Service-Value and Nash-Equilibrium Pricing: An Axiomatic Methodology

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Abstract

We present a normative methodology, for value-pricing B2B services, using a Nash Equilibrium mechanism. Value is fundamental to any service, yet it has defied a definition. The literature is conspicuously silent on how to define value, but abounds in richly descriptive characterizations. To overcome this deficit, we focus on the financial economics of service-value. We formulate an *axiomatic definition* and a *differential equation* that embodies the idea of service-value. We specify a set of value axioms and multidisciplinary postulates that coherently form our service-value constructs. Value-pricing is challenging. It is natural that providers desire a high price and customers want a low price. Realistically, both will agree on a win-win price. To uncover this price, we specify an algorithm to reveal the Nash Equilibrium. Once agreed, it validates providers' and customers' commitments, and payment obligations. Service value is *cocreated* by both provider and customer. For a reciprocal process, its treatment is remarkably asymmetric favoring the customer. We argue that one-sided descriptions of *value-in-use* and *value-proposition* are limiting mental models. We propose the additional ideas of *value-from-use* and *value-supposition* to strengthen the conceptual symmetry of cocreation. Our work reveals a critical gap in service science, metrology. Metrology, the science of measurements, is absent from service-science. Service-value is silent on the questions of quantities, units, scales, measurement principles and instruments. We argue for a call to action for Service Metrology. We sketch a roadmap of actionable suggestions to get started.

Key words: *pricing services, value-pricing services, services Nash Equilibrium, value co-creation, service science, services metrology*.

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Introduction

Pricing is an important strategic tool for any business. It influences demand, shapes usage, and leaves a lasting impression on customer relationships (e.g. Piercy *et al*. 2010). And it "has a huge impact on financial results … and other instruments of the marketing mix" (Hinterhuber 2004). "On average, a 5% price increase leads to a 22% improvement in operating profits" and a "12% and 10% corresponding increase in turnover and cost of goods sold", far more than other tools of operational management (*ibid*). Yet, in spite of these benefits, value-pricing services has not drawn much attention.

Scholars segment pricing strategies into three categories: cost-plus pricing, competition-based pricing, and customer value-pricing (*e.g*. Hinterhuber 2004, Anderson & Narus 1999, Avlonitis & Indounas 2005). In spite of its strategic importance, pricing is "neglected by managers … received little academic investigation … [assumed as] a zero-sum game" (Hinterhüber 2004). These issues motivate our goals for this paper: to present a methodology for value-pricing B2B services using a Nash Equilibrium mechanism. A Nash Equilibrium is a situational condition that exists when a provider's *and* a customer's service-value objectives no longer incent *either* party to seek more gains (*e.g*. Romp 1997). For example, the classical supply and demand curves' intersection. But to develop a value-pricing methodology, we face an immediate and direct problem. *The literature is conspicuously silent on a definition of service-value*. Among scholars, there is no conclusive consensus on the key properties that define service-value. Thus, we must begin by specifying a definition for service-value. And we to introduce *normative* axioms and *postulates* grounded on first-principles of product-service systems (Tang 2009) and applicable axioms and postulates from related disciplines. These rules are not arbitrary, the objective is to ensure our value-pricing methodology is aligns appropriately with other sciences. We consider science as *Wissenschaft,* not only as investigating domain knowledge, but also as the systematic approach for accumulating effective knowledge. To us science includes natural science, engineering, and the social sciences.

The remainder of this paper is structured as follows. Section 1.0 is a literature survey to learn the state-of-the-art and scholars' views of contemporary issues. In Section 2.0, we present a definition for service-value, analyze the nexus and dynamics of service-value cocreation. We specify an algorithm for our value-pricing methodology, to create a Nash Equilibrium condition. In Section 3.0, we discuss a significant gap in service science, *viz*. the conspicuous absence of metrology, the science of measurements. We propose an action plan. In Section 4.0, we discuss the service science's core concept of value cocreation. We discuss its asymmetric treatment in the literature. For example, the literature on *value-in-use* is extensive, but silent on *value-from-use*. We attempt to begin closing this gap. Section 5.0 closes with a summary of our conclusions, contributions, and next steps.

This article departs from the majority of other works service value-cocreation; it does not depend exclusively on qualitative narratives. Such narratives are used to supplement our quantitative and analytic approach to the study of services. Hence, some portions of this article include some abstract ideas and intricate mathematics. We use the US skiing sign, ♦♦♦ for "caution, steep terrain", to signal unfamiliar abstract arguments or harder passages with some mathematics in the text. Readers may wish to skim these sections, but to not skip them completely.

1.0 Literature review

1.1 Value Pricing

There are many definitions in the literature for value-pricing and its synonym value-informed pricing, but methods for value-pricing are rare. Kotler (1999, 102) is an exception, he shows how DuPont value-prices using value-bundles. He also argues how higher prices can be more value (Kotler 1980, 392). Similarly, Anderson & Narus (1999, 188) argue that "price should be set in relation to market offering's value", and convincingly argues that price≠value. Others offer qualitative advice, *e.g.,* value-price as "… the method of setting a price by which a company calculates and tries to earn the differentiated worth of its product for a particular customer segment when compared to its competitor". This idea applies equally to services *e.g.,* Nagle & Holden (1999) in Hinterhuber (2004). Ingenbleek (2007) states value-informed pricing "… as the extent to which a firm uses information in the process of price determination on the perceived relative advantages that if offered and how customers will trade off these advantages against the price (which has yet to be determined)[1]. On value-pricing, Kotler (1999) writes that sellers can "estimate the most the buyer would pay for the offering … don't charge that price …. charge something less – the value price - to leave the buyer with some 'consumer surplus'". Taking the customer's perspective, Zeithamel & Bitner (2000) write value-pricing "[… is widely used term has come to mean 'giving more for less' " … it involves assembling a bundle of services that are desirable to a wide group of customers then pricing them lower than they would cost alone."

Ingenbleek (2007) presents a comprehensive survey of the literature on value-pricing and judges "the body of literature [on pricing] is highly descriptive." He finds the literature is highly fragmented lacking integration that value-pricing receives little theoretical academic investigation. "The stream of research … is dominated by survey research, often limiting statistical analyses to descriptives … very few studies focus on the question of which practices are successful and which are not". The descriptions' key focus center on the idea of value co-creation, and "treating value creation as an all encompassing process leaves the underlying *locus* of value unclear" (Grönroos & Voima 2012). Barely visible are discussions of services' first-principles (*e.g.,* Tang 2009), which underpin descriptions.

A characteristic aspect of descriptive literature, though illustrative and descriptive of how value-pricing is practiced in the real world, have limited theory development (Ingenbleek 2007). The key questions are how rigorous is the practice, what first principles are revealed and reinforced by a description, and whether the practice is a gateway to a science. Therefore, why a description is, in fact, a general case of a phenomena that is generalizable and perhaps even extensible by other first principles in a cumulatively consistent, logical way, with more insight that enables progress of service science. Descriptive literature plays an important rôle; but it must lead to useful pathways to theory (Sutton & Staw 1995). Grönroos & Voima's (2012) judgment that "research insights on pricing practices are often not cumulative" is particularly insightful and meaningful. Value-pricing, in B2B, needs a frugal set of normative axioms to underpin value-pricing's theorical development. This is a serious gap that we will try to close in this paper. Possibly the most significant finding from the literature is that "service organizations pay very little attention in adopting customer oriented methods… They tend to use the traditional cost-plus methods …"

[1] Parenthes are from Ingenbleek (2007).

Managers are chided "to move away from these simplistic cost-plus formulas and treat pricing from a customer's point of view in all steps of the pricing process (Avlonitis & Indounas 2005).

