management."

Can the sentiments of partisanship between management and workers be reconciled? In the inaugural issue of the journal *Management Science*, Smiddy and Naum reflected Taylor's idea of "intimate cooperation" between workers and management (Taylor 1911, p. 14; Taylor, 2005, p. 13) by considering the true science of managing to be based upon "a valid, moral, and ethically acceptable philosophy of management by the impartial observation of social components as discrete entities within and related to a total common purpose." (Smiddy & Naum, 1954). So, what happened to the duality of the technical and social component in scientific management as originally intended by Taylor? Were Taylor's ideas misguided by an overestimation of managerial good nature and an underestimation of the possibility for management-labor conflict (Wagner-Tsukamoto, 2008) or is it a misconception of the meaning of "science" resulting in "no such thing as scientific management"? (Carney & Williams, 1997, p. 779). What can be done about scientific management today? Carney and Williams (1997, p. 781) proposed resolving the hard/soft dilemma of classical management which "took Taylor's principles to the extreme" by conflating the distinction between hard and soft sciences, so that "the workplace with its human and non-human content… be understood holistically as an information system."

Such is the discourse on Taylorism, which continues to be strong to this day. But what exactly is the state of affairs in this discourse? What is the sentiment of the

community of scholars on Taylor's ideas and their continuing applicability? This paper gauges the context, as well as the manner in which references to Taylor are made. References to Taylor are operationalized as citations that are recorded by a citation indexing database. Context and manner in which scholarly work is presented are operationalized as content in titles and abstracts of the scholarly works citing Taylor. Therefore, the main research questions are:

Research Question 1: What are the contextual and conceptual themes among scholarly sources that cite Taylor?

Research Question 2: How do these themes relate to ideas originally discussed in Taylor's Principles of Scientific Management?

The next section describes the paper's methods of inquiry.

Methods

Data Collection

To gain a comprehensive view of the influence Taylor's ideas had on scholarly activity, two separate studies of citing sources were designed. Combining breadth-first and depth-first search strategies, Study 1 focused on collecting as many scholarly works citing Taylor as possible, while Study 2 focused on collecting those for which an abstract was available. Details of the two studies are provided below. Studies 1 and 2 were complementary and offered two alternative views on the intellectual structure of scholarly work that is influenced by Taylor.

Study 1: In order to gain a broad perspective on scholarly work that is influenced by Taylor, queries on sources that cite publication variants of FW Taylor's *The Principles of Scientific Management* were submitted to the web search engine Google Scholar (http:// scholar.google.com.) Reference variants included the titles *Principles of Scientific Management*, as well as *Scientific Management*. Referenced years included 1911, 1912, 1947, 1948, 1964, 1967, 1971, 1998, and finally 2005, the publication year of 1st World Library's free internet version (available for free download from www.1stworldpublishing.com). In the interest of capturing Taylor's true impact on scholarly activity, all variants were combined. Data cleanup lasted for a few days, but in order to avoid reference inconsistencies, raw data collection was completed on the same day in early July 2010. A total of 5057 journal articles, books, and dissertations were collected, covering the period between 1914 and June 2010. Titles of these citing sources were used as input in the Latent Semantic Analysis step, as described in the next section. Citing source data included 3014 articles published in scholarly journals, proceedings, and periodicals, 1989 books and dissertations, and 54 sources of unknown type. Unlike titles of books or dissertations, article titles occasionally tend to be less self-sufficient; therefore article titles in Study 1 were concatenated with the corresponding periodical names. Examples of the journals represented in this data set include *Academy of Management Review* (42 articles), *Academy of Management Journal* (33 articles), *Public Administration Review* (31 articles), *Management Decision*

(25 articles), *Management* (23 articles), *Human Relations* (22 articles), *Administrative Science Quarterly* (21 articles), and many others, for a total of 1974 journals, conference proceedings, and other scholarly periodicals.

Study 2: In order to gain a deeper understanding of scholarly work that is influenced by Taylor, queries on sources that cite publication variants of F.W. Taylor's *The Principles of Scientific Management* were also submitted to ISI Web of Knowledge (http://isiknowledge.com – subscription may be required), the standard citation indexing service provided by Thomson Reuters. As in Study 1, a number of title variants, as well as publication year variants for Taylor's Principles of Scientific Management were used. As in Study 1, raw data collection was also completed on the same day in early July 2010. A total of 774 journal articles were collected, covering the period between 1994 and June 2010. Since the main point of interest was in collecting abstract data, some articles were excluded, reducing the number of usable articles to 671. The abstracts of these articles were used as input in the Latent Semantic Analysis step, described in the next section. All articles were published in scholarly journals. Examples of the journals include *Public Administration Review* (15 articles), *Academy of Management Review* (13 articles), *International Journal of Operations and Production Management* (11 articles) *Organization Science* (11 articles), and many others, for a total of 369 distinct journals.

