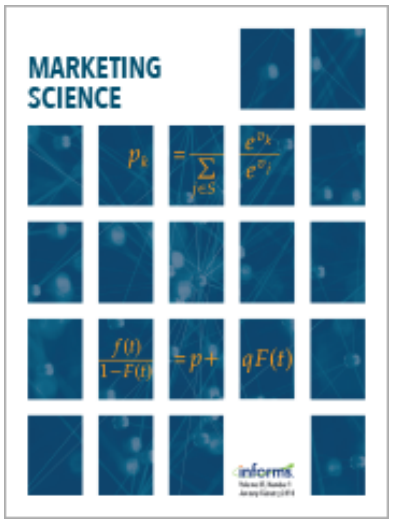

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Commentary

Relevancy Is Robust Prediction, Not Alleged Realism

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Remember James Boswell, ninth Laird of Auchinleck, author of the famous maxim that the road to hell is paved with good intentions? Trying to build realistic theories differs dramatically from having correct explanatory theories tested on objective criteria, e.g., verifiable prediction. Evaluating theories on whether assumptions are realistic is potentially subjective, biased, and arbitrary. A theory's domain determines whether its assumptions are sufficiently realistic and when assumptions must hold and to what degree, so testing assumptions in isolation puts an unnecessary burden on the assumptions (i.e., they must hold everywhere). For theories explaining cooperation and information exchange, predictions reveal that the prisoner's dilemma assumptions (only two prisoners, four possible outcomes, two possible actions, etc.) are sufficiently realistic. For theories explaining prisoner sentencing guidelines and probation policy, predictions might suggest otherwise. Scientific methods allow the evaluation of theories on criteria such predictive accuracy, reliability, validity, and robustness—not based on realism. When multiple explanatory theories survive initial testing, one derives conflicting predictions. For example, a theory that people are broccoli produces correct predictions (people are mortal) and incorrect predictions (people are biennial). Tragic consequences can occur when theory adoption depends on whether assumptions are disliked, unpopular, or exclude a favorite variable. Denounce journals that reject models with insightful new implications because the assumptions are too simple or merely disliked. The term "unrealistic" sometimes means personally disliked.

Key words: models; theory testing; mathematical models; scientific method; realism; mathematical assumptions; empirical research
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Introduction

My editorial (Shugan 2007a) argues that judgments concerning research should stress objective evaluations rather than the tastes of reviewers or the popularity of particular assumptions. It advocates greater emphasis on objective evaluations such as the accuracy and reliability of predictions rather than subjective evaluations based on realism. The paper argues, "Judging the realism of an assumption . . . is an arbitrary unscientific exercise in personal taste rather than an objective step in any scientific process or methodological development. We could easily criticize assumptions as unrealistic when they dismiss our favorite variable, contradict the past literature, or conflict with current beliefs," (Shugan 2007a, p. 454). Accepting this dubious requirement of realism implies that "all breakthrough research would require unrealistic assumptions . . . "(Shugan 2007a, p. 454) because breakthroughs often require assumptions that conflict with current beliefs. Hence, assessing realism is only possible after testing the implications and predictions of a model or theory. "Assumptions are realistic when they produce good theories, satisfactory predictions, valuable implications, and correct recommendations" (Shugan 2007a, p. 450). A theory's domain determines when its assumptions are sufficiently realistic, when assumptions must hold and to what degree, so testing assumptions in isolation puts an unnecessary burden on the assumptions (i.e., the assumptions must be exactly true everywhere).

As evidence, my editorial (Shugan 2007a) provides many examples of great theories initially rejected because their assumptions appeared unrealistic. In fact, this is the norm rather than the exception. For example, despite his eventually earning a Nobel prize, two leading scholarly journals rejected Akerlof's (1970) 13-page famous research paper, "The Market for Lemons: Quality Uncertainty and the Market Mechanism" because reviewers judged the assumptions so unrealistic that they considered the paper to be trivial (Shugan 2002). An additional notable example is German mathematician Carl Friedrich Gauss's famous model of non-Euclidean geometries (Heideman et al. 1985). Critics denouncing as unrealistic non-Euclidian assumptions (e.g., parallel lines diverging) "frightened Gauss into withholding the publication of his novel non-Euclidian geometry until after his death" (Fujimura 1998, p. 357) and destroyed the career of the mathematical prodigy János Bolyai. Most nonmathematicians would still

dismiss non-Euclidian assumptions as unrealistic. See Shugan (2002, p. 5) for other examples.

Only the context of the theory determines when and to what extent assumptions must hold! This comment clarifies questions raised about the editorial (Shugan 2007a) by Tsang (2009) and briefly elaborates on the evidence supporting my arguments.

