

Metrology in the early days of Social Sciences

Clara Monteiro Vieira¹, Elisabeth Costa Monteiro¹

¹ Pontifical Catholic University of Rio de Janeiro, Marquês de São Vicente, 225, Gávea, Rio de Janeiro, Brazil

ABSTRACT

Recent studies have been endeavoring to overcome challenges to ensure reliable measurement results in Social Sciences and Humanities facing the complex characteristics of this scientific field. However, the literature indicates that the founding designers of sociology as an academic discipline expressed concerns regarding social measurements more than a century ago. Based on a literature review, the present work investigates possible metrological aspects already addressed in the early days of Social Science, focusing on the methodological conceptions of two of sociology's early canons – notably Max Weber and Emile Durkheim. The present study reveals that the approaches contemporaneously developed by the two Social Sciences co-founders present diverse but fundamentally complementary configurations, allowing a wide range of social phenomena to be analyzable. Although employing their terminologies, both social scientists incorporated fundamental metrological concepts in their procedures' parameters, seeking to establish a single reference, using statistical analysis or determining measurement standards that resemble what is known today as reference material. The concern with applying metrological concepts since the early days of creating sociology as a science reinforces the need to invest extensive efforts to provide uniformity of measurements in this remarkably relevant field of application of Measurement Science.

Section: RESEARCH PAPER

Keywords: metrology; Social Science and Humanities; Émile Durkheim; Max Weber

Citation: Clara Monteiro Vieira, Elisabeth Costa Monteiro, Metrology in the early days of Social Sciences, Acta IMEKO, vol. 12, no. 2, article 16, June 2023, identifier: IMEKO-ACTA-12 (2023)-02-16

Section Editor: Eric Benoit, Université Savoie Mont Blanc, France

Received July 10, 2022; **In final form** March 31, 2023; **Published** June 2023

Copyright: This is an open-access article distributed under the terms of the Creative Commons Attribution 3.0 License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Funding: This study was supported in part by the *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001*.

Corresponding author: Elisabeth Costa Monteiro, e-mail: beth@puc-rio.br

1. INTRODUCTION

Providing metrological traceability of measurement results to the International System of Units (SI) is essential to ensure reliable and comparable quantity values in applications associated with all fields of knowledge. This aspect, however, has been a historical struggle since the early days, when efforts were directed to the elaboration of a metrological framework traditionally focused on promoting advances in the evolution of standards for measuring physical quantities.

After the signing of the '*Convention du Mètre*' (1875), the 1st '*Conférence General de Poids et Mesures*' (CGPM), which took place in 1889, established international prototypes for physical quantities of length and mass units, respectively, meter and kilogram, also incorporating the second as the unit of time, according to astronomers' definition [1].

The high complexity of chemical and biological measurements, which also involve quantities belonging to the field of Natural Sciences, only much more recently received

better attention and contributions to meet their metrological infrastructure demands [2]-[5].

Metrological authorities' first initiatives toward meeting demands for chemical measurements took place with the adoption, in 1971, of the unit mole (symbol mol), for the quantity amount of substance, at the 14th CGPM, and the creation of the '*Comité consultatif pour la quantité de matière*' (CCQM), in 1993 [1].

In turn, measurements of biological quantities, which are particularly associated with even more challenging metrological demands, were addressed only at the 20th CGPM (1999) [2]-[4]. However, unlike what happened in the case of chemical quantities, the metrological demands associated with biomeasurements did not receive specific support by creating a particular consultative committee for the area. The responsibility for advancing the reliability of biomeasurements was absorbed by the CCQM, whose name was changed in 2014 to '*Consultative Committee for Amount of Substance: metrology in chemistry and biology*' [3].

Equally required and even more challenging is the global metrological framework to provide trustworthiness and comparability for measurements in Humanities and Social

Sciences. Nevertheless, this issue has not yet been addressed in CGPM resolutions.

The sophistication of measurands associated with more complex areas involving Chemical, Biological, Human and Social Measurements requires dealing with the development of certified reference materials, creation of arbitrary units, and other alternative strategies to step forward to a metrological structure capable of harmonizing “nonphysical” measurements in all aspects of daily life demands.