1.2 B2B market with DMUs

Our unit of analysis will be the B2B market, where commercial transactions for products and services are businesses with decision-making-units (DMUs). In the remainder of this article, there will be no discussions on B2C or B2B services that do not have organizational DMUs. Price, in B2C markets, is committed by a consumer without a formal approval process other than the customer's own mental process and judgment (Lilien 2016, Exhibit 1, IBM 2014). This does not mean we do not think consumers as co-creators of value. The B2B and B2C is **not** a false dichotomy. The existence of the B2B2C business value-chains and value networks is very evident (Bitran 2000). In such networks and constellations of B2B and B2C units; as sketched by Kohtamäki & Rajala (2016), Vargo *et al.* (2020), clearly show the presence of vertices representing terminal B2C links. In our "meso-zooming", we consider significant that B2B, B2C, and B2B2C bilateral interacting nodes form networks with B2C customers. This is in contrast to a "zooming out" to a more transcending … it is all B2B (Vargo & Lusch's 2011)". All B2B is excessively abstract, precluding B2C and any *axiomatic separation* (Suppes 1960) in the services market. All B2B precludes nuanced explanatory power about segments in the services market. The "all B2B" aperture is excessively expansive and "exposes a risk of premature black-boxization of the concept" of value co-creation and its interactions (Leroy *et al.* 2013).

Therefore, we elect to meso-zoom into the B2B that have DMU's (decision making units) in value co-creation and purchase decision processes (Wind & Cardozo 1974). Johnston & Chandler (2012) provide an overwhelming literature survey that argues the importance of DMUs. DMUs are also called " 'organizational buying centers' in recognition of the increasing importance of technology, supply chains, and contemporary emerging issues" (e.g. Grewal *et al.* 2015). B2B with DMUs is a *bona fide* specification for a market segment (Choffay & Lilien 1980). Sales and purchase decisions in B2B markets are truly complex and complicated. Complexity is an inherent technical and structural property of a system; but complicatedness is the cognitive load complexity imposes on the DMU and its management (Tang 2001). Complexity cannot be wished away, on the contrary, it increases relentlessly by all participants in the interior and exterior of a complex system. DMUs are designed to be multidisciplinary and multifunctional in an organization to reduce complicatedness for senior executives. DMUs are sense-making mechanisms to more accurately and effectively decode complexity (Weick 1195) for senior management to reach uncomplicated and accurate judgments. DMUs are also sense-making mechanisms to more accurately and effective decode exterior and interior complexity (Weick 1195) to enable executives to make uncomplicated and accurate judgments (Tang 2001). B2B cross-functional bilateral relationships are key to enabling value co-creation interactions. They enable allocation of resources in more effective and efficient ways (Enz & Lambert 2012). These reasons motivate businesses to form DMUs and implement a variety of creative processes to improve consensus, balance diverse interests, and negative corrosive and coercive influences, during purchasing life cycle. This gives a voice to those, who will ultimately implement and held accountable (e.g. Ho *et al.* 2010, Choffay & Lilien 1980, Venkatesh *et al.* 1995). Dedicated pricing teams can maximize knowledge sharing and capabilities to create business success

(Liozu et al., 2012). Executive decision-making research shows that multidisciplinary teams form collectively more complementary Team Mental Models (TMM) (Mohammed et al. 2010) and as a result team performance enhances organizational effectiveness (Tang *et al.* 2018, chapter 3). Hence, under proper leadership, a DMU, as an ensemble, is collectively more intelligent than any single individual participant.

For value-pricing services, the "locus of participants" (Grönroos & Voima 2012) in value cocreation must not be "limited to customers' "possession, usage, mental/imagined states", but must include providers (Grönroos & Gummeerus 2014). This balance of participation will give value co-creation a richer and more nuanced meaning. The buying DMU research, like the value-pricing literature "tends to be descriptive, with an over-reliance on anecdotal information so that research is devoid of any theoretical foundation…" (Spekman & Gfønhaug 1986). *We will propose an axiom-set based methodology that is consistent with scientific norms.*

1.3 Methods and Normative Methodology

For a given discipline, a method is a procedure predicated on a mental-model for the practice in the "right way". It is about *what* you do, *how* you do it, and *why* you do it (Caws 1966). "Right way" means that outcomes will be "better". "Better" means that the outcomes will be more satisfying and add to the corpus of useful knowledge and effective practice. There is also a social dimension. "Consistent use of a method makes you member of a community" of practitioners who share the same beliefs (Wendell 2008). The Scientific Method is a widely accepted metal-model for the practice of science in the "right way" (e.g. Feynman 1964, Andersen & Hepburn 2009). Scholars also use the term "canonical" as a synonym for "the right way" to communicate the singular importance of the "right way". In science, *there are many accepted criteria to underpin the "right way"; these are stated as rules, axioms, and first-principles. These are norms for the praxis*. A method that has established norms is called a normative method. Every method has a superordinate goal that justifies and gives ontological meaning to its existence and usage. For example, the goal of science is to understand nature; the goal of engineering is to build useful artifacts (Seering 2003), the goal of rational decision-making is to construct alternatives and to be enable selection of the most rational choice to maximize outcomes (e.g. Baron 2000, Bazerman 2002). In summary,

- A method is a canonical way of thinking and solving problems.
- A methodology is an instantiation of a method.
- A normative method's specified set of rules enhance to validity the created knowledge.
- Norms inform the practitioner what is the "right way" in the praxis.
- No method is 100% right all the time.

There is a distinction between a method and a methodology. They are frequently conflated (without too much damage). Chemists, biologists, epidemiologists, seismologists are all scientists. But each profession has idiosyncratic *instantiations* of the Scientific Method, which are discipline, domain, or problem specific. *These instantiations are more accurately called methodologies*. For example, classical mechanics has its methodologies based on Newtonian or Hamiltonian mechanics. Quantum mechanics, because phenomena are at the Plank-scale, has a different set of methodologies. Similarly, theory of real numbers is grounded on the Peano axioms, from which the operations of arithmetic follow. In geometry there is a very clear distinction between Euclidean and non-Euclidean geometry.

Both focus on the fundamental ideas of points, lines, distances, and so on. But the latter disposes of the Euclidean axiom that asserts that non-parallel lines must intersect on a plane. But non-parallel lines do not intersect on the surface of a sphere. This is non-Euclidian geometry. It is *separation axioms* like these that permit meaningful predictions for distinct domains of knowledge inquiry (Suppes 1960). Which is why we do not include B2C in this paper.

For our value-pricing methodology of B2B services, normative rules are specified as axioms. The axioms are multidisciplinary and integrated into mathematically coherent constructs (Bacharach 1999). The axioms are derived from our definition of service-value, something that is notably absent in the literature.

We need a normative B2B value-pricing methodology, because the literature is largely descriptive, with barely-visible theory-development, the result is a dearth of knowledge accumulation. Accumulation *per se* does not indicate scientific progress. For example, there is much accumulation in astrology, a pseudo science (Hansson 2017). "Science is built with facts, as a house is with stones. But a collection of facts is no more a science than a heap of stones is a house" (Poincaré 1908). Accumulation, *per se*, is a necessary condition, but insufficient. The accumulation must ultimately become an edifice of stable beliefs that represents the intellectual embodiment of a scientific discipline. The mortar that holds the stones together are the axioms of the system that drive new concepts, and propel intellectually richer and more productive ideas and knowledge (Wolpin 2013). This is the key property of "genuine accumulation" in "normal science" (Kuhn 2012). Crisis, contradictions and apparently unexplainable results, are inevitable. But they may signal the emergence of a new paradigm (Kuhn 2012). A new paradigm then becomes an engine that pushes scientific progress. *Service Science needs methodologies to accelerate genuine accumulation*. Ahead are big challenges in B2B (Lilien 2016); they include "methodological issues"; like the rôle of qualitative research, case studies, and development of *metrics* (ibid).

We will propose a services methodology, which norms that align with normal science (Kuhn 2012). A few examples will make these ideas clearer. The goal of the Scientific Method is: to understand nature. To *understand nature* in "the right way" one must follow the general procedure of the Scientific Method (e.g. Feynman 1964). Feynman sketched something like this: (i) observe some aspect of the universe, (ii) create a tentative description, a hypotheses, which he called "guesses", (iii) use the guess to make predictions, (iv) test with experiments, analyze results to confirm guesses' consistency with the real world, (v) reflect on the results and repeat previous steps as required.

