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Standards project the future

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Abstract: Standards are shown to be fundamental to measurements and measurements emerge with early agrarian civilizations. This paper proposes that each of the six human civilizations: hunter/gatherer, agrarian, city state, industrial, information, and the future, may be better understood by examining the general form of standards necessary for that civilization. Then the latest form of standards offers some insight into future value systems.

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Standards in some form appear in all human societies and have been used for thousands of years.[i] Such ubiquity and increasing use indicate a fundamental requirement for the existence and function of standards. This paper identifies that each emerging human civilization also generates a new form of standards, termed a succession of standards.[ii] Yet, in physics, the simplest standard units of a measuring instrument are assumed to be arbitrary (except metrology) and are often treated as unity in calculations i.e., of no significance to the calculation. Measurement standards identify that standards are only arbitrary in the first use and are significant in all measurement comparisons.

1. Measurement standards

In 1893 Lord Kelvin said, "When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind: it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of *science*, whatever the matter may be." [iii]

Measurements are the beginnings of science. Standards are the beginnings of measurements. And measurement standards emerge at the beginning of civilization. All physical measurement quantities consist of a numerical value and a separate property[iv] expressed in units, with its own standard numerical value. One or a combination of the seven BIPM physical measurement standards, e.g., for metre, kilogram, or second, define the numerical value of the unit of a physical property (e.g., length, mass, time).[v]

Consider the measurement results: 50 metres, 10 kilograms, 2 seconds, where 50, 10 or 2 are the numerical values and the property's units are metres, kilograms, or seconds. In a measurement process, the measurand (that which is measured) is relative to a unit standard or factor thereof, represented by (but not exactly equal to) an interval on a measurement instrument's scale.

In physics theory today, a calibrating instrument is assumed to be solely for the purpose of correcting the measurement instrument and a physical standard is considered arbitrary.[vi] However, a relative measurement system, which includes the calibrating instrument and standard, is fundamental to any theory of measurement for three reasons:

1. A measurement is a comparison of two or more things with the same property.[vii] An example of a comparison without a common property: "comparing apples to oranges". The property of each scale or physical measurement instrument, is defined by a unit standard, making measurement result comparisons possible.
2. The unit standard, or factor thereof, defines the numerical value of each interval of a measurement instrument via a calibration process.
3. The distribution of the numerical values of each measurement instrument's interval relative to the unit standard determines the precision of the measurement instrument.

These three reasons identify that calibration to a measurement standard is required to define the property measured, define the numerical value of the unit standard and determine the precision of the measurement instrument. Standards are necessary for a comparable measurement to occur and only arbitrary in their first use.

2. Standardization

Standardization, the establishment of a standard or standards, is a sequence of three processes: design, implement, and use, that occur to establish a standard (see Table 1).[viii] The three processes may be accomplished by different groups. These groups are often not mutually exclusive, that is, one company or even one person or may represent a designer, builder/developer or end user at different times. A government may require a standard (then termed a regulation) which forces the three processes. The three standardization groups identify how the establishment of standards is diffused through a society.

Standardization processes	Standardization groups
Design a standard	Designers
Implement the standard	Manufacturers/Developers
Deploy the standard	End users

Table 1. The three standardization processes/groups

All three processes must occur for a standard to become established. Each group in this standardization sequence usually calls their part of the process "standardization".

3. The successions of human activity

Measurement standards are an early (and easily definable) succession within the broad history of references and standards identified in Table 2. Beginning about 10,000 BCE with hunter/gatherers, Table 2 identifies how the increasingly complex successions of standards are applied in each of the six major economic periods of human civilization. Since the economic activity in each succession is different, dividing references and standards into these six successions allows for more rigorous study.