Particularly regarding Human and Social Sciences, the influence of the subjective perceptions of researchers and research participants on the research process [6] and difficulties in defining concepts [7]-[9] are some of the elements of the complexity in the study of social phenomena. Such intricacies hinder but do not prevent initiatives to ensure reliability and comparability of measurement results in the Social Sciences and Humanities.

Recent studies have been endeavoring to meet the challenges associated with the complex characteristics of this scientific field [7]-[37]. Among the current academic initiatives, it is worth mentioning the successful incorporation of measurements in Social Sciences among investigations addressed by the International Measurement Confederation (IMEKO) [36]-[40], being evidenced a massive effort of this scientific community to promote metrology in this field, including efforts to lead both physical and “nonphysical” measurement in a single, consistent concept system [34]-[37].

Despite the apparent novelty of the actions that are currently emerging to incorporate the concepts of metrology in Social Sciences aiming at contributing to robust and comparable measurement results in this field of application; the literature indicates that the founding architects of this science as a formal discipline, notably Max Weber and Émile Durkheim, already expressed concerns about the adequacy of the approaches employed for measuring social phenomena [41], [42].

This paper explores the fundamental aspects of the measurement methods proposed more than a century ago by those two founding authors of sociology as a scientific field. Moreover, the present article seeks to identify the possible connections between these preliminary sociological approaches and the current metrological conceptions.

2. ANALYTICAL FRAMEWORK OF SOCIAL SCIENCE FOUNDERS

Playing relevant roles on the foundation of sociology as a scholarly discipline, both Émile Durkheim and Max Weber devoted a portion of their work to the development of a methodology for the study of social phenomena and were especially interested in reliable strategies and comparable results on social measures. They presented, however, quite different approaches.

2.1. Émile Durkheim

Émile Durkheim (1858-1917, France) was the first to establish sociology as a formal academic discipline (University of Bordeaux, 1895) [43]. Influenced by the positivist current of thought, Durkheim turned to the Natural Sciences – especially bioscience – when performing Social Science investigations [42], [44]. He thought of society as an organism, whose parts (or “organs”) need to function well together to ensure the whole’s healthy functioning [42], [44].

Durkheim defined ‘social facts’ as his main object of study. ‘Social facts’ would be ways of feeling, acting, and thinking identifiable by three main traits such as generality, being applied to all members of a given society; exteriority from each individual, once they were not created by any particular person’s consciousness, but learned by people, generation after generation, and lasting much longer than the human lifespan; and coercivity, by which individuals are constrained into specific actions, not necessarily in conformity to each person’s intention [42].

With a focus on analyzing social facts and their role in society, Durkheim addressed the social phenomena from the macro-level. Just as it is impossible to capture what is going on in someone’s mind by looking at each cell of their nervous system, Durkheim states that one wouldn’t be able to explain a social fact simply by looking at its manifestations in the individual level [42]. He emphasized, after all, that a whole is not just the sum of its parts, but a specific reality formed by their association [42]. Therefore, in Durkheim’s approach, social facts ought to be explained through other social facts [42].

With a marked tendency toward an empirical approach, Durkheim used statistical strategies extensively. By increasing the number of cases whenever possible, the variable-oriented model of the comparative analysis performed by Durkheim aims to establish generalized connections between variables [45]. The general patterns pursuit guided Durkheim’s statistical approach to dealing with the time dimension from a transhistorical perspective [45].

Collective behaviors are, then, identified as an average effect of a variable by searching for statistical regularities of social facts [45]. Estimating the average effects of independent variables would allow investigating the ‘effects-of-causes’. Therefore, with the emphasis on generalizations over details, Durkheim establishes causality relationships, associating a phenomenon (social fact) to its cause or its effects (another social fact) [42].

For instance, in his famous study “*Le suicide: Étude de sociologie*” [46], performed with three religious’ communities (Protestants, Catholics, and Jews), Durkheim demonstrated that a social fact, the suicide rates, presented a statistical correlation with a macro-level variable constituted by the degrees of social integration, as