Latent Semantic Analysis

Latent Semantic Analysis (LSA) was introduced as an information retrieval technique (Deerwester et al., 1990) but subsequently evolved into a cognitive science theory of meaning (Landauer, 2007). For an introduction to the mathematics of LSA and a small numerical example that illustrates how the analysis works, see Martin and Berry (2007). For a rigorous discussion on how LSA detects the underlying topical structure of a document corpus and why LSA's capability for discovering hidden topics allows it to successfully model synonyms, multiple words with similar meaning, and human memory, see Valle-Lisboa and Mizraji (2007). LSA and the related method Latent Semantic Categorization were used for the identification of key research areas and themes in the body of IS research (Larsen et al., 2008; Sidorova et al., 2008). This article implements LSA by following steps similar to those described in Sidorova et al. (2008), and by following the recommendations in Evangelopoulos, Zhang and Prybutok (2012).

Term frequency matrix. LSA starts with the Vector Space Model (VSM) (Salton, 1975), where a collection of d documents is projected on a set of t dimensions representing dictionary terms. The collection of documents is then quantified as a $t \times d$ matrix $\mathbf{X}$, containing the number of times each term appears in each document (term frequencies), where columns are documents represented as vectors in a space of terms. Following common practice, some trivial terms such as "the," "of," etc., called *stopwords*, were excluded from the term dictionary. Terms that share a common stem were consolidated (term *stemming*, Porter, 1980). The original raw frequency counts in $\mathbf{X}$ were transformed by applying the *inverse document frequency* transformation (TF-IDF) which penalizes common terms and promotes rare ones. After being weighted, the term frequencies were also normalized so that the sum of squared transformed frequencies

of all term occurrences within each document was equal to one (term *weighting* and *normalization*, Salton & Buckley, 1988). The term dimensionality was further reduced by keeping terms that accounted for 99% (Study 1) or 95% (Study 2) of variability among the top 100 principal components of the term frequency matrix (*communality filtering*, Sidorova et al., 2008). Examples of terms with high communality, that were retained, include *organization*, *management*, *ethics*, *leadership*, *Taylor*, *manufacturing*, *TQM*, etc. Examples of terms with low communality, that were dropped, include *cheap*, *frequency*, *manipulation*, *decomposition*, etc. At the end of all these pre-processing operations, the final term frequency matrix **A** had a dimensionality of 728 terms by 5057 documents in Study 1, and 1634 terms by 671 documents in Study 2.

Singular Value Decomposition. Matrix **A** was subjected to the Singular Value Decomposition (SVD), $\mathbf{A} = \mathbf{U}\mathbf{\Sigma}\mathbf{V}^{T}$, where **U** are the term eigenvectors, **V** are the document eigenvectors, the superscript ^{T} denotes transposition, $\mathbf{\Sigma}$ is a diagonal matrix of singular values (i.e., square roots of common eigenvalues between terms and documents), $\mathbf{U\Sigma}$ are the term loadings on the common principal components of terms and documents and $\mathbf{V\Sigma}$ are the document loadings on the same common principal components. Full SVD extracted a number of principal components equal to the smallest of the term or document dimensionalities, i.e., 728 principal components (equal to the number of terms) in Study 1, and 671 principal components (equal to the number of documents) in Study 2. Following Zhu and Ghodsi (2006) the profile log-likelihood estimation method was employed in order to detect an "elbow point" on the eigenvalue's scree plot for each study. After applying this method, the first 40 principal components were kept for Study 1, and the first 20 principal components were kept for Study 2. In pursuit of the research questions, in order to explore the semantic content in the two collections at various levels of granularity, a 2-factor solution was also examined for Study 2.

Factor rotations and labeling. Varimax rotations were applied on term loadings and then reciprocated on document loadings. For a more comprehensive discussion on how to find a new base with meaningful dimensions and transform the entire LSA space to the new base, see Hu et al. (2007). In a fashion similar to what is typically done in numerical factor analysis, the rotated term loadings and document loadings were coexamined in order to produce factor labels. For example, in Study 1, the first factor had *organ-*[*ize, ization*] (7.08), *manag-* [*e, ement*] (0.49), and *theori-* (0.47) as the top-loading (stemmed) terms, with numbers in parentheses showing the loadings. Notice that the top-loading term *organ-*[*ize, ization*] has a very high loading, equal to 7.08, while the following terms have loadings that are 0.49 or less. This sharp contrast in loadings continued throughout the 40 factors comprising the solution in Study 1. The top-loading titles for the first factor were "staffing organizations" (0.97), "organization" (0.97), "Sine Ira et Studio – or Do Organizations Have Feelings?" (0.97), "Ethnography in organizations" (0.97), "The management of organizations" (0.84), etc. Notice that the document loadings decreased very slowly, signifying that nearby documents in this rank-ordered list are about equally related to factor 1. A coexamination of top-loading terms and top-loading documents made it clear that the first factor was about the *Organization*. Factor labeling continued in this fashion until the set of 40 labels in Study 1 was completed. In order to validate the labeling process, a confederate was asked to label the 40 factors independently of the author's labeling.