	Civilization	Standard Succession	Standards function	Economic Activity
6	The future	Adaptable	Learn and negotiate	Focused information
5	Information	Compatible	Communications	Networks
4	Industrial	Similar	Common designs	Manufacturing
3	City states	Design	Organized measurements	Building
2	Agrarian	Measurement	Counts of common symbols	Agriculture
1	Hunter/gatherer	Symbols	Identify common properties	Trade

Table 2. The successions of civilizations and standards

Table 2 models the evolution of technology. The first three civilizations (1 - 3) apply references (assumed or given rather than defined). The next three civilizations (4 - 6) are more likely to apply specifications (private), standards (public), or regulations (government). Each standards succession expands on the previous succession to support the emerging technology and the more complex economic activity that identifies that civilization. Each standards succession may also be further subdivided. As example the Compatible Succession (5) would include the seven layers of the Open System Interconnect (OSI) model or 5 layers of the Internet model.

Starting at the bottom of Table 2, each succession identifies a new civilization that emerges by applying a new succession of standards to support a new economic activity that increases economic value. The most widely used standards from one succession often continue during other later successions. Each standards succession identifies how the control of early societies with references and later the control of markets with standards occurs and how this control is based upon a new economic activity.

Bartering

Human developments—such as the use of fire, metal, prepared plants, butchery, structures—emerged before recorded history. As early humans found that they could benefit from each other's different developments and resources, they learned to barter. Barter is the first economic advance over the hunter/gatherer civilization and requires more advanced communications. Beginning well before 10,000 BCE, cave art includes a graphic protolanguage using symbols.[ix] These symbols, the first succession, provide the increased communications needed for a bartering economy.

Agriculture

Settled societies, based around agriculture, started about 10,000 BCE,[x] and sometimes had extra food to barter. As communities were established and expanded, counts and measures were necessary to grow enough food in an area or to barter resources with others. The Sumerians, whose cuneiform writing describes bartering transactions, developed standard measures of weight, volume, and length.

A comparison between two measurement results is achieved via a common reference (eventually a standard) currently represented by a unit of measurement (a BIPM symbol). Measurement, the second standards succession, supports greater economic activity.

Building

Beginning about 3000 BCE, the planning and building of larger structures, including wooden ships, emerged in different parts of the world. The seven wonders of the ancient world were human-built structures, which required plans using symbols and measurement. These designs or organized measurements, the third succession, plan and predict the completed structure.

Manufacturing

The first assembly line, producing sea-going galleys, began in Venice, Italy about 1400 at the Arsenale. [xi] Repetitive assembly applies and creates similarity,[xii] the fourth succession, and similar goods increase efficiency. Any manufacturing process produces goods which are similar (Succession 4) to each other. The variation of these goods is measured relative to one or more specifications (private), standards (public), or regulations (government).

An example: while the liter measurement standard ensures the same measure of liquid in a barrel (making bartering fairer), a reference barrel design defines similar construction and shape among barrels. Making each barrel similar offers economic advantages to the barrel maker in manufacturing efficiencies, to the trucker in handling efficiencies, and to the bartender in use and maintenance.[xiii] The combination of these three increases in efficiency creates significant new economic value.

The desire for such increased efficiency, a self-reinforcing effect,[xiv] creates larger and more valuable markets. As a market becomes larger, controlling it also becomes more valuable:

- Patents and copyright—new similarity value systems—allow market control. The first patents emerged in the 1400s in Venice, Italy.
- Cartels emerge, controlling industries and markets, requiring antitrust law.
- Controlling a useful standard (e.g., barrel size) is another form of market control.

Economic control via patents which apply to similarity is of significance in manufacturing. As example, the pharmaceutical industry (drug manufacturers) relies on patents which apply to similar drug chemistry and/or manufacturing process to protect the large upfront expenditures required to develop, test and receive approval for a new drug. Thus the developmental part of the pharmaceutical industry is very supportive of patents while the generic manufacturing part of the pharmaceutical industry is not.

Networks

Networks begin with the standardization of compatibility. In the European Union, standards that define compatibility are often termed Information and Communications Technology (ICT) standards. Notice in Fig. 1 the design of the socket is compatible (has the same interface) with the plug design, but is not similar. All plugs may be similar, and all sockets may be similar. A plug and a socket must be compatible to function, but they are not similar.