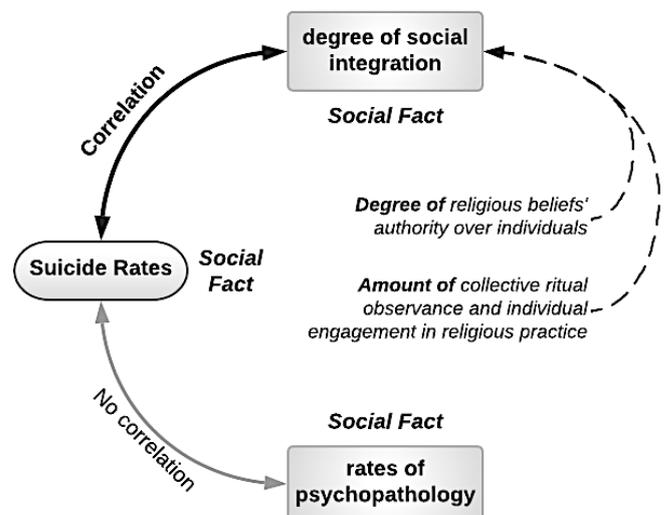


Figure 1. Diagram of correlating connections between macro-level variables to analyze causality associations with suicide rates in diverse contexts within the Durkheim study.

illustrated in Figure 1. The statistical analysis allowed Durkheim, for example, to associate suicide rates to aspects of social context, whereas, contrary to what one might expect, there was no correlation with rates of psychopathology.

2.2. Max Weber

Max Weber (1864–1920, Germany) introduced, in 1919, a sociology department at the Ludwig Maximilians University of Munich, in Germany [47]. Contrasting to Durkheim's objectivity, Weber's approach prioritizes subjective interpretations of social events. These aspects are considered those that provide the underlying sense to the individual's objective behaviors, explaining them. Therefore, Weber addressed the social phenomena from the micro-level, considering subjectivity and meanings attributed to social actions [41], [45], [48]-[50].

The approach included the development of the so-called Ideal Type. This theoretical construct consists of an abstract model with internal logic serving as a measuring standard for evaluating complex cases [45], [48], [51]. The strategy allows for understanding particular historical processes and individual motivations, considering as many variables as possible, and analyzing the kind of relationship among them by the concept of elective affinities, which refers to their mutual contributions [52]. Therefore, an in-depth understanding of a complex unity is reached by a case-oriented comparison concentrating on a small number of cases, with a large number of attributes interacting within long-lasting processes [45].

As a result, the roots of a specific event must be rebuilt when performing qualitative investigations involving historical comparisons by Weber's case-oriented strategy.

3. METROLOGY AND THE ANALYTICAL FRAMEWORK OF SOCIAL SCIENCES' FOUNDERS

Current proposals for making psychosocial and physical properties measurable, ensuring the quality of measurements associated with both physical and psychosocial properties, consider object-relatedness (objectivity) and subject-independence (intersubjectivity) as essential attributes to be satisfied [34], [36]. Objectivity refers to the connection between the information obtained and the measured property. This characteristic requires an appropriate theory of the property to make insignificant the definitional uncertainty and demands a reduced influence from other phenomena, which renders instrumental uncertainty negligible [35], [36]. For a uniform interpretation by different measurers, the measurement must be intersubjective, which depends on the metrological traceability of results to the same reference scale, if available. As described in [36], this quality dimension can be structured by developing item banks aiming at building reference scales associated with each of the properties, in combination with Rasch model fitting [33]-[36]. The Rasch model is an approach widely employed to measure latent traits in a variety of disciplines within humanities, social sciences and health [21]-[33], [36], [53], [54].

Preceded by the studies developed throughout the 19th century by the German Karl Marx (1818-1883), also known as one of the founding creators of the Social Sciences, Émile Durkheim and Max Weber were the first to establish this field of research as a formal discipline. The scientific contributions of these two contemporary researchers emerged at the end of the 19th century, after the memorable signing of the intergovernmental treaty of the Meter Convention, which took place in Paris in 1875 and established the *Bureau International des*

Poids et Mesures (BIPM), an international organization in which the Member States coordinate the harmonization and advances in measurement science and measurement standards. In the case of the French sociologist Émile Durkheim, this historical space may have paved the way for the interest in the quality of measurement evidenced in his work. Weber's contributions to Social Sciences measurements, in turn, emerged after the creation, in Berlin, of the first National Metrology Institute in 1887, the *Physikalisch-Technische Reichsanstalt* (PTR), later renamed to *Physikalisch-Technische Bundesanstalt* (PTB). As Berlin was the historical space experienced by Max Weber, this metrological context may also have influenced the methodological approach this Social Science co-founder developed.