In mathematics, the goal is to develop "system[s] of conclusions from definition and postulates that must be consistent …" (Courant *et al.* 1996). The following steps outline the mathematical method: (i) define/specify an axiom set, (ii) define rules of inference, (iii) prove lemmas, propositions, and theorems, (iv) extend and generalize. Set theory starts with a definition of a set, the ⋂ and ⋃ operators, articulated axioms. On these foundations, deeper and more insightful theorems are proven. Topology begins this way.

For rational decision-making (*e.g.,* Bazerman 2002), the goal is to formulate decisions that will produce optimal or maximized results. To do so, the recommended procedure is: (i) frame and define the problem/opportunity facing the decision-maker, (ii) specify objectives, (ii) specify alternatives, (iv) analyze alternatives, (v) select the choice alternative, (vii) communicate the learning from decision life cycle. As another example of

the separation theorem (Suppes 1960), rational decision-making can be separated by the bounded rationality. Complex sociotechnical decisions cannot be optimized or maximized, one must satisfice (Simon 2001). Or decision-makers can choose to make robust decisions instead of maximized decisions. Robust decisions are designed and engineered for insensitivity to uncertainty when uncontrollable factors are not eliminated but systematically addressed (Tang 2018). Next, we specify our axioms and the reasons why it is key to value pricing.

1.4 Normative Axioms

We need normative axioms because unlike planetary motion, or charged particles attracting each other, value-pricing decisions do not occur spontaneously. They are acts of human will. We need norms, rules, and standards. Normative rules and its axioms enforce rigor, and consistent professionalism. Normative requirement is about how the praxis value-pricing is "done right" in the "right way". Thus, the requirement for rules (norms) that must be followed. Recall that rules are necessary, but insufficient for scientific rigor. Ancient Rome's decision-making rules of haruspicina and augury, though practiced consistently with religious compliance (*e.g.* Britannica, 2020), are not scientifically normative. Normative rules are useful if its application consistently yields ontological and epistemological cumulatively effective results. Axioms play that rôle. We note that no set of axioms is always completely consistent or error free, *e.g.* Arrow's Impossibility Theorem (1950), Ellsberg Paradox (1961), parsimony of von Neuman and Morgenstern axioms (Aumann 1962), Gödel's Incompleteness Theorems (Raatikainen 2021), Euclidean geometry, Newtonian mechanics, and so on. We will say no more about these topics. They are outside the scope of this article.

Let us consider a few examples of norms. An example of domain specific norms are the rational decision paradigm's axioms established by von Neumann & Morgenstern's (1964); *viz.* axioms of completeness, transitivity, continuity, and independence. Similarly, Service-Dominant Logic's (SDL) has five axioms (Vargo & Lusch 2016). Our proposal, for the Value-Pricing rules, includes the Nash Equilibrium as a superordinate rule grounded on services' first-principles (Tang 2009). *Normative rules are not arbitrary, even if consistently applied.*

These fundamental ideas notwithstanding, we must offer concrete actionable guidance of value-pricing norms/axioms. We must move beyond pure positivism (*e.g.,* Bridgman 1927). Chase (1969) offers ten demanding criteria, some of which have been discussed in previous paragraphs. They are: (i) originality, (ii) logical rigor, (iii) disciplinary ethics, (iv) clarity and conciseness, (v) theoretical significance, (vi) mathematical precision, (vii) pertinence to current research, (viii) replicability, (ix) coverage of significant literature and (x) practical. To Mitrouchev (2021) an economist, practical means, (i) applicable to a wide range of choice requirements, (ii) able to address many aspects that are important and people care about, and (iii) given the situation, it can create consensus that "makes individuals *measurably* "better off".

Papers that concentrate on theory building are particularly helpful, *e.g.* Eisenhardt & Graebner (2007) discuss the importance of case studies as a strategy to "developing constructs, **measures**[2], and testable theoretical propositions' to bridge the gap between

[2] Emphasis is due to this writer.

qualitative narratives and theory building. Baharach (1999) in a widely referenced paper provides guidance as to what is good science: the presence of variables, hypotheses, and constructs that come together nto a body of coherent knowledge and practice.

1.5 Value

"Value is perhaps the most ill-defined and elusive concept in service marketing and management" (Grönroos and Voima 2013). "While the concept of value has been bandied about for years, considerable confusion regarding the concept remains. Business and academic researchers continue to struggle with how to define and assess value (*e.g.* Mitrouchev 2021)" and Badinelli (2015) poses this issue as a manifesto. Yet, value is a most fundamental idea of the Service Dominant Logic, SDL, (Vargo & Lusch 2008). An idea that is repeatedly articulated in SDL and the new "core axioms" (Vargo & Lusch 2017). Axiom 2 declares value cocreation as a defining tenet of services, which is universally embraced by students and scholars of service and SDL. Cocreation is a direct result of the Inseparability property of IHIP (e.g. Tang 2009). *The centrality, of value and cocreation and how it is brought into existence, is fundamental. An idea of this prominence must not remain undefined*. "Every definition implies an axiom, since it asserts the existence of the object defined" (Poincaré 1908). "Exactness cannot be established in the arguments unless it is first introduced into the definitions" (Halstead 1905). This is a *de rigeur* practice in every domain of science. For example, the term energy in physics, the idea of numbers in mathematics, the notion of uncertainty in decision-making, the specification of sets in topology, the demarcation of boundaries in systems, and so on. *That value remains undefined is an overdue challenge to service science; it impedes understanding of value cocreation.*

However, in the absence of a precise definition for value, scholars have not been idle. There is a very large number of descriptions and characterizations for value. Value is: difficult to measure (e.g. Karmarkar & Roels 2015, Grönroos 2008, Ulaga 2003); what customers care about (Keeney 1996); a multidimensional and multifaceted construct (*e.g.* Hinterhuber 2008; Liozu *et al.* 2011, Ulaga 2003); a functional, social, emotional, epistemic, and conditional specification (e.g. Smith & Colgate 2007); a "construct with benefit and sacrifice components" (Ruiz et al. 2008); functional, economics, operational, strategic, social, symbolic, emotional, epistemic, situational, environmental properties (Lindsten 2016); phenomenological, always cocreated, multi-dimensional, emergent (Vargo et al. 2017); value-in-use (e.g. Grönroos 2017, Vargo & Lusch 2017); a set of benefits, exchange for price (Anderson & Narus 1999); very useful with a low price and high value (Anderson & Narus 1999); a utility, economic worth, perceived satisfaction, net benefit, means-end, phenomenological (Ng & Smith 2012); the extent to which customer becoming better off (e.g. Ng *et al.* 2010, Grönroos & Voima 2013, Grönroos 2008); personal, customer determines, on multiple levels, longitudinal, formed in visible/invisible spaces, … (Voima 2010); a perception that changes with financial information (Enz & Lambert 2012); set of benefits and utility (Lee *et al.* 2015); and so on. These characterizations are good examples of what complicatedness means; the intensely heavy load imposed on researchers (Tang 2001).

To surmount this cognitive load, scholars also work on what service-value is ***not***. This is very good system-thinking; *viz.* specify the boundaries of an idea. Service-value cannot be: value-in-use, because the service provider's activities [and resources] are involved (Grönnroos & Voima 2012); cocreated, rather it is realized by actors as an outcome of a

commitment to service co-creation" (Hilton et al. 2012). Service-value cannot be the absence of specific gaps as in SERQUAL (Zeithamel & Bitner 2000), which apportions gaps entirely on the provider and none on the customer; an assumption that violates[3] the spirit of the cocreation axioms in SDL (Vargo and Lusch 2016). Disconfirmation and value are different constructs (Bolton and Drew 1991).