Is Explanation Better Than Prediction?

Despite claims by Tsang (2009), my editorial (Shugan 2007a) does not attempt to argue that one research objective is better than another. In fact, my editorial (Shugan 2007a, p. 454) states, "If assumptions produce a model, theory, method, or conceptualization that achieves the desired objective, then we should consider the corresponding assumptions to be realistic." It argues that "different assumptions are appropriate for different research objectives" (Shugan 2005, p. 4). Many explanatory theories are tested with prediction (e.g., Bertini and Wathieu 2008, Bradlow and Park 2007, Cui and Curry 2005, Gilbride and Allenby 2006, Syam et al. 2008, Toubia et al. 2007). Explanatory and predictive theories are both valuable, but all theories are subject to potential predictive falsification—hopefully, not subjective opinions about the realism of their assumptions.

Does Shugan (2007a) Differ from Friedman (1953)?

Yes, it is useful to distinguish between Milton Friedman's and my arguments about assumptions in mathematical models. My editorial (Shugan 2007a) strongly supports Friedman (1953) but provides a more limited argument. Friedman (1953) diminishes the importance of seemingly realistic assumptions. My editorial (Shugan 2007a) only argues that realism is an inappropriate criterion for evaluating assumptions because of its inherent subjectivity (compared with more objective metrics of predictive accuracy) and inherent ambiguity without the context of a theory. Assumptions need only hold in the region and extent required by the theory.

My editorial (Shugan 2007a) does not conclude that assumptions are irrelevant. For example, it states that "creatively linking assumptions to reality might help diagnosis of the cause of poor model predictions" (Shugan 2007a, p. 455). Consequently, many critical remarks for Friedman (1953) are irrelevant for Shugan (2007a). For example, Nagel (1963), who agrees with Friedman's conclusion but not the details of Friedman's argument, is not relevant here.

Criticizing Milton Friedman's justifications in his own research stream is very unfair, because the publication process can request authors to justify assumptions (at least, based on my personal observation over many years in many editorial positions). Criticizing Milton Friedman's inconsistent use of the term realism is also unfair because it is precisely the ambiguity and the subjectivity of the term that makes the term problematic. In sum, the point of the editorial (Shugan 2007a) is that objective evaluation should always trump subjective and opinionated criteria for model evaluation. Moreover, assumptions are only sufficient conditions where the theoretical context defines sufficiency.

What Are Shugan's (2007a) Main Arguments?

Before continuing, consider the following list of contested arguments in the editorial (Shugan 2007a):

1. Evaluate theories on more objective criteria such as predictive accuracy rather than highly subjective criteria such as whether the assumptions are popular or realistic. The editorial (Shugan 2007a) provides considerable evidence for this position. Beyond the traditional argument that science, technology, and medicine was able to advance when objective predictive validity trumped subjective evaluation, my editorial (Shugan 2007a) provides specific examples of when predictive tests eventually changed extant beliefs about conventional assumptions.

2. It is difficult, if not impossible, to evaluate assumptions in isolation (i.e., outside the context of the theory). It is analogous to evaluating a painting based on individual brushstrokes. "Assumptions are the analogous ingredients of a chef's gourmet recipe. Individual ingredients are meaningless, compared with the desired end" (Shugan 2007a, p. 456). For example, the assumption that a manufacturer makes only one product might work for some theories and not for others. As evidence, note that (1) the literature accepts the same assumption in some contexts but not others, and (2) we lack objective methods for objectively evaluating assumptions without a specific context. A theory's domain determines whether its assumptions are sufficiently realistic or even necessary. Of course, the ingredients do matter and influence the outcome.

3. "Weaker sufficient conditions fail to guarantee weaker necessary conditions" (Shugan 2007a, p. 453). One compelling example is overfitting where the model spuriously fits random error (or irrelevant detail), but the model yields the wrong explanation and inaccurate prediction. Hence, because theories or models with weaker assumptions need not provide more general implications, purported realism alone fails to demonstrate a benefit or substitute for predictive testing. Theories dictate when and to what degree assumptions must hold.

4. Related to the concept of overfitting, theories and models abstract to remove distracting details and reveal relationships useful for interpreting,

understanding, optimizing, forecasting, and building future models. "Making supposedly more realistic assumptions often results in more variables, relationships, indeterminacy, and complexity" (Shugan 2007a, p. 456). Hence, adding complexity only for the sake of realism defeats the objective of modeling, risks overfitting, and nullifies the benefits from abstraction.

5. Regardless of the objective, views on realism must change when confronted with objective evidence that theoretical predictions match or fail to match verified observation.