The efforts invested in developing methodologies that sought to achieve comparable results from the measurements of social phenomena were a distinctive feature of Durkheim and Weber's scientific production. Their proposals, however, were characterized by quite different approaches. Their methods were not aimed at the same objects of study, which can commonly lead to a false idea of divergence. Instead, their methodological approaches were complementary, dealing with analyses carried out in both dimensions, macro-sociological by Durkheim and micro-sociological by Weber.

Driven by the positivist influence, Durkheim built Natural Sciences' analogies with Social Sciences. It is worth mentioning that both scientific fields share metrological challenges that still linger to the present time. With highly-complex measurements, the measurement requirements framework in such fields of study is not yet adequately addressed or simply not at all. Interestingly, in his book from 1894 "*Les règles de la méthode sociologique*" [42], Durkheim already acknowledges such challenges that sociology has in common with biology, but to a greater extent. As he states [42]: "*Tous ces problèmes qui, déjà en biologie, sont loin d'être clairement résolus, restent encore, pour le sociologue, enveloppés de mystère*" (p.39).

Dealing with general analyses involving a large number of social cases but limiting to few variables, Durkheim employed a quantitative approach with statistical techniques, including correlation procedures to define the strength of the association between different Social Facts, regression analysis to explore the impact of the change in one social variable relative to another, also predicting values of the random social variable based on the fixed social variable values. The measurement reference consisted of the average mathematical relationship between variables [42].

Durkheim pursues stable objects as a necessary condition for objectivity. The more detached the "social facts" from the "individual facts" by which they manifest themselves, the more objectively represented as a constant, thus eliminating subjective interference, as he states [42]:

"On peut poser en principe que les faits sociaux sont d'autant plus susceptibles d'être objectivement représentés qu'ils sont plus complètement dégagés des faits individuels qui les manifestent.

En effet, une sensation est d'autant plus objective que l'objet auquel elle se rapporte a plus de fixité; car la condition de toute objectivité, c'est l'existence d'un point de repère, constant et identique, auquel la représentation peut être rapportée et qui permet d'éliminer tout ce qu'elle a de variable, partant de subjectif" [42].

Durkheim's quest for objectivity can be considered analogous to a pursuit towards minimizing the definitional and instrumental uncertainties of social measurements.

As for Max Weber's methodology, the social properties under analysis were conceived in a micro-social dimension,

concentrating on a few cases but encompassing a large number of variables, thus leading to a significant increase in the complexity of the measurand compared to Durkheim's simplified general model.

The reference in Weber's approach is built by an abstract model, consisting of a synthetic "ideal construct" that encompasses multiple essential attributes. This strategy resembles the production of Reference Materials for chemical or biological measurements, areas for which the realization of SI units is still unavailable. In these fields, it is possible to provide metrological traceability by developing Reference Materials with sufficient homogeneity and stability regarding specified properties, being established to be fit for their intended use in the measurement or examination of nominal properties [55].

Weber's approach considers cases as a whole, constituted of variables that cannot be disassociated. Like the procedure using Certified Reference Materials as "primary reference standard," Weber's conception claims that the produced Ideal Types should be made available as a reference for further investigations of other cases, which would enable uniformity of interpretation through the intersubjectivity of measurement results.

Both Durkheim's and Weber's strategies are concerned with establishing a well-defined reference to provide the necessary measurement standard to enable the comparability of results, considering the specific characteristics associated with their main object of study. These features denote the concern with ensuring the intersubjectivity of the measurement results, which, in turn, will be provided only by establishing global metrological traceability of the measurement results to reference properties [34]-[37].

Furthermore, these preliminary approaches developed in the foundations of Social Sciences have been applied up to the present. Durkheim's Suicide Assessment has been recently implemented and validated in gerontological practice [16], [17]. Recent studies regarding metrology for the social sciences have also addressed ideas from Durkheim's immediate predecessor, Gabriel Tarde (1843-1904) [18], [19]. Considering quantification in the psychosocial sciences more demanding than in the natural sciences, Tarde qualified this measurement challenge as a new level of intellectual achievement [18].

As for Max Weber, his concept of "ideal type" came to serve as the basis for later developed measurement models addressing psychosocial properties [20]. That was the case of the Guttman scale, with its' proposal of "perfect scale" requirements to yield invariant measurement. Weber's concept of "ideal type" is also linked to principles underlying the Rasch measurement approach - a "probabilistic realization" of the Guttman scale, as described in the literature [20].