If value is such an important, rich and catholic concept, with no definition, then how does a DMU know how much value will the service deliver, and which was cocreated? If you can't define it and you can't measure it; then, is service a science (e.g. Kuhn 2012, Popper 2005) or a pseudoscience (Hansson 2017)? A definition is overdue. Badinelli's (2015) manifesto declares:

> "… nobody has precise definition of value, a model of its construction, or a methodology for evaluating it." … furthermore "Any research in cocreate processes provokes a host of questions about the very objective of cocreation." Indeed, there is an urgency "to advance the disciplines' knowledge of the definition and measurement of value." The crucial question is posed: "How can we measure something that has no precise definition?"

Here are two very salient ideas. One is the fundamental importance of a definition for value and the other is its measurement. As in value for services, energy is the single most fundamental idea in physics. Nobel laurate, Feynman famous for his wit, succinct, and pithy language said this about energy in physics:

> " … we have no knowledge of what energy is[4] … However, there are formulas for calculating the same numerical quantity and we add it together it gives '28' – always the same number."

Between definition and measurability, Feynman (2011) favors measurability. Which is why Badinelli's manifesto (*ibid*) is central to work on understanding value.

1.6 Summary

Value-based pricing is the most preferable pricing strategy in an industrial context (Hinterhuber, 2008; Liozu et al. 2011; Ulaga 2003, Avlonitis & Indounas 2005). Yet "Value is perhaps the most ill-defined and elusive concept in service marketing and management" (Grönroos & Voima" 2013).. "… nobody has precise definition of value, a model of its construction, or a methodology for evaluating it." … " Then: "How can we measure something that has no precise definition? (Badinelli 2015)". The absence of a definition for value and measurement impedes the specification of an effective and useful value-pricing method for research and the practice. What is needed is a method for the practice of a discipline in the "right way" with axioms and postulates so that service outcomes will be more consistent, predictable, and additive to the corpus of effective practice.

2.0 Normative Value Pricing Methodology

> *Value* is what customers *want, price* is what *must be paid. Getting paid* is what providers *want, value* is what they *must* deliver. *When wants-musts are in equilibrium, everyone wins.*
>
> Chinese folk wisdom

[3] Tang & Li have a completed paper. Ready for submission.
[4] This is characteristic of Feynman's "surely you are joking". Of course, he knows what is energy. He wants to emphasize is the importance of measures.

2.1 Definition for Value

We *see how scholars struggle to define service-value. To cut through this problem, we elect a service's economic effect as the property to determine service-value*. (Service has many other important properties that are significant. We defer that to Section 5.0. The goal of a service is to provide benefits to a customer; *e.g.,* make a *customer* economically better off. Customers prefer more economic gains, rather than less, and losses are to be avoided. Economic gains can be measured in monetary units. But, this is only half of the argument. Any service must also make *providers* better off. They too invest time, energy and resources in a service and also expect benefits. *This ontological symmetry in services is frequently overlooked*. This is a bias, a topic we will return to in detail. First, a definition:

Definition: B2B *Service-Value* is extent to which a service engagement's benefits make providers and customers economically better off, albeit in different ways.

Benefits cannot be the same or equal for a provider and a customer. They necessarily have distinct expectations. Each has distinct business models, financial structures, and compensation schemes. In addition, each party brings different skills and resources and to implement a service. Customer-centric bias is incorrect and inappropriate.

Economic value is the most salient and natural property (Gärdenfors 2004) of B2B-DMU services. It is quantitative, with units, scales, and widely accepted ways to measure and evaluate. A *natural property* is "one that is natural for the purposes of problem-solving, planning, memorizing, communicating, …" and "actions in functional spaces" (Gärdenfors 2008). This definition aligns with Anderson *et al.* (1992) seminal declaration that monetary units are the right units for service value for business markets. Other service properties are not excluded by our definition; such as, satisfaction, quality, and others (Woodruff 1997). All contribute, in different degrees, to a more complete understanding of what is service-value and how to measure it. But we must begin at a starting line.

This approach is consistent with physics. For example, what is an electron and how do you measure an electron? An electron is a baryon part of the standard model of subatomic particles. An electron has three measures: mass≈9.109×10^{-31} kilograms, spin=½$\hbar$, and charge of 1.60217662×10^{-19} coulombs. Together, these three quantities present a complete characterization of an electron, *i.e.,* name, quantities to measure, and scaled units. Or how do you measure nuclear radiation? There is no one number. Radiation is atomic decay with the resultant emissions of α, β, and γ particles. For each kind of radiation there is a different measure of quantity and units. For ionizing radiation on the human body, the measure of dosage, in SI units, is a joule per kilogram of recipient mass. *One has to understand the fundamental property and effect of the concept we seek to measure*. This holds for service-value.

2.2 Normative Axioms

For a complex sociotechnical system, identifying and specifying the essential axioms is an extremely complex and very complicated task. Achterbergh & Vriens (2009) tell us how to cut this Gordian knot. *We must rely on our prior knowledge*. Gaugh (2003) states that "Science starts from common sense; the belief that the world is comprehensible to us". Reinforced by experts, these are our value-pricing axioms,

axiom 1. Parity and Chilarity
axiom 2. Units.
axiom 3. Intensity.
axiom 4. Deceleration
axiom 5. No free lunch.

- Applicable to provider and customer, but in different ways.
- Benefits are denominated in monetary units.
- Value = ***f*** (benefits intensity, costs, expenses).
- Value exhibits diminishing returns.
- Provider's and customer's cocreation is not free.

And for consistency with sociotechnical disciplines, we have the following postulates,

- Behavioral economics. Prospect theory (Kahneman & Tversky 2000).
  Losses are experienced more severely than gains.
- Cognitive Psychology. Weber-Fechner law (Dehaene 2003, Dzhafarov & Colonius 2011).
  Perception and stimulus is a logarithmic function.
- Game Theory. Nash Equilibrium (Romp 1997).
  A Nash Equilibrium (NE) exists, when each party's current strategic position does not incent anyone to make more changes to improve their position.
- Corporate Finance. Financial accounting, GAAP and DCF (Weston & Brigham 1997).
  Positive revenues are gains, costs and expenses reduce gains.
- Complex sociotechnical systems. Bounded rationality (Simon 2001) for.
  Maximization and optimization are rarely possible, they require too much data, too much computing, and too much time. Plan and accept satisfactory outcomes, *satisfice*.

♦♦♦ 2.2 Benefits

What's good for the goose, is good for the ganger American folk wisdom

Anderson et al. (1992) presciently wrote that value in business markets must be determined in monetary units. We can calculate value from financial statements (Weston & Brigham 1997). Value now has a name, quantities, units, and scale. It is measurable by using recognized accounting rules and methods. Measurements follow these chains of events:

For provider, the *supply side* sequence is, where → means "cause",

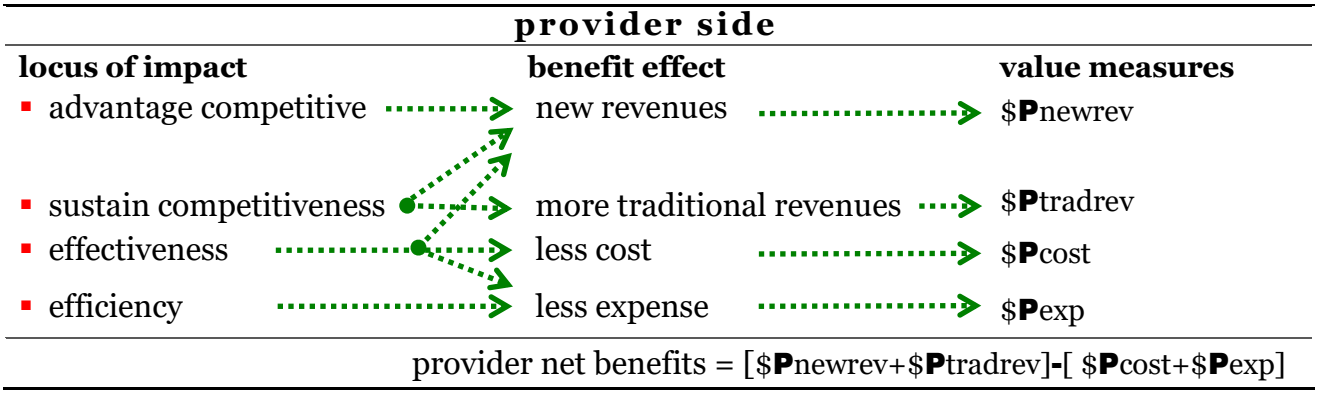
provider service actions → provider effects → provider measurable quantities