The two sets of labels were practically identical (degree of agreement equal to 100%). The reason the 40 factors in Study 1 were so sharp is perhaps due to the simple nature of the documents (i.e., a cohesive collection of article and book titles). As a result, high contrasts in term loadings made labeling very straightforward in Study 1.

Study 2 required some more involved labeling effort. For example, the first factor in Study 2 had *job-* (0.73), *characterist-* [*ics*] (0.48), *motiv-* [*ate, ation*] (0.46), and *satisfac- [tion]* (0.44) as the top-loading terms. The top-loading document titles were as follows: "Finding workable levers over work motivation" (0.48), "The Work Design Questionnaire (WDQ): Developing and validating a comprehensive measure for assessing job design and the nature of work" (0.46), "Integrating motivational, social, and contextual work design features" (0.44), "Predicting employers' satisfaction with newcomers Knowledge, skills, and abilities" (0.36), etc. Please note that in Study 2 only the abstracts were analyzed by LSA. However, a parallel examination of the titles of top-loading articles was expected to be – and actually was – helpful in labeling the factors. After some careful coexamination of terms, titles, and abstracts, it was determined that the first factor is about *Job characteristics*, *satisfactio*n, and *motivation*. The 40-factor solution produced by LSA in Study 1 and the 20-factor and 2-factor solutions produced in Study 2 are presented in more detail in the results section.

Results

Contextual themes

The 40-factor solution in Study 1 (analysis of titles obtained from Google Scholar) offered a view of themes that emerge in the body of scholarly work that drew from Taylor. Factor labels are presented in Table 1, together with some corresponding source counts. The high-loading sources counted in Table 1 were selected based not on a hard threshold (such as the 0.40 loading threshold that is typically used in numerical factor analysis), but, instead, on the heuristic assumption that each document should load, on average, on one factor. This heuristic has also been used in Sidorova et al. (2008). A side-effect of this heuristic was that it offset cross-loading documents (i.e., titles that are strongly related to more than one theme) with an equal number of non-loading documents (i.e., titles that are only weakly related to various themes) which do not contribute to the source count presented in Table 1. Thus, the counts in Table 1 added up to the total number of documents (the discrepancy between 5,057 and 5,058 is only due to rounding error). Table 1 also breaks down the document count into a number of time periods, based on the document (citing source) publication year. Finally, for each factor, Table 1 lists the *variance explained* or *communality* (i.e., the sum of squared loadings of all documents on each factor), expressed as a percentage of *total communality* (i.e., the sum of communalities across all factors). Variance explained is a measure of factor presence in all documents, even those where the factor is only peripherally related, whereas the document count is a measure of a factor's ability to produce fully dedicated documents.

A few selected themes are described below. The descriptions start with each theme's coverage among the citing sources and, in a dialectic fashion, continue by relating back to ideas presented in Taylor's *Principles of Scientific Management*. In the paragraphs that

follow, citations to Taylor are made based on page numbers in the 1st World Library's 2005 edition (www.1stworldpublishing.com).

F40.1. Organization. A fundamental socioeconomic business unit, the organization provides the context where management is practiced. Citing sources cover the organization mostly from a theoretical point of view. Taylor (2005, p. 9) adopts a stakeholder view of the organization, stating maximum prosperity of each stakeholder as the "principal object of management."

F40.2. Public administration. Citing sources apply organizational and management theories to the public sector, including the debate on whether government can really run like a business. Taylor (2005, pp. 5-6) relates to public administration from the very first page of his introduction, when he makes a reference to President Theodore Roosevelt's speech on "national efficiency" before laying out the goals of his undertaking.

F40.3. Human resources. Citing sources look at human resources from strategic, social, managerial, as well as developmental viewpoints that also cover ergonomics. Taylor (2005, p. 7) views human resources as a production unit and states the increase of productivity of human effort as one of the main objectives of scientific management.

F40.4. Theory. Theory, the intellectual pursuit of understanding and explanation of various phenomena, is often contrasted with practice. Citing sources look at theory in the context of systems theory, control theory, organizational theories, and often make the distinction between theory and practice. Taylor (2005, p. 26) declares the understanding of "theory, or philosophy, of scientific management" as the main motivation for writing his book.

F40.5. Work. In the context of Study 1, work is treated as a synonym to labor. Citing sources look at work studies, the science of work, and work motivation. Taylor (2005, p. 9) pursues the "highest grade of work" for all workers, through a maximization of their efficiency.

F40.6. Management. Most citing sources refer to the general management of organizations, while fewer look at specific industry contexts (archeological management, lumber mill management, etc.) or specific management functions (strategic management, operations management, etc.). Quite a few citing sources discuss scientific management and, therefore, cross-load on both the management (F40.6) and the science (F40.19) themes. Taylor was fully aware that his work was about management, as evident from the title. His purpose (and, indeed, his accomplishment) was to revolutionize management by making the transition from "personal management" to "systematic management" (Taylor, 2005, pp. 6-7), also arguing that "the best management is a true science" (Taylor, 2005, p. 7).