What Are Assumptions?

"Dictionaries define assumptions as something taken as true without formal proof" (Shugan 2007a, p. 450). That definition is limited because it excludes both statements with some proof and statements that are only sometimes true. A better definition is that "assumptions are sufficient conditions that guarantee the validity of the subsequent findings but whose violation by no means necessarily invalidates those findings" (Shugan 2007a, p. 450). That definition allows readers to judge whether the sufficient condition is explicit and allows verification of whether the findings logically follow from the assumptions (i.e., are valid). Note that speculating whether an assumption has a negligible effect on prediction before observing theoretical predictions or trying to classify assumptions by importance without knowing the entire theory (as Musgrave 2007 and Tsang 2009 attempt) again substitutes subjective opinion for more objective evaluation.

Can Assumptions Be Inadmissible?

Yes, there are inadmissible assumptions and not all assumptions yield coherent theories. However, judgments on inadmissibility should avoid appeals to realism. Mutually inconsistent assumptions are inadmissible (Shugan 2007a, pp. 454–455). For example, the assumption that firms are unaware of rival strategies is inconsistent with the Nash equilibrium assumption. The assumption of a beta posterior distribution is inadmissible given a gamma prior and Poisson likelihood. Factually incorrect assumptions are inadmissible. For example, the assumption that there are 250 days in a Julian calendar year is inadmissible.

Moreover, meaningless statements are inadmissible. For example, "yellow is large" (Shugan 2007b, p. 735) is an inadmissible assumption. None of these inadmissibility criteria would eliminate, for example, the assumption that an arbitrary manufacturer produces one product despite empirical evidence that every real manufacturer produces more than one product. None of these inadmissibility criteria implies that a theory based on the supposedly more realistic assumption of producing two products is better than a theory based on the assumption firms produce only one product.

Faulty logic is also inadmissible. Avoid the fallacy of affirming the consequent (i.e., the converse error). For example, the premise that unrealistic assumptions can result in invalid predictions does not imply that realistic assumptions yield valid predictions. Similarly, a correct theory does not imply always correct assumptions (e.g., an assumption could be redundant, sufficient, or one of many substitutable conditions). A non sequitur is inadmissible. Employing consistent logic, seeking verifiable predictions, and verifying factual observations differ from evaluating assumptions based on the evaluator's concept of realism.

Given Predictive Accuracy, Is Realism Required?

No. Asking whether realistic assumptions are necessary reveals a fundamental misunderstanding of the basic issue of the objective testing of models. Life is easy when our favorite theories predict well. Life is much more difficult when disliked theories predict well. Life apparently becomes easy again when we can reject disliked theories only because we dislike an assumption for whatever reason. We should seek objective criteria for model evaluation. When we believe that an assumption is faulty for whatever reason, we must substitute our favorite assumption and show that our supposedly improved theory with purportedly improved assumptions does provide improved predictions. Hence, the clear answer to the question of whether theorists must justify assumptions as realistic is an emphatic no. Theorists must show their favorite theories consistent with verifiable observations. Similarly, detractors must reject theories based on verifiable evidence inconsistent with theoretical predictions and not on whether they dislike the assumptions, the theory, or the predictions. Theories are not immune to predictive scrutiny merely because they claim to provide favored explanations or claim to be more realistic. Consistency with verifiable observation trumps perceived realism, at least when seeking correct explanations.

Are Realistic Assumptions Good?

Not always. Certainly, theories that explain observed phenomena are very valuable, at the very least, because they yield useful remedies for relevant problems, directions for further inquiry, and predictions of future events. However, one must always remember that embracing the wrong explanation usually makes matters far worse. Do not confuse arguments concerning how to test theories with arguments concerning the desirability of explanatory theories. Many (if not all) great disasters were the consequence of

incorrect explanations seemingly based on realistic assumptions. For example, in most cases product placements are valuable, particularly free product placements. Appeals to realism might suggest that realistic advertisers should also consider content in addition to exposure. Unfortunately, accounting for content (in addition to exposure) caused the M&M's division of Mars, Inc., to make the colossal blunder of rejecting a free product placement in director Steven Spielberg's 1982 blockbuster science-fiction film *E.T.*: *The Extra-Terrestrial*. Although it seemed realistic to consider the potential negative downside from associating M&M's candies with alien life forms, the eventual placement of Reese's Pieces candy as E.T.'s favorite candy proved otherwise (Powers and Cosgrove 2004, p. 48; Newell et al. 2006). Again, regardless of whether assumptions tentatively appear realistic or not, only observed outcomes will reveal whether the assumptions are realistic in the context of the theory. Only after theories are tested should judgments occur about whether assumptions are realistic within the domain of the theory.