And provider service actions → customer service actions, so the *demand* side sequence is,

customer service actions → customer effects → customer measurable quantities

and of course, provider service actions →← customer service actions. This is cocreation. Provider and customer, will cocreate value driven by "better off" expectations. Table 1,

Table 1. **Financial construct for "better off"**. Following an engagement with a customer, a provider this is the "better off" construct and its logic . A provider is better off in four ways: (i) gaining a competitive advantage resulting in new revenues, (ii) remain competitive with more revenues from its existing base with a resulting effect on traditional revenues, (iii) improving costs, and (iv) reducing expenses. The logic of any business is, for the benefits it expects, manage these four essential variables to impact profit in a positive way If done competently, the business will be economically better off. Conveniently these quantities are available in the financial documents of the firm. Consider the period accounting, for a service provider. The **P** denotes "provider".



Following GAAP accounting rules (*e.g.,* Weston & Brigham 1977), and by arithmetic we get calculate *provider's net benefits,* as shown in Figure xx.. Suppose *provider's reservation price* is **$P^{r}price** for a given service. There is a benefit to the provider if adopted at this price by a customer agrees. The **value-from-use** that can be obtained at **$P^{r}price** by a **provider, from** a customer is,

[$Pnewrev+$Ptradrev+**$P^{r}price**]-[$Pcost+$Pexp]=**$P^r**netbenefit (1)

Equation (1) is the **value-from-use** obtained by a **provider, from** a customer for the provided service negotiated at provider's reservation price.

Then we have equation the general equation (2),

[$Pnewrev+$Ptradrev+**$P**]-[$Pcost+$Pexp]=$Pnetbenefit (2)

By the no-free-lunch axiom, $Pnetbenef **is not** created, by the provider with **no** effort, **no** expenditures, or **no** resources.

We now turn our attention to the customer. Axiom 1 stipulates that axioms apply to provider and customer, albeit in different ways. Therefore, the customer's net benefit must **subtract** the price demanded by the provider. Therefore, from the customer's side, the net customer benefits are as in equation (2) where the letter **C** denotes "customer" and **$C^{r}price** is a customer's reservation price for a specific service available to a customer.

[$Cnewrev+$Ctradrev-**$C^{r}price**]-[$Ccost+$Cexp]=$Cbenefit (3)

Equation (4) is the **value-in-use** obtained **by a customer,** from a **provider's** service. Suppose a customer judges the available service at a reservice price of **$C**, then we have the general equation (4),

[$Cnewrev+$Ctradrev-**$C**]-[$Ccost+$Cexp]=$Cnetbenefit. (4)

*The revenues stream, cost and expense quantities in the structures of the provider and client are **not** identical*. Resource configurations being a series of "multiplex interactions" to "create, extend and modify their resource base for improved effectiveness and efficiency (Razmdoost *et al.* 2009). Then for reservation price **$P^{r}price ≠ $C^{r}price.** Providers aspire to gain a higher price than their reservation price; while customers aspire to gain a lower price than their reservation price. It follows that,

value-in-use ≠ value-from-use. (5)

This inequality is strengthened by Edvardsson *et al.* (2011) "asymmetric proposition" in service exchange and value cocreation. This the ***chilarity*** condition of axiom 1. Similar variables, similarly structured, but in one equation **$P**^{r} price is added, and in the other **$C**^{r} price is subtracted. It follows that the accounting of revenues cost and expenses for the provider and the customer are vastly different.

♦♦♦ 2.3 The Value Equation

Value is expressed in monetary units, a ratio scale (Khurshid & Hardeo 1993) that is extensively measurable with simple concatenation operations (Suppes *et al.* 1971). From the axioms and sociotechnical consistency rules, we infer the following about service-value,

- Service-Value, SV, is monotone increasing function of benefits.
- At point where SV=0, i.e. there is no value; thereafter it is negative.
- Provider *Benefit-Intensity ratio* is $BIR_{provider} = f($**(**provider benefit**+**$**P**$**)**/(costs+expenses)**)**
  Customer *Benefit-Intensity ratio* is $BIR_{customer} = f($**(**customer benefit**-**$**C**$**)**/(costs+expenses)**)**
- For a provider, change in value is proportional to change in benefit intensity ratio,

$$\Delta V = \boldsymbol{\alpha} * \Delta B/B$$

α*ΔB/B is the uplifted benefits-intensity ratio by **α**. **α** is a mandated company-intensity multiplier, an aspiration factor. It is a heuristic. We have,

$$V = \boldsymbol{\alpha} * dB/B.$$

Hence, $V = \log \boldsymbol{\alpha} * B$.

Using this equation, define **V**alue-for-**P**rovider, **V4P** by log(*Provider Benefit Intensity ratio)*

$$V4P = \log[\boldsymbol{\alpha}*(\$Pnewrev + \$Ptradrev \boldsymbol{+} \boldsymbol{\$P})/(\$Pcost + \$Pexp)]] \quad (6)$$

Equation (6) is the *Weber-Fechner Law* (e.g. Dehaene 2003, Dzhafarov & Colonius 2011). It states that perception is a logarithmic function. This also aligns with prospect theory, which states that losses are experienced more severely than gains (Kahneman & Tversky 2000). Equation (6) is also multi-disciplinary. *It is descriptive and* ***analytic.***

Similarly, we have the **V4C** equation. **β** is the customer's company mandated parameter. **$C** is subtracted in the numerator. **V4C** is the log of the Customer Benefit Intensity ratio.

$$V4C = \log[\boldsymbol{\beta}(\$Cnewrev + \$Ctradrev \boldsymbol{-} \boldsymbol{\$C})/(\$Ccost + \$Cexp)]] \quad (7)$$

2.4 Calculated Example of Nash Equilibrium

Consider equation (6) with the following values, **α** =20, [$Pnewrev+$Ptradrev]=$600], **$P**, and [$Pcost+$Pexp]]=$60, then,

$$V4P = \log \boldsymbol{20} * [\boldsymbol{(}600 + \boldsymbol{\$P})/\$60] \quad (8)$$

And Figure 1 is a plot of equation (8).

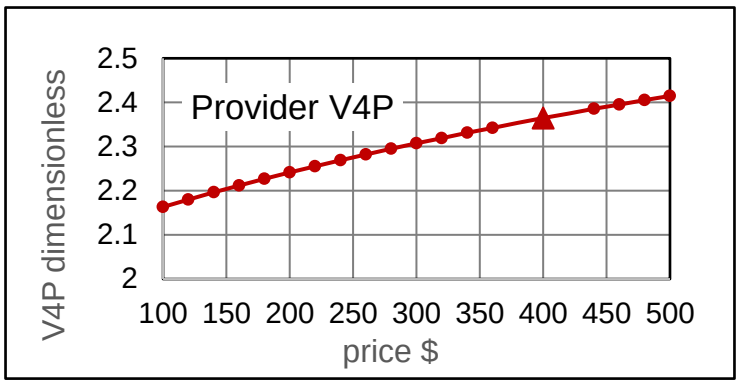


Figure 1. Plot of Provider Value V4P.

This is a specific numerical example of equation (6) as expressed by equation (8). V4P is monotone increasing. **$P** is the price for the service that needs to be determined for a Nash Equilibrium. The reservation price of $400.00 is marked with a triangle.

For equation (7) with **β** =25, [$Cnewrev+$Ctradrev]=$600], **$C,** [$Pcost+$Pexp]]=$70,

V4C=log **25***[**(**900-**$P**)/$70]. (10)

This equation's plot is below, Figure 2.