F40.7. Systems/Information Systems (IS). Information systems as we know them today did not exist in Taylor's time. One source of inspiration for the citing sources was Taylor's (2005, p. 22) dislike of "piece-work systems" which relate to citing sources systems approaches. Another, is the expectation that IS should increase organizational efficiency. Finally, Human-Computer Interaction draws inspiration from Taylor's idea that tool performance should be optimized through a series of scientific experiments. Interestingly, Taylor (2005, p. 35) did call for the "systematic recording and indexing of data" and for a "room in which to keep all the records."

An examination of the remaining themes listed in Table 1 completes the tale of scientific management. A tale of industrial relations (F40.10), industrial psychology (F40.26), employee motivation (F40.22), work (F40.5) and job design (F40.18). A tale of performance (F40.16), task analysis (F40.33), and studies of time (F40.40) and motion. A tale of leadership (F40.13), high-level (F40.20) perspectives (F40.34), innovation (F40.35), and change management (F40.17). The tale of Taylor (F40.32), the man who called for more science (F40.19) in management (F40.6) practices (F40.24). The tale of scientific management, the glorious American way (F40.37) of managing production (F40.36), services (F40.30), human resources (F40.3), processes (F40.29), public administration (F40.2), schools (F40.28), health care (F40.14), information systems (F40.7), and total quality (F40.25).

Table 1: *Contextual themes in citing sources: Study 1, 40-factor solution*

		High-loading source count					
Factor No.	Factor Label	1914-2010 (total)	1914-1970	1971-1990	1991-2000	2001-2010	% Var. explained
F40.1	Organization	185	12	44	52	76	4.19
F40.2	Public Administration	180	4	44	40	91	3.93
F40.3	Human Resources	202	3	35	63	101	3.31
F40.4	Theory	196	13	39	57	83	3.30
F40.5	Work	150	9	38	43	58	3.23
F40.6	Management	85	7	17	24	36	3.21
F40.7	Systems/Information Systems	158	3	28	61	62	3.08
F40.8	Education	162	4	33	52	70	2.94
F40.9	Organizational aspects	123	3	39	26	52	2.80
F40.10	Industrial Relations	128	20	33	31	44	2.79
F40.11	Information Technology	142	1	21	54	65	2.75
F40.12	Social environment	148	5	47	38	55	2.66
F40.13	Leadership	158	6	18	31	99	2.58
F40.14	Health Care	126	0	24	32	69	2.57
F40.15	Development	140	2	31	40	65	2.55
F40.16	Performance	133	3	18	31	79	2.50
F40.17	Change	151	5	25	50	71	2.45
F40.18	Job Design	101	0	27	26	48	2.40
F40.19	Science	158	9	57	41	50	2.39
F40.20	High-level view of Business	130	4	15	37	74	2.36
F40.21	Knowledge	124	0	5	18	95	2.30
F40.22	Organiz. Behavior & Motivation	128	10	57	20	40	2.30
F40.23	Culture	126	0	20	37	66	2.29
F40.24	Practices	131	3	17	42	66	2.28
F40.25	Total Quality Management	96	1	4	53	38	2.27
F40.26	Industrial psychology	125	11	44	28	42	2.26
F40.27	Communication	117	3	25	37	52	2.19
F40.28	Schools	133	2	16	47	67	2.18
F40.29	Processes	115	1	21	39	52	2.12
F40.30	Service	100	1	24	25	49	2.10
F40.31	Learning	121	1	5	34	79	2.09
F40.32	Taylor & History of Sci. Management	94	2	18	22	52	2.07
F40.33	Analysis (of tasks)	115	7	21	30	56	2.06
F40.34	Perspectives	111	2	18	33	57	2.02
F40.35	Innovation	74	2	10	18	43	2.02
F40.36	Production and Operations	99	8	17	30	41	1.98
F40.37	The American way	104	5	31	29	38	1.92
F40.38	Economics	69	2	17	27	21	1.91
F40.39	Administration & Control	35	3	14	6	11	1.85
F40.40	Time	85	6	13	20	46	1.81
	Total	**5058**	**183**	**1030**	**1424**	**2359**	**100**

From themes to contexts and topics

The 20-factor solution in Study 2 (analysis of abstracts obtained from ISI Web of Knowledge) offered a view of contexts and research topics that emerge in the scholarly work that drew from Taylor's principles. Most of the contextual themes extracted in Study 1 were confirmed by Study 2. However, since the documents in Study 2 had a more complex representation, based on abstracts rather than titles, the 20 factors also account for some more complex concepts. Factor labels and a breakdown of high-loading article counts into three time periods, are presented in Table 2. The percentage of variance explained by each factor is also presented in Table 2. The top factor, *job characteristics*, *satisfaction*, *and motivation* (F20.1) accounts for 6.46% of variance explained and has 60 high-loading articles. Knowledge (F20.4) also explains a high percentage of variability (5.62%), but only loads on 34 articles. These statistics indicate that knowledge has a small semantic presence in a large number of articles that cross-load on this factor weakly, in order to produce a combined variance explained of 5.62%, while it also has a substantial semantic presence in a smaller number of articles, namely 34, that load on this factor with a strong loading. In other words, a large number of articles relate to knowledge indirectly, but a smaller number are fully dedicated to knowledge. In contrast, a much larger number of articles, namely 51, are fully dedicated to the topic of *employment* (F20.5), even though the variance explained by employment is smaller than that explained by knowledge, indicating a smaller number of articles that indirectly relate to employment.