According to Duncan (1984), "social measurement should be brought within the scope of historical metrology" [56]. Duncan's suggestion may become a reality as soon as the CGPM resolutions start addressing the demands for the development of global metrological infrastructure aimed at ensuring the reliability and the comparability of measurement results in Humanities and Social Sciences, consequently promoting the integration of this complex scientific field into the International System of Units [3].

4. CONCLUSION

Despite never formally being addressed by international metrological organizations, Social Sciences were established as a discipline shortly after the intergovernmental metrological

structure creation, in 1875, by the Metre Convention signature. The present study explored the concepts potentially associated with the reliable framework provided by metrology among the preliminary measuring strategies developed by two founding designers of the Social Sciences.

Sharing the challenging aspect of measurement complexity and unavailability of a corresponding SI unit traceability of measuring results with Chemical and Biological properties, since its early years, the Social Sciences founding authors embodied ideas close to metrological concepts to ensure comparability as much as possible. The two major methods developed when the Social Sciences discipline was born conceived different levels of measurement dimensions but equally looked for defining a robust measurement standard to be employed for comparative analysis.

Emile Durkheim's objective and quantitative approach was directed to generalizations, using statistics to study numerous cases, focusing on a few variables, and defining reference by a mathematical-statistical average type, as well as pathological cases according to their corresponding deviations. Such strategy points toward the possibility of stepping forward to the measurement quality attribute of objectivity, minimizing definitional and instrumental measurement uncertainty components.

In turn, Max Weber's subjective and qualitative method examined the social phenomenon from a micro-dimension perspective, dealing with few cases and multiple variables, by means of which it aims at the highly-complex feature of social events. 'Ideal Type' constructs, which were defined as standard references, would, then, embody the essential social variables for the appropriate description of a social phenomenon. In this sense, Weber's Ideal Type can be interpreted as a Reference Material designed to allow the comparability of the results obtained by evaluating a specific construct by several researchers, which indicates a tendency towards an intersubjectivity attribute of measurement quality.

The efforts implemented by the founding architects of the Social Sciences from the earliest moments when it was still being established as a science reinforce the present calls for scientific advances to meet the multiple demands for metrological traceability stemming from all areas of knowledge. Complying with these requests constitutes an essential endeavor for establishing the worldwide uniformity of measurements.

ACKNOWLEDGEMENT

Authors acknowledge the support provided by the Brazilian Agency CAPES (*Coordenação de Aperfeiçoamento de Pessoal de Nível Superior*) - Brazil - Finance Code 001.

REFERENCES

- [1] BIPM, The International System of Units, 9th ed., Sèvres: International Bureau of Weights and Measures (2019). Online [Accessed 24 April 2023] <https://www.bipm.org/en/publications/si-brochure>
- [2] E. Costa Monteiro, L. F. Leon, Metrological reliability of medical devices, *J. Phys.: Conf. Ser.* 588 (2015), pp. 012032. DOI: [10.1088/1742-6596/588/1/012032](https://doi.org/10.1088/1742-6596/588/1/012032)
- [3] E. Costa Monteiro, Bridging the boundaries between sciences to overcome measurement challenges, *Measurement: Interdisciplinary Research and Perspectives* 15(1) (2017), pp. 34- 36. DOI: [10.1080/15366367.2017.1358974](https://doi.org/10.1080/15366367.2017.1358974)
- [4] E. Costa Monteiro, Magnetic quantities: healthcare sector measuring demands and international infrastructure for providing