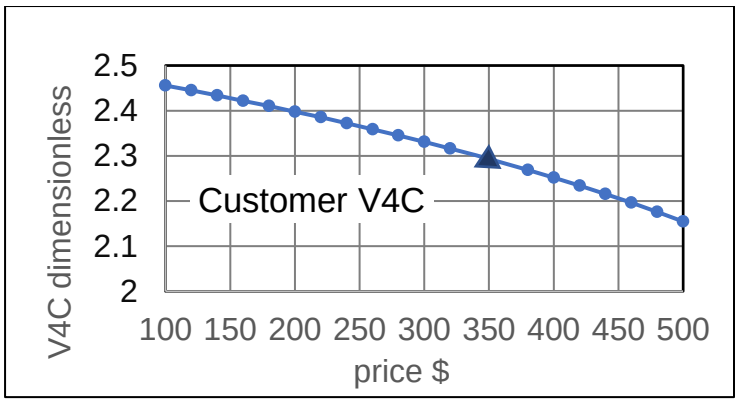


Figure 2. Plot of Customer Value V4C Equation (10).

This is a numerical example of equation (7), the counterpart of equation (6) with β=25. Its new and traditional revenues are $$900.00. (cost+expense)=$70.00. **$C** is the price for the service that needs to be determined by the Nash Equilibrium. The reservation price $350.00 is marked with a triangle.

Consider Figure 1, the provider's side V4P, pictured by the **red** line. **$P**^{r}=$400.00 is the provider's reservation price (red triangle). If the provider insists on higher prices than $400.00, shows the provider as aggressive, with a strong pricing appetite. This attitude, or a flexible one, is revealed by the interactions during the exploratory buying phase.

Now consider Figure 3, the customer's V4C, pictured by the **blue** line. $**C**^{r}=$350.00 is the customer's reservation price (blue triangle). Suppose the provider is adamant about its $400.00 reservation price, then no deal is possible. On the other hand, if the customer is flexible, then a deal is possible. If both are flexible, then a deal is likely. Their mind set is revealed during the exploratory buying phase of provider and customer interactions.

In this example, to establish a Nash Equilibrium: the buyer has to be prepared to pay more than it wishes, and the provider has to be ready to lower its price. We have simplified the process by not addressing complicating issues. For example, the issues of moral hazard and adverse selection (*e.g.* Koszegi 2014), information asymmetry (Stiglitz 2001) are also serious issues in price negotiations. We defer discussions on this for future work.

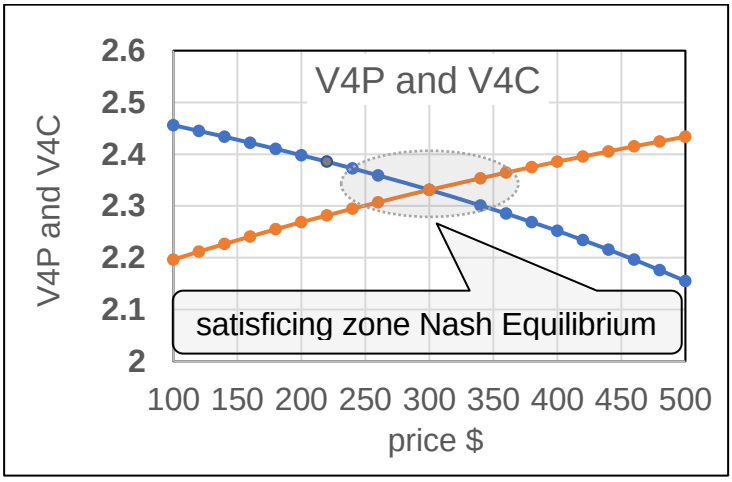


Figure 3. Plot of Provider Value V4P and V4C intersection.

This plot puts Figure xx and Figure yy together to uncover where they intersect. At this point both V4P and V4C have the same value. Provider's asking price is the same as customer's buying price, $300.00. Neither party has a motive to make changes, which become showstoppers. This is the Nash Equilibrium. A deal can be reached. This price becomes the **transaction price,** which is what everybody desires.

♦♦♦ 2.5 Cocreation Phases

In this section, we zoom-in on the cocreation process. We decompose it into three phases, before, at, and after commitment of a transaction price uncovered by the Nash Equilibrium. This will reveal more nuanced and textured details of the cocreation process.

We adapt Grönroos & Voima's (2012) value creation "joint spheres" and Rajala *et al.* (2015) "domains of value conceptions" in Figure 4. Recall, we developed analytic expressions for provider and customer economics in the cocreation process. One expresses the estimate by the customer's **value-in-use** in the *customer's sphere*. Therefore, value-in -use is a customer's expectations and experience from a provider's service, which a customer will confirm and evaluate after the service is implemented. The other is an estimate by the provider of **value-from-use** in the *provider's sphere*. Therefore, value-from-use is a supposition that a provider will reify and confirm when the service is implemented.

A Nash Equilibrium is unlikely to be established spontaneously. In B2C markets, this is possible to occur, like a fast-food lunch. In B2B markets, this is most rare. Providers and customers engage in many discussions before making commitments about price. For high price engagements, provider and customers typically sign cocreated Memorandum of Understanding (MOU), Statement of Work SOW), and later actually commit to a price with attachments documenting the scope and scale of a service engagement, Tables 1, 2, and 3. This is both a value cocreating and a value cocapturing process (Lepak et al. 2007,Bowman and Ambrosini 2000).

Figure 4. Value cocreation "joint spheres" and "domains of value conceptions". Cocreation is a joint process between a provider and a customer. The nexus of this process takes place in a sociotechnical space of *joint spheres* and *of value conception* where the negotiations take place to develop a Nash Equilibrium. Value-in-use lies in the customer sphere. Value-from-use lies the provider sphere. Value proposition applies to the customer in the customer sphere. Value supposition applies to the provider who supposes it will accrue benefits.

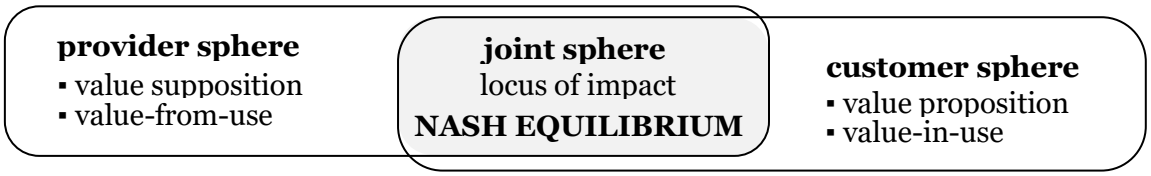


Table 2. ***ex ante* exploration phase**. In south-west quadrant **3**, there is no service opportunity; provider has no idea of its V4P and likewise customer has no idea of its V4C. In **1**, the provider has a V4P and its reservation price **$P^r**, but customer has no V4C equation. Provider can only estimate customer's value-in-use and **$C^r.** In **4**, the customer has a V4C and its reservation price **$C^r**, but customer has no V4P equation, provider can only estimate provider's value-from-use and **$P^r**. In **4**, customer and provider have sufficient information, such that provider can develop a Statement of Work (SOW) for the customer. At this phase, both provider and customer should firm-up their findings and work to converge to a Nash Equilibrium. Explore and interact more.