Table 2: *Contexts and research topics in citing sources: Study 2, 20-factor solution*

		High-loading article count				
Factor No.	Factor Label	1994-2010 (total)	1994-2000	2001-2005	2006-2010	% Var. explained
F20.1	Job characteristics, satisfaction, motivation	60	18	18	24	6.46
F20.2	Manufacturing & Production	44	16	13	15	5.77
F20.3	Cognitive work	41	15	9	17	5.65
F20.4	Knowledge	34	9	16	9	5.62
F20.5	Employment	51	19	12	20	5.49
F20.6	Human-computer interaction	36	15	14	7	5.08
F20.7	BPR & Innovation	32	15	11	6	5.04
F20.8	Occupational health	25	13	7	5	4.94
F20.9	Time & culture	40	18	14	8	4.92
F20.10	Public administration	32	11	15	6	4.87
F20.11	Nursing	26	13	8	5	4.86
F20.12	Schools	31	13	8	10	4.81
F20.13	Operations mgmt. & service operations	27	9	7	11	4.70
F20.14	Competence	36	14	8	14	4.69
F20.15	Approaches for measurement & evaluation	35	13	13	9	4.67
F20.16	Total Quality Management (TQM)	27	17	6	4	4.66
F20.17	Taylor, Taylorism, & scientific mgmt.	27	11	9	7	4.60
F20.18	Ethics	16	9	4	3	4.52
F20.19	Leadership	20	9	3	8	4.45
F20.20	Education	31	12	11	8	4.20
	Total	**671**	269	206	196	**100**

High-level perspectives in research influenced by Taylor

In order to afford a view of the semantic space created in Study 2 from a vantage point, factor solutions at higher abstraction levels were extracted. A 3-factor solution extracts a systems and *processes* factor, a *physical work* factor, and a *mental work* factor. The three factors produce three corresponding lists of high-loading articles that are of almost equal size. In this paper the 3-factor solution is not pursued any further, as the 2-factor solution is found to be more interesting.

The 2-factor solution produces factors that are labeled as shown in Table 3. The high-loading terms for the first factor (F2.1) include *design, manufacturing, production/ product, task, information, performance, improvement, human, quality, technology, process, analysis, measurement, lean*, etc. The high-loading articles for this first factor talk about "quantifiable productivity improvement," "product development," "requirements analysis," "manufacturing organizations," "management of change," "cognitive task analysis," "human factors in engineering," "process improvement," "industrial work design," "knowledge management," etc. This factor is labeled as *technical aspects of engineering & managerial activity* (F2.1).

The high-loading terms for the second factor (F2.2) include *education, public, culture, politics, nursing, school, profession, health, social, administration, care, labor, arguing, economics, ethics, theory, institution, relations*, etc. The high-loading articles for this second factor talk about "trained brains," "bureaucracy in public administration," "cultural cleansing of workplace identity," "discourse in nursing texts," "role changing among educators," "education reforms," "political science," "accountability and the culture of distrust," "school reform," "teacher labor process," "competence in professional practice," etc. This factor is labeled as *social, psychological, & cultural aspects of human activity* (F2.2).

Table 3: *High-level semantic factors in citing sources: Study 2, 2-factor solution*

Factor No.	Factor Label	Article count	% Variance explained
F2.1	Technical aspects of engineering & managerial activity	351	54.77
F2.2	Social, psychological, & cultural aspects of human activity	320	45.23
	Total	**671**	**100**

Relating the lower-level contexts and topics to the higher-level perspectives, Table 4 presents factors from the 20-factor solution extracted in study 2 that cross-load with the two high-level perspectives from the 2-factor solution. In order to further explore the relationship between the 20 contexts and topics and the two high-level perspectives, the observed article counts shown in Table 4 were compared to corresponding expected counts under the independence assumption, obtained through a chi-square test. The 20 topics were then divided into three groups, based on whether they cross-load on factor F2.1 more than expected ("primarily technical aspects of engineering & managerial activity"), on factor F2.2 more than expected ("primarily social, psychological, & cultural aspects of human activity"), or on both factors about equally ("balanced").