Beyond business blunders, many great human tragedies were the consequence of incorrect understandings and just plain bad explanatory theories that yielded flawed predictions. Good intentions, including the intention to be realistic, can be seriously misguided and should not be considered "science." Theories must rise or fall based on their objective predictions rather than the popularity or the alleged realism of their assumptions. Forty to fifty-five million rural people starved to death because of Chinese military and political leader Mao Zedong's Great Leap Forward program (Thaxton 2008, p. 2), which tragically replaced a market-driven agricultural economy with a centrally planned economy (Bachman 1991, p. 2; Smil 1999). As noted by numerous empirical researchers (most notably, Amartya Sen), similar efforts including the seemingly innocuous regulations on food production caused similar disastrous consequences in other countries (Sen 1981, Shugan 2007c). Remarkably, the intention of the Mao's Great Leap Forward program seemed very noble.

The tragically wrong explanatory theory involved deceptive appeals to realism. It seemed unrealistic to believe that greedy and self-interested farmers acting without coordination could achieve or come close to the food production of an optimized centrally planned economy that selected crops and held the collective property rights to farm land. Without testing the predictions of this flawed explanatory theory at least on historic data (not used to formulate the theory) or with a small-scale experiment, the consequences were never foreseen. Unfortunately, the faulty reasoning associated with central planning persists and history frequently repeats itself (Sen 1981).

When the Chinese government observed the collapse of the Soviet economy after the massive starvation caused by Mao Zedong's nationalization and Soviet central planning, potential successor and general secretary of the Chinese Communist Party Zhao Ziyang began to understand the powerful incentives that could be created by protecting property rights and destroyed by nationalization. Zhao Ziyang's reforms produced the predicted consequences observed in other settings until he was ousted because of his sympathetic stance toward the student demonstrators in the Tiananmen Square protests of 1989. He spent the last 15 years of his life under house arrest.

Shugan (2007b) provides another compelling detailed example of the discovery of a theory about the source of the plague *Bacillus* that inflicted massive human disaster across the world, devastating and decimating countries. Many misguided extant explanatory theories were tragically wrong. For example, many plague-inflicted communities assumed that minority ethnic groups were poisoning the water. That direly wrong explanation for the plague led to the absolutely horrendous persecution of those minority groups. At the time, blaming the plague on malevolent people probably seemed more realistic than the explanation that the plague was spread by seemingly harmless common fleas being transported by small, very common rodents. In this tragic instance, forcing theorists to make predictions might have cast doubt on the minority group explanation because some observations were inconsistent with the poisoning explanation (see Shugan 2007a).

The persistence of wrong theories based on popular assumptions is a frequent motivation for the adoption of the scientific method. This method calls for objectively testing theories through predictions rather than through the popularity or purported realism of the assumptions. Studying the history of the scientific method reveals that the primary motivation for testing explanatory theory based on prediction was precisely the subjective bias associated with the assumptions of the prevailing theory (Shugan 2007a).

Realism is subjective, opinionated, and in the eye of the beholder. It greatly depends on the prejudices of the researcher. For example, some researchers might believe that it is unrealistic to assume that consumers maximize utility, whereas other researchers might believe that it is unrealistic to assume that consumers are irrational. Some researchers consider it unrealistic to assume that consumers answer honestly on questionnaires, whereas other researchers consider it unrealistic to assume that aggregate data can substitute for questionnaire data. In these cases, the realism of the assumption depends on the subsequent theory rather than some isolated subjective judgments about reality.

Are Assumptions That Are More Realistic Better Than Less Realistic Assumptions?

No, striving for more realism risks "the phenomena of over-fitting, where predictive accuracy diminishes when increasing the flexibility (i.e., relaxing the assumptions) of a statistical model" (Shugan 2007a, p. 453). Consider researchers who argue that their assumptions are more realistic. For example, the realism advocate argues that assuming that consumers are rational is unrealistic. To support this argument, the realism advocate lists many observations that appear (at least, superficially) to be consistent with irrational behavior. The realism advocate argues that their highly complex model of irrationality fits all of these observations better than assuming rationality and that the odds of their complex model fitting all of these observations are one in one billion. Hence, all models assuming rationality should be rejected.

However, with high-speed computational capabilities, a modern computer could attempt to fit a billion models to observed data and report a model with perfect fit. Given that capability, the one-in-one-billion odds seem much larger than in the past and now fail to impress. Certainly, many false conspiracy theories gain their dubious credibility from their advocates' ability to search innumerable observations for those consistent with the conspiracy. After celebrating those consistent observations, the conspiracy advocates recite the one-in-one-billion argument. Worse, the apparent consistency is only superficial. Meticulous fact checking guided by theoretical predictions would provide refutation.