***ex ante* explorations**

provider V4P in place	**customer V4C in place: none**	**customer V4C in place: yes**
yes	▪ explore using **$P^r** to uncover **$C^r** to estimate value-in-use. **1**	▪ stay flexible, get info, prepare Statement of Work, and negotiate to zero-in on Nash Equilibrium **2**
none	▪ no service opportunity. **3**	▪ explore using **$C^r** to find **$P^r** to estimate value-from-use. **4**

Table 3. **Commitment phase**. In **3**, discussions and negotiations must have been unproductive. No deal is likely. Outlook is pessimistic. On **1** and **4**, negotiations have been productive. The information uncovered during the process is useful. The process has given both the provider and customer much confidence. The provider has moderated its price and the customer has appropriately agreed to a higher price based on uncovered favorable information. SOW and MOU signed. A mutually committed price has been agreed. We have a Nash Equilibrium. Implementation is next.

commitment

provider V4P in place	**customer V4C in place: none**	**customer V4C in place: yes**
yes	▪ uncovered information during negotiations is favorable. Refine value-in-use & value-from-use. **1**	▪ confident with information. ▪ commit Nash Equilibrium. **2**
none	▪ uncovered information during negotiations not good, no deal. **3**	▪ uncovered information during negotiations is favorable. Refine value-in-use and value-from-use. **4**

Table 4. *ex post* implementation phase. This is about implementation assessment, **2** is the key one to consider. Evaluating outcomes is critical. Provider must review its parameter **α**, and **$P^r**, the customer its parameter **β** and **$C^r**. Both provider and customer must examine their financial statements, costs, expenses and their resource allocation practices

***ex post* implementation**

provider V4P in place	**customer V4C in place: none**	**customer V4C in place: yes**
yes	▪ not applicable at this phase **1**	▪ assess service outcomes and NE ▪ analyze variables, parameters, value-in-use, value-from-use. **2**
none	▪ no service implemented **3**	▪ not applicable at this phase. **4**

2.6 Summary

Our presentation of value and value-pricing is descriptive, analytic, and our methodology is normative and prescriptive. The idea for our value-pricing pricing methodology is simple. For a given service, provider has a reservation price, and the customer has its reservation price. Given that each party has different resources, and skills, these two reservation prices are not identical. An agreement to engage in a service, is likely if there is a meeting of the minds on a price that is mutually acceptable. The provider may settle for something less than its reservation price, and the customer may settle to a higher price than its reservation price. A Nash equilibrium makes that possible. Our win-win methodology demonstrates how to arrive at an mutually *satisficing* (Simon 1997, 2001) service price.

Our normative value-pricing methodology is focused on the economic-value of services, grounded on axioms, and buttressed with multidisciplinary postulates. So that, altogether, derivation of our methodology has a firm ontological base. Using the axioms and postulates, for a given service, we derived a set of service-value equations anchored on the concept of cocreation. One is the *value-**in**-use* obtained *by the customer* from a *provider's* service. The other is the *value-**from**-use* obtained *by the provider* from a willing customer. We show they are not equal. In the literature, *value-**in**-use* is consistently discussed over and over, but *value-**from**-use* is conspicuously absent. This asymmetric treatment is a bias. If in fact, value-from-use did not exist, value pumps would be possible. *This is a fundamental conceptual **gap** in service science.*

3.0 Metrology and Measurement

Service is endowed with many properties. *Service-value is the most salient, but undefined and unmeasurable. This is another fundamental gap in service-science, no metrology.* Metrology is the science of measurements (*e.g.,* Ashworth 2004, BIPM 2021). There are two issues: defining value, and measuring value (Badinelli 2015). Service's key purpose is to produce customer value. Relying on common sense (Gaugh 2003) and our prior knowledge (Achterbergh & Vriens 2009), we chose *economic-value* as the most salient and natural property for service-value. Informed observers (von Foerster 1981, von Foerster & Poerksen 2002) (Anderson & Narus 1999, Anderson *et al.* 1992) would readily concur with our choice as a meaningful step. Economic-value, is also the property that can be most readily expressed in monetary terms, and readily measured. *But, we must think about quantities like scientists, not arithmeticians.*

A quantity is a "property" (Ellis 1968) of an artifact. A quantity has semantic meaning that has an "informative and "determinative" relationship between property and quantity (*ibid*). For example, charge and coulombs, distance and light-years. *A quantity must be named and expressed in units*. And *units must be endowed with scales*. Scaled quantities can be *ordered* or *ranked;* simply, comparatively, or extensively using *ordinal, interval, ratio* and *extensively measurable* scales (*e.g.,* Khurshid & Hardeo 1993, Franz *et al.* 1971, Otto & Wood 2001). Ordinal is a simple comparison of better or worse, but ***not*** by how much, like the 7-point Likert scale. Arithmetic with Lickert scales are not permitted. An interval scale can only indicate the extent of separation between and among comparisons, *i.e.* better or worse and by how much, e.g. Farenheit and Celsius degrees. But, the zero point in interval scales is arbitrary. For ratio scales, the zero point is not arbitrary, it has meaning,

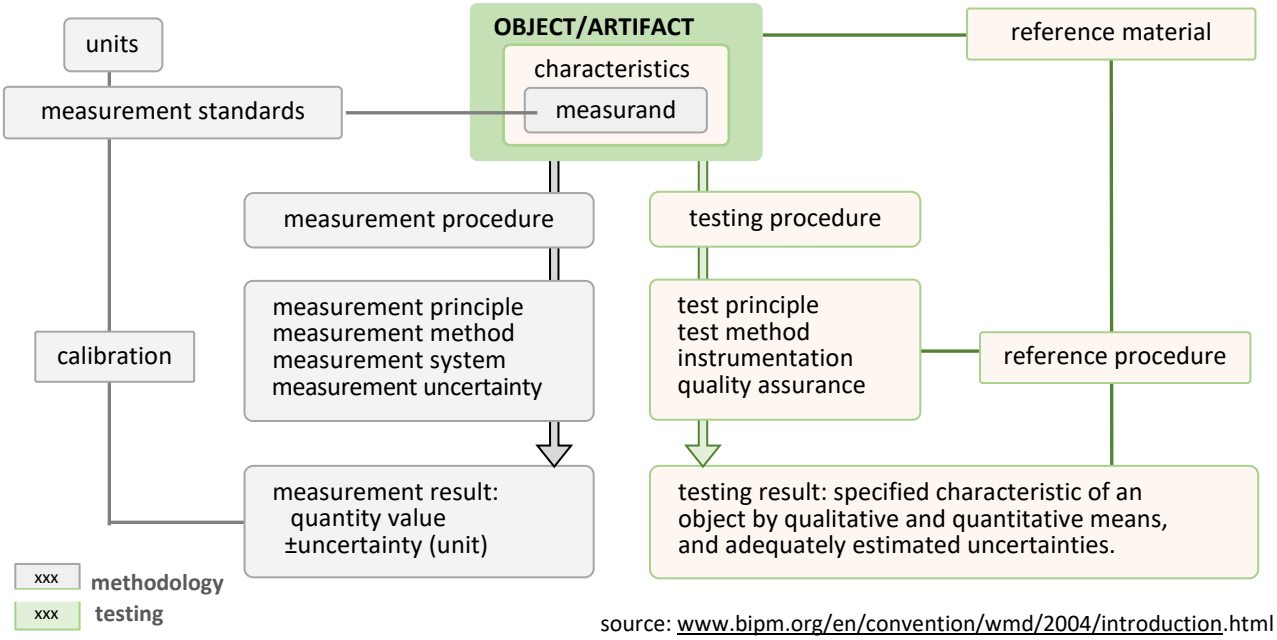
e.g. zero degrees Kelvin. Most significantly, arithmetic operations are legitimate (*ibid*), e.g., two rocks, weighing 2⅛ kg and 3⅞ kg, weigh a total of 6.0kg; not just that the two rocks are heavier than either one alone. Nominal scales, indicate only yes or no categorical-type properties; like being alive or dead… They have much narrower usability in services.

Quantities, units, and scales are important because they facilitate reasoning and inference; enabling scientific rigor. They are necessary for scientific measurement systems. But, to the *Bureau International Des Poids et Mesures* (BIPM) in Paris, service science does not appear worthy of membership. 2012 International Vocabulary of Metrology (VIM) declared:

" … there is no fundamental difference in the basic principles of measurement in physics, chemistry, laboratory medicine, or engineering. Furthermore, an attempt to meet conceptual needs of measurement in fields such as biochemistry, food science, forensic science, and molecular biology.". No service science (Tang 2012).