Table 4: *Cross-loadings between the 2-factor and 20-factor solutions in Study 2*

			Cross-loading articles	
	Factor No.	Context or Research Topic	F2.1	F2.2
Primarily Technical aspects of engineering & managerial activity (F2.1)	F20.3	Cognitive work	41	3
	F20.7	BPR & Innovation	31	4
	F20.2	Manufacturing & Production	42	9
	F20.16	Total Quality Management (TQM)	21	7
	F20.6	Human computer interaction	29	11
	F20.1	Job characteristics, satisfaction, motivation	51	20
	F20.13	Operations mgmt. & service operations	23	11
Primarily social, psychological, & cultural aspects of human activity (F2.2)	F20.18	Ethics	1	14
	F20.12	Schools	6	31
	F20.20	Education	6	28
	F20.17	Taylor, Taylorism, & scientific mgmt.	5	23
	F20.11	Nursing	6	25
	F20.10	Public administration	8	30
	F20.5	Employment	17	45
	F20.19	Leadership	8	15
	F20.8	Occupational health	11	20
	F20.9	Time & culture	16	28
Balanced (both F2.1 and F2.2)	F20.4	Knowledge	25	19
	F20.14	Competence	25	16
	F20.15	Approaches for measurement & evaluation	22	15

Discussion

The analysis of titles in Study 1 offered a comprehensive, yet somewhat superficial view of Taylorist references. Most themes listed in Table 1 are *contexts* for discourse with references to Taylor. Referring to our first research question, these included components of management practice such as the organization, leadership, administration and control, work, production and operations, performance, innovation, change, job design, and time. They also included social and psychological dimensions of management such as industrial relations, industrial psychology, organizational behavior and motivation, the social environment, knowledge, learning, and culture. Finally, they included industries such as public administration, education, health care, information technology, and services. What ideas from the *Principles of Scientific Management* inspired such discourse? Addressing our second research question and making references to Taylor (2005), we can trace these themes to a number of statements and opinions presented in the original text. The concept of *change* (F40.17, see Table 1) is ubiquitous. The entire book was motivated by a desire to bring about change from the old management style to a new, scientific management that could deliver higher levels of efficiency to the industry, higher living standards to the workers, and higher levels of competitiveness to the nations. Taylor's two main illustrations, the pig iron case study (pp. 37-48) and the bicycle balls case study (pp. 79-89) were used with the intent to inspire physical changes through job redesign, as well as changes in attitude (pp. 119-121). *Leaders* (F40.13) must not just be "born right", they must also "be trained" (p. 6), since it ultimately falls upon the managers to "assume the burden of gathering together all of the traditional *knowledge* (F40.21)" (p. 33). The need for education (F40.8) was also

pervasive throughout the text. For managers, it is formal college education, with the employment of "a young college graduate", (p. 49) and "college men" (p. 51). For workers, it is organized in-house vocational training, where "expert teachers […] are at all times in the shop, helping and directing the workmen" (p. 113), teaching them "to do a higher class of work" (p. 131). Calling upon management to "take over all work for which they are better fitted than the workmen" (p. 34), Taylor essentially called for a shift in the managers' skill set, and that is a call that has greatly shaped business education in the 20th century and beyond. *Organizational behavior* (F40.22) was also mentioned extensively. From the very beginning of the text, "soldiering," or the worker's deliberate and systematic slow work (p. 13), is cited as a main problem in the individual, industry, and society. Scientific management was then proposed as a method capable of transforming the worker until "he has acquired a friendly mental attitude toward his employers and his whole working conditions" (p. 131). Finally, regarding the applicability of scientific management to a variety of industries, the text focused primarily on manufacturing, but did hint on the generalizability of the ideas presented in it across industries by arguing that "the training of the surgeon has been almost identical in type with the teaching and training which is given to the workmen under scientific management" (p. 115).

The analysis of abstracts in Study 2 allowed for an examination of not just *what* is being discussed, but also *how* scholars articulate their discourse on Taylorism. As Study 2 examined two distinct levels of discourse abstraction, the middle level of contexts and topics, and the higher level of broad perspectives, it also allowed for some higher level findings. Referring to our first research question, at the middle level of semantic aggregation the themes extracted in Study 2 include management concepts and practices such as leadership, competence, knowledge, time and space, business process reengineering (BPR), total quality management (TQM), and Taylorism. They also included topics of scholarly research such as approaches for measurement and evaluation, occupational health, job characteristics, satisfaction, motivation, human-computer interaction (HCI), and cognitive work. Finally, they included industries and application contexts such as operations management & service operations, manufacturing & production, public administration, education, schools, and nursing. Addressing the second research question, it should be noted that many of these themes overlap with the findings from Study 1 and have already been discussed earlier. *Job characteristics* (F20.1) were extensively discussed throughout Taylor's text, which strongly advocates their systematic study through scientific experiments. By pursuing intimate cooperation and harmony between management and the workers, scientific management seeks employee *satisfaction* (F20.1) as "each workman […] is enabled to do a much higher, more interesting […] kind of work" (Taylor 2005, p. 116). The applicability of Taylor's principles on *cognitive work* (F20.3) was illustrated with the bicycle balls case study (pp. 79-89), where "girls" perform inspection of bicycle parts, a work that "required the closest attention and concentration […], [while they were] comfortably seated and […] not physically tired" (p. 80). By envisioning a time when markets are so enlarged that "their men will have almost constant work even in dull times" (p. 131), Taylor expressed his strong interest in issues of *employment* (F20.5). *Business process reengineering* (F20.7) was, of course, not yet invented as a term in 1911,