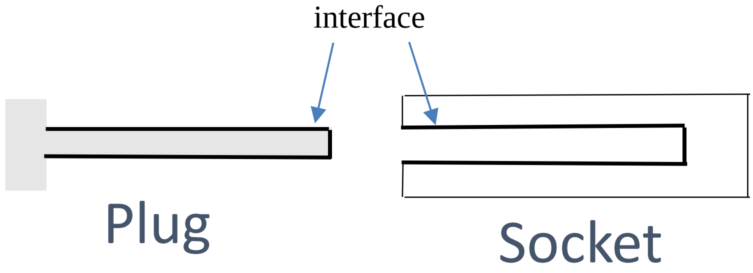

Figure 1. Compatibility (Succession 5.)

Consider the plug in Fig. 1 to be an invention (perhaps patented). Then the patent protects the rights to manufacture all plugs that are similar. Consider the socket similarly: a patent on the socket protects the rights to manufacture all sockets that are similar. However, the interface between a plug and a socket is just an agreement between the plug designer and the socket designer, nothing was invented. But, a patent that applies to a plug or socket may control the interface between the plug and the socket.

Patents on similarity incentivize innovation, but the view of patents on compatibility is nuanced. Communications hardware and software developers are supportive of patents on compatibility standards, as patent royalties on compatibility are an additional revenue source for them. But network providers find patents on compatibility create royalty costs, which they pass on to end users, increasing end user costs and reducing demand for their networks.

Networks began with railroads (~1800), then water and gas distribution companies, electric power, telegraphy, broadcast and telephone communications, among others. The larger the network, the more desirable; the more desirable the network, the larger it will become. This self-reinforcing effect often creates one dominate network which may exhibit monopoly behavior. This effect led to the creation of public utility companies to prevent the less desirable effects of monopolies, since the need to standardize the network interfaces (e.g., pipe threads and telephone connections) to control monopoly behavior was not understood then.

The control of compatible communicating interfaces, via one railroad, one utility company, one telephone system, patents on compatibility or now private Applications Programming Interfaces (APIs)[xv], often become the means to exert monopoly behavior. Unfortunately anti-trust law does not recognize the subtle distinction between similarity instigated by invention and legally supported by patents, and compatibility, based on agreements which can support monopoly behavior.

When a network connection is controlled and not standardized, only the network owner can provide a connection to it. This is another form of market control, so networks are often government regulated as a utility (a new economic activity) to reduce different forms of market control. Additionally, when compatibility is recognized, a connection to a desired network may be standardized, reducing a company's market control and increasing diverse economic activity.

Independent compatibility standards for electronic mail, the Internet, the web, and wireless and cellular networks developed as these networks were created, speeding market growth. Without network compatibility standards, market control is greater and economic activity may be reduced. Network connections by railway gauge, pipe threads, electrical outlets, and telegraph and telephone wires were originally privately controlled, which slowed economic activity and still make multi-country commerce and travel more inconvenient.

The public value of public standardization on the US (AT&T) network became clear when the Federal Communications Commission Part 68 regulations standardized compatibility of telephone connections[xvi] by supporting divestiture of AT&T (reducing market control) in 1984. In fact divesture was not necessary, only public standardization of the telephone connections, which would reduce monopoly control.

After divesture, new companies innovated using the Part 68 compatibility standards and created large new markets for private telephone switches (PBXs), answering machines, data modems, and feature phones. Standardized compatibility, the fifth succession, is part of what makes such innovation possible.

Focused information

Advertising information increases sales for the seller and increases selection and competition for the buyer. Information in the form of political persuasion is powerful in democracies. When this information can be directed to specific individuals (i.e., focused information) it is even more valuable and powerful. Focused information is acquired from an individual's prior history. Focused information began when smartphones connected to networks in 2000. By 2020 focused information was created based upon individual's web searches, geographic location, ecommerce activity, social network links, influencers, and credit activities. Various web services companies support these functions via application programming interfaces (APIs) which are accessible to all end users but only open to developers acceptable to the web services company.

Few web service companies are cartels, but all control their markets using APIs. All APIs could, in theory (and should for health, safety, or antitrust law), allow competing developers to connect. The above history of networks indicates that when controlled interfaces are standardized, greater economic value will be created and more broadly distributed. The same seems likely to be true for APIs.