Service Science needs a ***metrology****, the science of measurements (e.g.,* Ashworth 2004). Metrology includes "experimental and theoretical determinations, at any level of uncertainty, in any field of science and technology, and the basic principles governing quantities and units". Metrology as a system is shown in Figure 5. The crux of the system is the existence of *measurement principles,* the basis for measuring by the instruments and methods. For example, for the concept of length, quantity is distance, unit is the meter, and one meter is defined as the distance traveled by light in a vacuum in one second.

Figure 5. System view of Metrology. At the core of metrology is an object or artifact that has fundamental properties; such as, service economic-value. The object is the measurand of the measurement system. Standards describe the measurand, which have associated quantities and units, to be calibrated to produce numbers in ratio scales. Between measurand and measurement, stands a procedure to measure based on first principles. For example, in SI units, one volt is defined as 1 volt=1 kg m^2 s^{-3} A^{-1} (one-kilogram meter squared per second cubed per ampere). One the right-hand side are the testing requirements, principles, and procedures for testing. Uncertainties are understood in the statistical sense, not in the broader Knightian sense (Dizikes 2010).



source: www.bipm.org/en/convention/wmd/2004/introduction.html

This gap in metrology hinders development of service science as a mature academic discipline and professional practice. Form Service Science working group, with an appropriate mandate, to produce a working paper to propose a definition for value. All the numerous characterizations in Section 1.5 have a strong claim. But scholars will admit that their importance will vary. Saaty's AHP (Saaty 2004), which uses *ratio scales* and linear algebra, can be used to develop a prioritized consensus. Value is "elusive and complex". Keeping the number of dimensions down to a manageable number will be a challenge. Miller's (1956) famous "7±2 finding" is a practical heuristic, especially with AHP. Invite academics, industry experts, practitioners, NIST (2021) and BIPM (2021) to contribute. Circulate the working paper before making it "official". Follow a similar procedure for definition of quantities, units, scales, and measurement principles the service value quantities. Then organize an international conference to announce and release a publication on this subject.

5.0 Conclusions

This paper is about a normative value-pricing methodology, for the B2B-DMU services market, using the Nash Equilibrium mechanism. Our approach to this task is distinctive: multidisciplinary and rigorous. We developed a normative, descriptive and prescriptive approach. Our approach is grounded on axiomatic principles and postulates. The approach is multidisciplinary and analytic using mathematics. Mindful of Poincaré's (1908) dictum that findings should be cumulative, not a "pile of rocks", but additive to an edifice dedicated to science. It would be presumptuous to claim to have built an edifice. We contributed modestly a door, perhaps opened a window, and pointed out where windows and doors should be built.

It is useful and practical to define service-value in monetary units. We eschewed the Swiss Army knife approach. In the absence of a definition, for service value in the literature (Section 2.1), we used economic value as a fundamental property of service to address. The result is this normative, descriptive, and prescriptive article about a value pricing methodology. To inject rigor to our service-value definition and methodology, we specified axioms and postulates from distinct disciplines and integrated them into a mathematically coherent concept. The postulates serve as "protective belts" to support verisimilitude (Lakatos et al. 1980). Recognizing that economics is a science, a *Wisssenschaft,* our work is grounded on value co-creation from Service Science; Fechner's Law from Cognitive Psychology; Prospect Theory from Behavioral Economics; Nash equilibrium from Game Theory; Discounted Cash Flow and financial accounting from Corporate Finance (Section 2.2). Altogether they underpin our conceptual architecture for value-pricing our definition for service-value.

Crucially, we uncovered metrology as a significant conceptual gap in the literature. We sketched an action plan to bridge this gap. Metrology is the science of measurements (*e.g.,* Ashworth 2004). It involves the study of properties, quantities, units, scales and measurement principles. This work is essential to service science and service-value. In Section 3.0, we outlined an actionable approach to address other key properties of service value. We look forward for INFORMS (2021) to take the lead on Metrology. "If scientists don't pay attention to metrology, then who does" (O'Connell 1993).

Value cocreation in the literature is asymmetric; this inhibits the development of an appropriate mental model for service-value. The concept of chilarity in the service literature. Value co-creation is a core premise of service science (Vargo & Lusch 2016). However, it is asymmetric and biased in view of the rôles, efforts, and resources that both provider and customer must invest into a service effort. It follows that service value cannot be unidimensional and only understood from the customer perspective as *value-**in**-use*. This omits the emphasis that in **co**-creation providers resources must be applied to the service endeavor. We try to balance this cocreation asymmetry. We argue for the idea of *value-**from**-use,* an idea that is absent in the literature. To bridge this gap, we derive equations for *value-**in**-use* and *value-**from**-use*. *We* show [*value-in-use*] ≠ [*value-from-use*] and that [price]≠[value]. These equations support Grönroos (2011) conclusion that: "…when value-in-use is taken as the starting point the statement the customer is always a co-creator of value' is indeed misleading".

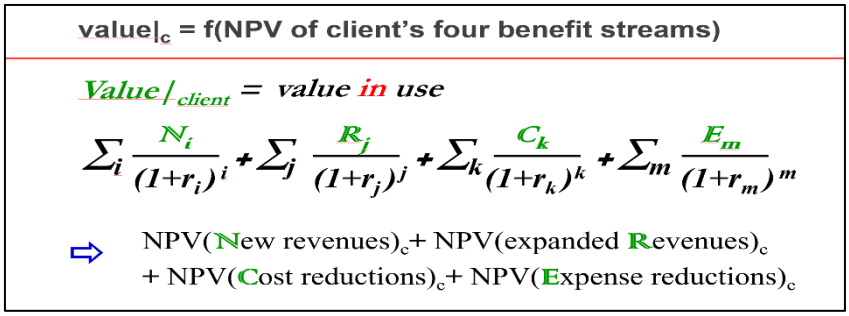
Service-value is measurable using financial accounting and income statements. This does not preclude of other fundamental properties of service-value from investigation. We measure service's economic value and illustrate measures using *period financial accounting*. We show how service-value addresses revenue in flows, cost and expenses. For a provider and a customer, the accounting measures addresses service-value in monetary units. According to our symmetry principle, for a provider and a customer, are effective accounting measures. We show *period* accounting. Many B2B service projects with designated organizational DMU's have protracted engagements that may take years to complete. For example, building dams, canals, high speed rail, and so on. In those cases, *program* accounting is also used, to measure and evaluate economic value (Appendix A).

The provider's service-value function is distinct from the customer's value-function, but they have a fixed point, that is the Nash Equilibrium point. In the Nash Equilibrium was established with simplifying assumptions. Recall that a NE is the condition under which each party's strategies are such that there is no incentive to act in other ways (*e.g.* Romp 1997). For example, the intersection of the classical supply and demand curves. We develop a normative methodology to reveal a Nash Equilibrium point. Such a point exists for our problem of open, convex, non empty sets (e.g. Nachbar 2010). We argue that our economic-value of a service extends more fully the concept of cocreation. It brings symmetry to the cocreation interactions between provider and customer. Game theory has many useful concepts that can be used in service science, *e.g.* perfect and imperfect information, mixed strategies, cooperation and non-cooperation, signaling, externalities, and so on. They are worthy of further study. Other challenging topics for service science include contract theory and Nash Equilibria fixed points for the topological spaces of provider and customer value topological spaces.

The World Bank (2021) reports that 76.9% of the US GDP is in services; *viz.* $16.5 trillion. That is approximately the combined GDP of five major economies,

GDP(Japan+Germany+India+UK+France)=$17.4 trillion. Services is vital to our economy and to 78.98% of our labor of 160.74 million people that are employed in services. These are staggering statistics. The work outlined in this article is challenging, but its impact will serve it well to our economy and those who work in services.

APPENDIX A. Program view of Benefits.



NPV: Net Present Value used in Discounted Cash Flow (Weston & Brigham 1977). The terms r_i, r_j, r_k, r_m are the associated discounts rates for those revenue flows. The value-from-use expression is similar and not repeated.

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