however, the text was full of calls for the introduction of new tools, new processes (pp. 71-78, the bricklaying case study), worker retraining, and a new relationship between management and the workers. Good *occupational health* (F20.8) was and is still a clear goal of scientific management: "in no case is the workman called upon to work at a pace which would be injurious to his health. The task was always so regulated that the man […] will thrive while working at this rate during a long term of years and grow happier and more prosperous" (p. 36). In fact, Taylor went so far as to declare that "If this man is overtired by his work, then the task has been wrongly set and this is as far as possible from the object of scientific management" (p. 125). The study of *time and space* (F20.9) are important components of carrying out task analysis: a college graduate who conducts the experiments is typically recording "with a stop-watch the proper time for all of the motions that were made by the men" (p. 50). *Measurement and evaluation* (F20.15) are main activities performed in the pig iron case study (pp. 37-48), the bricklaying case study (pp. 71-78), as well as the bicycle balls case study (pp. 79-89). Finally, the "vigorous" search for *competence* (F20.14) is presented as a generally acknowledged industry reality. However, "our duty, as well as our opportunity […] [is to] make this competent man, instead of hunting for a man whom someone else has trained" (p. 6). In sum, the answer to the second research question is that the extracted themes, including management concepts and practices, scholarly research topics, and application contexts, corresponded well to the ideas originally discussed in Taylor's *Principles of Scientific Management*.

At the higher level of semantic aggregation, the ideas articulated by the authors citing Taylor in Study 2 corresponded to traditional technical views of management (work design, task analysis, process design, performance measurement – F2.1), as well as more human-centered, collaborative, socially balanced views (occupational health, industrial psychology, organizational behavior, ethics, public administration, education, health care – F2.2).

After a close look at the high-level factors, an interesting pattern can be noted: factor F2.1 corresponded well with the technical fields of production and operations management, management science, ergonomics, job characteristics, and performance measurement that have primarily *supported* Taylor's approach, whereas factor F2.2 corresponded well with human-centered, social and psychological views of management that have, to a large extent, antagonized Taylor. A careful examination of articles that load on the second factor reveals that quite a few of them are not much in favor of Taylor. Toman (2003) examined scientific management as an example of "failed technology". Strangleman & Roberts (1999) found a managerial understanding of culture that can be traced back to Taylor as "dangerously wrong." Traynor (1996) examined discourse in nursing texts to discover interest in caring, holism, and qualitative research approaches at a time dominated by "so-called market rationalism." Sinclair, Ironside and Seifert (1996) spoke of "reduced autonomy, deskilling, and work intensification" of teacher labor, stating that the application of Taylorism in the classroom led to "increasingly oppressive working practices." Yet, not all articles loading on this factor were critical of scientific management. Some treated the scientific approach as positive (Power, 1994), and some others pointed out that too much attention on the negatives of scientific management steers the debate away from more important issues (Reid, 2003).

This paper argues that factor F2.2 was strongly related to discourse on sociotechnical systems as introduced in Trist and Bamforth (1951) and reviewed in Trist (1981), the socio-cognitive engineering approach proposed in Sharples et al. (2002), and the sociotechnical approach to work organization as presented in Prida and Grijalvo (2008). This high-level perspective is, therefore, dubbed as *sociotechnical views*. This is an important aspect of Taylor-based discourse, as it contributed to the evolution of Taylorist ideas in the post-industrial era of the second half of the 20th century. Reflecting the interrelatedness of social and technical aspects of an organization or a society as a whole, sociotechnical theory argues that matching, or "joint optimization" of the two components (technical—plant and machinery, and social—social relations and work organization) is necessary in order to maximize overall system performance (see, e.g., Kelly, 1978 for an overview).

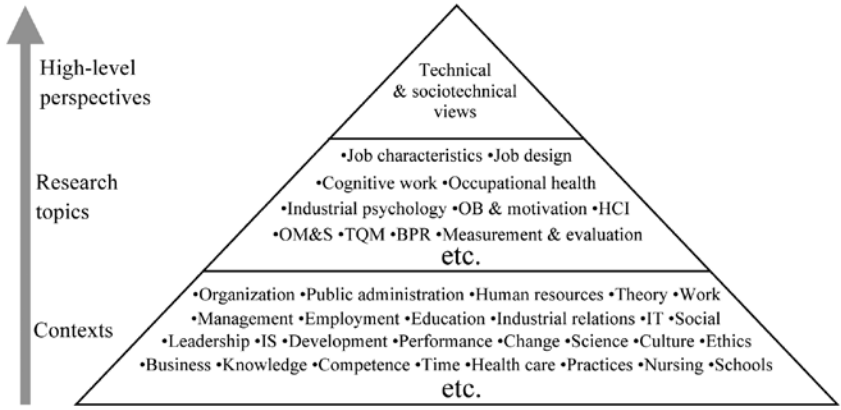
Some sober-minded authors have observed that, even though sociotechnical theory was viewed, at least in the early days, as the antithesis of Taylorism, sociotechnical theory has not discovered any general inapplicability of scientific management (Kelly, 1978), and some others go as far as to propose that the two perspectives can be synthesized (Rousseau, 1977). In fact, Taylor himself presented ideas that were not far from the notion of joint optimization in sociotechnical systems: "intimate cooperation between workers and management" (Taylor, 2005, p. 130) and "almost equal division of the work and the responsibility between the management and the workmen" (p. 34). For Taylor, scientific management provided learning opportunities for workers (p. 6, p. 115) as well as for managers (p. 33), and a desirable future (p. 66) for workers, with involvement in decision-making (p. 117) and promotion prospects (p. 116). Still, the controversy about Taylor's legacy is such that it makes his biographer Robert Kanigel call him the "misunderstood visionary" (Kanigel, 1997, dustjacket). But why is it that Taylor invokes such partisan feelings? Were his ideas hijacked by managers who didn't want to keep their end of the bargain? Are the workers still "soldiering"? Or is it that the two sides simply won't agree to an "intimate cooperation" and keep putting the blame on one another?