- metrological traceability, *TMQ – Techniques, Methodologies and Quality* 1 (2019), pp. 42-50. Online [Accessed 24 April 2023] https://publicacoes.rigual.org/wp-content/uploads/2023/01/edesp1_19_42_50.pdf
- [5] A. Bristow, Assignment of quantities to biological medicines: an old problem re-discovered, *Philos. Trans. Royal Society A: Mathematical, Physical and Engineering Sciences* 369 (2011), pp. 4004-4013. DOI: [10.1098/rsta.2011.0175](https://doi.org/10.1098/rsta.2011.0175)
- [6] R. Damatta, *Relativizando: uma Introdução a Antropologia Social*. Rocco, Rio de Janeiro, 2010, ISBN 8532501540. [In Portuguese]
- [7] T. L. Kelley, *Interpretation of educational measurements*. Macmillan, New York, 1927.
- [8] T. Salzberger, S. Cano, L. Abetz-Webb, E. Afolalu, C. Chrea, R. Weitkunat, K. Fagerström, Addressing traceability in social measurement: establishing a common metric for dependence, *Journal of Physics: Conf. Ser. IOP Publishing*, 1379(1) (2019) art. No. 012024 DOI: [10.1088/1742-6596/1379/1/012024](https://doi.org/10.1088/1742-6596/1379/1/012024)
- [9] P. H. Pollock III, B. C. Edwards, The definition and measurement of concepts, in: *The Essentials of Political Analysis*. Cq Press, 2019, ISBN 9781506379593, pp. 1-33.
- [10] L. Mari, E. Ugazio, Preliminary analysis of validation of measurement in soft systems, *J. Physics: Conf. Ser.* 238(1) (2010) art. No. 012026. DOI: [10.1088/1742-6596/238/1/012026](https://doi.org/10.1088/1742-6596/238/1/012026)
- [11] W. P. Fisher Jr, A. J. Stenner, Metrology for the social, behavioral, and economic sciences, National Sciences Foundation Social, Behavioral, and Economic Sciences White Paper (2011). Online [Accessed 24 April 2023] http://www.truevaluemetrics.org/DBpdfs/Metrics/William-P-Fisher/FisherJr_William_Metrology-for-the-Social-Behavioral-and-Economic-Sciences.pdf
- [12] L. Mari, P. Carbone, D. Petri, Fundamentals of hard and soft measurement, in: *Modern Measurements: Fundamentals and Applications*. A. Ferrero, D. Petri, P. Carbone, M. Catelani (editors). Wiley-IEEE Press, 2015, ISBN 978-1-118-17131-8, pp. 203-262.
- [13] M. Djuric, J. Filipovic, S. Komazec, Reshaping the future of social metrology: utilizing quality indicators to develop complexity-based scientific human and social capital measurement model, *Social Indicators Research* 148(2) (2020), pp. 535-567. DOI: [10.1007/s11205-019-02217-6](https://doi.org/10.1007/s11205-019-02217-6)
- [14] T. Salzberger, S. Cano, L. Abetz-Webb, E. Afolalu, C. Chrea, R. Weitkunat, J. Rose, Addressing traceability of self-reported dependence measurement through the use of crosswalks, *Measurement* 181 (2021) art. no. 109593. DOI: [10.1016/j.measurement.2021.109593](https://doi.org/10.1016/j.measurement.2021.109593)
- [15] M. Delmastro, *On the Measurement of Social Phenomena: A Methodological Approach*. Springer International Publishing, 2021, ISBN 978-3030775353.
- [16] S. M. Marson, R. M. Powell, Suicide among elders: a Durkheimian proposal, *International Journal of Aging and Later Life* 6(1) (2011), pp. 59-79. DOI: [10.3384/ijal.1652-8670.116159](https://doi.org/10.3384/ijal.1652-8670.116159)
- [17] S.M. Marson, M. Hong, J. Bullard, The measurement of suicide assessment and the development of a treatment strategy for elders: Durkheim an approach, *Journal of Sociology and Social Work* 5(1) (2017), pp. 99-114. DOI: [10.15640/jssw.v5n1a10](https://doi.org/10.15640/jssw.v5n1a10)
- [18] W. P. Fisher Jr, Almost the Tarde model?, *Rasch Measurement Transactions*, 28(1) (2014), pp. 1459-1461. Online [Accessed 24 April 2023] <https://www.rasch.org/rmt/rmt281.pdf>
- [19] W. P. Fisher Jr, The central theoretical problem of the social sciences, *Rasch Measurement Transactions* 28(2) (2014), pp. 1464-1466. Online [Accessed 24 April 2023] <http://www.rasch.org/rmt/rmt282.pdf>
- [20] G. Engelhard Jr, *Invariant Measurement: Using Rasch Models in the Social, Behavioral, and Health Sciences*. Routledge, 2013, ISBN 978-0415871259.