Standardizing adaptability requires an independently developed and maintained adaptability standard for an API that compares communications layers and functions, negotiates compatibility and learns to provide desirable information. When adaptability is standardized, the control of the API is independent of the web service company, reducing the web services company's market control.

When an API includes the meta-function of adaptability, proprietary control of a public API is possible by transferring—in both directions—a trademarked character string (e.g., “Amazon”) that identifies proprietary ownership. Such trademark strings (a new economic activity) allow companies to control their innovations and still support standardized APIs. The same meta API may be used to identify and negotiate specific national, regional or even personal data privacy requirements, e.g., the EU General Data Protection Regulation (GDPR).

Implementing adaptability, the sixth succession, creates new self-reinforcing effects: individual's desire for specific compatibility, functionality, or security; company's desire for proprietary value (sans monopoly); and a nation-state's desire for control of virtual borders. Adaptable APIs, providing a list of capabilities to each end, will also significantly improve troubleshooting.

As examples of company's that provide web services: Microsoft, Google, Facebook, Apple and Amazon use the private control of APIs and/or the application stores that provide compatible applications to expand their market dominance. These large companies have been fined in the EU and are being examined in US for misuse of their dominate market position. The fines and examinations have not significantly changed their monopoly control. When adaptable APIs are standardized and maintained in public standardization bodies, such companies may be able to find a better balance between the economic rewards for innovation and the unfair advantages of monopoly control.

4. Conclusion

The unit representations of measurement standards in physics are necessary. Standards, created by the three processes of standardization, identify the numerical value of their units, define the properties measured and establish the precision of the results. Measurement standards are a required part of agrarian development and provide a basis for the later four civilizations each with a unique succession of standards. Each unique succession of standards identifies a new form of standards required to utilize each emerging technology and participate in the increased economic activity. Examining the successions of standards helps explain the broad governance and economic trends that have shaped human civilization. Standards are an essential part of measurement, technology and each civilization.

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[i] L. Verman, Standardization, Archon Books , Hamden, CN., USA, 1973, page 1. "A little reflection will show that standardization in its broader view has furnished the base on which nature has created the universe."

[ii] An earlier description of the successions of standards was published in Bridge, the 50th anniversary issue of the Journal of the National Academy of Engineering, January 7, 2021, Vol 50, Issue S.

[iii] Lord Kelvin, Popular Lectures and Addresses vol. 1 (1889) 'Electrical Units of Measurement', delivered 3 May 1883.

[iv] J. C. Maxwell, A Treatise on Electricity and Magnetism, 3rd Ed. (1891), Dover Publications, New York, 1954, p. 1.

[v] BIPM, the intergovernmental organization through which governments act together on matters related to measurement science and measurement standards, the SI base units, https://www.bipm.org/en/measurement-units/si-base-units, 03 December 2022.

[vi] D. H. Krantz, R. D. Luce, P. Suppes, A. Tversky, Foundations of Measurement, Academic Press, New York, 1971, Vol. 1, page 32. "The construction and calibration of measuring devices is a major activity, but it lies rather far from the sorts of qualitative theories we examine here". This three volume work is the foundational text on representational measure.

[vii] L. Euler, Elements of Algebra, Chapter I, Article I, #3. Third ed., Longman, Hurst, Rees, Orme and Co., London England, 1822. "Now, we cannot measure or determine any quantity, except by considering some other quantity of the same kind as known, and pointing out their mutual relation."

[viii] The six dimensions of standards: Contribution towards a theory of standardization, E. Baskin, K. Krechmer and M. Sherif, *Management of Technology, Sustainable Development and Eco-Efficiency*, edited by Louis A Lefebvre, Robert M Mason, Tarek Khalil, Elsevier, 1998, page 53.

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[xiv] Arthur WB. 1988. Self-reinforcing mechanisms in economics. In: The Economy as an Evolving Complex System, eds Anderson PW, Arrow KJ, Pines D. Boston MA: Addison-Wesley Publishing Company.

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[xvi] von Alven WH. 1983. Designing telephone and data equipment for the new competitive environment. IEEE International Conf Communications Record 1:405–409.