Towards the negative side of the discourse on Taylor, authors do not always make an effort to be courteous. Quoting David Lockwood's book *The Blackcoated Worker*, Bain et al. (2002) read "routinized and disciplined work with little chance of promotion" and they instantly recognized Taylor and Scientific Management, even though they admit that neither of the two is mentioned *per se* by Lockwood! What happened to Taylor's idea of enabling each workman to do "a much higher, more interesting, more profitable kind of work"? (Taylor, 2005, p. 116). Scientific management has been reduced to "target setting" and "monitoring" (Bain et al., 2002) and Taylorism becomes a synonym of "deskilling" (Cooper & Taylor, 2000). So much for "intimate cooperation" (Taylor, 2005, p. 25) and "profit sharing" (Taylor, 2005, p. 87) between labor and management being the "essence of scientific management": Taylor said so, but Taylorism didn't!

Comparing the results from Study 1 and Study 2 presented in this paper, one would observe that the extracted factors are complementary and, to some extent, overlapping. Figure 1 synthesized the two studies and summarizes their results at three levels of semantic granularity, visually organized in the form of a pyramid. The themes placed at the lower level of the pyramid represent the contexts in which

Taylor's ideas apply in scholarly work and managerial practice. The research topics placed at the middle level represent processed, more conceptual themes that indicate the scientific lenses through which the contexts placed at the lower level are examined by researchers. These research topics showed how Taylor's ideas continued to evolve in contemporary management research. The two high-level perspectives placed at the top of the pyramid, *technical* and *sociotechnical views*, represent the two main philosophical views in which Taylorism may be examined, and reflect a debate over what Taylorism is, what it is not, and what it ought to be that is still alive today: after all, Taylor may be a real historical figure who went on the record to express his own ideas, but Taylorism is a social construct. Altogether, the pyramid of discourse on Taylorism presented in Figure 1 charts the intellectual territory of practices, ideas, and philosophies inspired by F.W. Taylor, and suggests the continuing relevance of Taylor's original work of 1911 in our time.

Figure 1: *Pyramid of discourse on Taylorism*



Limitations

This paper examined the body of published works that cite Taylor's seminal work, *The Principles of Scientific Management*. In the first study, citing sources data were collected using the internet search engine Google Scholar. Even though the collected sources covered the current scholarly activity that references Taylor fairly well, the limited cataloguing scope of Google Scholar biased the findings. The use of titles as a representation of articles and books also has certain limitations, as titles are not always designed to represent content. As this limitation was addressed in the second study with the introduction of article abstracts collected from ISI Web of Knowledge, citing source coverage was significantly reduced, with collected articles starting with the year 1995. In other words, as depth representation was attempted to be improved upon, coverage breadth and vice-versa were still missing. Still, the noticeable agreement between the results produced by the two studies builds confidence in the main findings.

Conclusion

This paper charted the intellectual territory in the body of scholarly works that cite Taylor. Adopting a bottom-up fashion, it started with the examination of 40 themes extracted from 5,057 article and book titles corresponding to scholarly sources that cite Taylor. These themes, extracted quantitatively as principal components of word usage patterns, primarily correspond to the contexts in which Taylor's ideas have influenced scholarly work and managerial practice. The paper continued with the examination of 20 contexts and topics extracted from 671 article abstracts corresponding to academic research sources that cite Taylor. The latent semantic analysis of Taylor's citing sources concluded by distilling two high-level perspectives that characterize views of management when Taylor was used as a reference: the *technical* and the *sociotechnical* view. Taken together, these two perspectives reflected Taylorism's post-industrial evolution and suggested its continuing relevance into the 21st century. Upon a close look, one cannot help but notice a number of scholarly works, typically aligned with the sociotechnical view, antagonizing Taylor to the point of misquoting him. On the occasion of the 100th anniversary of *The Principles of Scientific Management*, perhaps we should set aside Taylorism for a moment and go back to Taylor. His text is now more accessible than ever.

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