- [21] N. Kærgård, Georg Rasch and modern econometrics, Presented at the Seventh Scandinavian History of Economic Thought Meeting, Molde University College, Molde, Norway, 2003.
- [22] W. P. Fisher Jr, Invariance and traceability for measures of human, social, and natural capital: Theory and application, *Measurement*, 42(9) (2009), pp. 1278-1287. DOI: [10.1016/j.measurement.2009.03.014](https://doi.org/10.1016/j.measurement.2009.03.014)
- [23] H. Zhong, J. Xu, A. Piquero, Internal migration, social exclusion, and victimization: an analysis of Chinese rural-to-urban migrants, *J. Res. Crime & Delinquency* 54(4) (2017), pp. 479-514. DOI: [10.1177/0022427816676861](https://doi.org/10.1177/0022427816676861)
- [24] J. Melin, S. J. Cano, A. Flöel, L. Göschel, L. R. Pendrill, Construct specification equations: 'recipes' for certified reference materials in cognitive measurement, *Measurement: Sensors* 18 (2021) art. No. 100290. DOI: [10.1016/j.measen.2021.100290](https://doi.org/10.1016/j.measen.2021.100290)
- [25] L. Pendrill, N. Petersson, Metrology of human-based and other qualitative measurements, *Measurement Science and Technology*, 27(9) (2016) 094003. DOI: [10.1088/0957-0233/27/9/094003](https://doi.org/10.1088/0957-0233/27/9/094003)
- [26] T. G. Bond, C. Fox, *Applying the Rasch Model: Fundamental Measurement in the Human Sciences*. Psychology Press, 2013, ISBN 9780429030499.
- [27] N. S. da Rocha, E. Chachamovich, M. P. de Almeida Fleck, A. Tennant, An introduction to Rasch analysis for psychiatric practice and research, *Journal of psychiatric research* 47(2) (2013), pp. 141-148. DOI: [10.1016/j.jpsychires.2012.09.014](https://doi.org/10.1016/j.jpsychires.2012.09.014)
- [28] J. Uher, Measurement in metrology, psychology and social sciences: data generation traceability and numerical traceability as basic methodological principles applicable across sciences, *Quality & Quantity*, 54(3) (2020), pp. 975-1004. DOI: [10.1007/s11135-020-00970-2](https://doi.org/10.1007/s11135-020-00970-2)
- [29] B. D. Wright, A history of social science measurement, *Educational measurement: issues and practice* 16(4) (1997), pp.33-45. DOI: [10.1111/j.1745-3992.1997.tb00606.x](https://doi.org/10.1111/j.1745-3992.1997.tb00606.x)
- [30] W. P. Fisher Jr, A. J. Stenner, Theory-based metrological traceability in education: a reading measurement network, *Measurement*, 92 (2016), pp. 489-496. DOI: [10.1016/j.measurement.2016.06.036](https://doi.org/10.1016/j.measurement.2016.06.036)
- [31] J. A. Baird, D. Andrich, T. N. Hopfenbeck, G. Stobart, Metrology of education, *Assessment in Education: Principles, Policy & Practice* 24(3) (2017), pp. 463-470. DOI: [10.1080/0969594X.2017.1337628](https://doi.org/10.1080/0969594X.2017.1337628)
- [32] G. Rasch, *Probabilistic Models for some Intelligence and Attainment Tests*. University of Chicago Press, Chicago, 1980, ISBN 978-0226705538.
- [33] G. Rasch, On general laws and meaning of measurement in psychology, *Proc. of the fourth Berkeley Symposium on mathematical statistics and probability: held at the Statistical Laboratory, Berkeley, United States*, 1961, pp. 321-334.
- [34] L. Pendrill, *Quality Assured Measurement: Unification Across Social and Physical Sciences*. Springer, 2020, ISBN 978-3030286972.
- [35] A. Maul, L. Mari, M. Wilson, Intersubjectivity of measurement across the sciences, *Measurement* 131 (2019), pp. 764-770. DOI: [10.1016/j.measurement.2018.08.068](https://doi.org/10.1016/j.measurement.2018.08.068)
- [36] L. Mari, M. Wilson, A. Maul, *Measurement Across the Sciences*. Springer Ser. Meas. Science and Technology, 2021, ISBN 9783030655587.
- [37] L. Mari, Is our understanding of measurement evolving?, *Acta IMEKO* 10(4) (2021), pp. 209-213. DOI: [10.21014/acta_imeko.v10i4.1169](https://doi.org/10.21014/acta_imeko.v10i4.1169)

- [38] M. Wilson, W. Fisher, Preface, *Journal of Physics: Conference Series* 772 (2016) 011001.
DOI: [10.1088/1742-6596/772/1/011001](https://doi.org/10.1088/1742-6596/772/1/011001)
- [39] E. Costa Monteiro, Measurement Science Challenges in Natural and Social Sciences, *IOP Conf. Series: Journal of Physics: Conf. Series* 1044 (2018) 011001.
DOI: [10.1088/1742-6596/1044/1/011001](https://doi.org/10.1088/1742-6596/1044/1/011001)
- [40] M. Wilson, W. Fisher, Preface of the special issue, psychometric metrology, *Measurement* 145 (2019) p. 190.
DOI: [10.1016/j.measurement.2019.05.077](https://doi.org/10.1016/j.measurement.2019.05.077)
- [41] M. Weber, *Methodology of social sciences (1903-1917)*, Routledge, 2017, ISBN 978-1138528048.
- [42] E. Durkheim, *Les Règles de la Méthode Sociologique (1894)*. UltraLetters, 2013, ISBN 978-2930718408. [In French]
- [43] H. Alpert, *Emile Durkheim and his Sociology*. Columbia University Press, 1939, ISBN 9780231909983.
- [44] E. Durkheim, *De la Division du Travail Social (1893)*, Presses Universitaires France, 2007, ISBN 978-2130563297. [In French]
- [45] D. Della Porta, M. Keating, *Approaches and Methodologies in the Social Sciences: a Pluralist Perspective*. Cambridge University Press, 2008, ISBN 978-0521709668.
- [46] E. Durkheim, *Le Suicide: Étude de Sociologie (1897)*, Hachette Livre Bnf, 2013, ISBN 978-2012895508. [In French]
- [47] A. Anter, S. Breuer, *Max Webers Staatssoziologie: Positionen und Perspektiven*. Nomos Verlagsgesellschaft, 2007, ISBN 978-3832927738. [In German]
- [48] M. Llanque, *Max Weber, wirtschaft und gesellschaft. Grundriss der verstehenden soziologie, Tübingen 1922*, in: *Schlüsselwerke der Politikwissenschaft*. S. Kailitz (editor). VS Verlag für Sozialwissenschaften, 2007, ISBN 978-3-531-90400-9, pp. 489-493. [In German]
- [49] R. Holton, Max Weber and the interpretative tradition, in: *Handbook of Historical Sociology*. G. Delanty, E. F. Isin (editors). SAGE, London, 2003, ISBN 978-0761971733, pp. 27-38.
- [50] M. Weber, *The Protestant Ethic and the Spirit of Capitalism (1905)*, Merchant Books, 2013, ISBN 9781603866040.
- [51] L. A. Coser, *Masters of Sociological Thought: Ideas in Historical and Social Context*, 2nd ed. Harcourt Brace Jovanovich, New York, 1977, ISBN 0155551302 9780155551305.
- [52] E. Klüger, *Análise de correspondências múltiplas: fundamentos, elaboração e interpretação*. BIB - Rev Bras Inf Bibli em Ciências Sociais, (86) (2018), pp. 68-97. Online [Accessed 24 April 2023] [In Portuguese]
<https://bibanpocs.emnuvens.com.br/revista/article/view/452>
- [53] S. F. Suglia, L. Ryan, R. Wright, Creation of a community violence exposure scale: accounting for what, who, where, and how often, *Journal of Traumatic Stress* 21(5) (2008), pp. 479-486.
DOI: [10.1002/jts.20362](https://doi.org/10.1002/jts.20362)
- [54] S. L. Belvedere, N. A. De Morton, Application of Rasch analysis in health care is increasing and is applied for variable reasons in mobility instruments, *Journal of clinical epidemiology* 63(12) (2010), pp. 1287-1297.
DOI: [10.1016/j.jclinepi.2010.02.012](https://doi.org/10.1016/j.jclinepi.2010.02.012)
- [55] JCGM 200:2012, *International Vocabulary of Metrology – Basic and general concepts and associated terms*, 3rd ed., Paris: Joint Committee for Guides in Metrology, 2012. Online [Accessed 24 April 2023]
<https://www.bipm.org/en/committees/jc/jcgm/publications>
- [56] O. D. Duncan, *Notes on social measurement: Historical and critical*, Russell Sage Foundation, New York, 1984, pp. 38-39.