Better evidence of a good explanatory theory is the ability to predict new observations, particularly in entirely new domains on entirely new variables. An explanation gains far more credibility from its predictive capability than almost any other form of evidence (barring a complete deductive proof). There is no compromise between explanation and prediction. Good theory can do both.

Why Are Predictions Testable While Assumptions Are Not?

Note that some research admirably builds on past research. Then, the conclusions of prior research could become the assumptions of subsequent research. For example, past research using assumptions about consumer behavior predicts a long-term relationship between product quality and sales. Subsequent research might assume a predicted relationship and thus predict competitive outcomes using the earlier relationship as an assumption. Consequently, whether a statement (here, an assumed relationship) is an assumption or a theory depends on the context.

Having stated that, testing assumptions differs from testing theories. Sometimes it is possible to test an assumption in isolation as a stand-alone theory. However, falsification of the assumption as a stand-alone theory is insufficient to falsify the assumption when it is only part of a theory. For example, consider a theory of shortages that predicts that regulating prices below the market-clearing price causes shortages, less incentive to increase future supply, and less conservation by buyers. Suppose that theory of shortages assumes a quadratic cost function, and without that function the model is intractable. As a stand-alone theory, the quadratic cost function makes explicit predictions concerning how unit cost increases as sales volume increases. However, despite complete falsification of those cost predictions, falsification of the cost function assumption as a stand-alone theory reveals nothing about whether the theory of shortages explains or predicts the impact of regulating prices.

Remember that when assumptions are part of a theory, the theory limits the region where the assumption must hold as well as the necessary level of approximation. However, as a stand-alone theory, the assumption must hold exactly everywhere. Using a recipe analogy, assessing the quality of a wine as a stand-alone beverage differs from assessing the quality of a gourmet recipe using the wine as only one ingredient.

Mazzeo (2006, p. 618) finds that in the industrial organization literature on entry and product choice, "researchers have acknowledged that simplifying assumptions regarding the competitive interaction among firms and potential entrants are necessary to estimate any structural model, and so [they] have attempted to demonstrate the impact of alternative sets of assumptions on the results." Hence, robustness of the output determines whether assumptions are satisfactory.

Is More Detail Better?

No. Perhaps one of the most underestimated talents of the human mind is the ability to abstract from detail. Infants and machines lack this critical skill. Infants initially are unable to discern between important sensory input and unimportant sensory input. As they develop, infants hear many sounds and learn to ignore sounds not found in their native language (e.g., Kuhl 2000). Infants have relatively plastic brains allowing many possible pathways, but as they develop they learn which details are important and which to ignore. In fact, some developmental disorders result from information overload when the brain is unable to ignore irrelevant sensory details (Frith 2003, p. 180). One of the key and often unappreciated skills learned by MBA students in business schools is

the ability to abstract. Business cases teach students to sift through the irrelevant details and distill the relevant facts. Abstraction is a benefit when there is no loss in predictive ability. Of course, achieving clarity is important. Bradlow (2008, p. 5) states, "Home run papers have that aura of simplicity—but usually that is due to hard work on the part of the authors."

Are Grossly Unrealistic Assumptions Admissible?

Yes. If anything is grossly unrealistic, it is the expectation that one research article can do it all. Initial research might find that a grossly unrealistic assumption produces great predictions. Subsequent research might reveal why. When a theory with unbelievable assumptions consistently predicts better than our favorite theory, our beliefs require reassessment. This is the history of science, technology, and medicine.

Can Assumptions Be Metaphors?

Whether the prisoner's dilemma is a metaphor or a literal application of a general theory depends on the validity of the theory rather than on whether the assumptions are liked or viewed as realistic. Albert W. Tucker's famous prisoner's dilemma game (Tucker 1950) certainly assumes two prisoners, only four possible outcomes, insufficient evidence to convict, guilty prisoners, prisoners acting in their own best interests, prisoners unable to communicate, prisoners knowing four possible outcomes, police who can lessen sentences for confessing, no possible retribution, no possible reputation effects, and severe sentences for conviction without confessing among still more assumptions. These assumptions are sufficient to find that both prisoners will confess, resulting in a worse situation for both than had the prisoners coordinated their decisions. We forgive the assumptions only because the predictions are good despite unrealistic assumptions. As usual, the realism of the assumptions depends on the context. These assumptions appear to be metaphors because we know theoretical predictions involve cooperation. However, were the predictions about sentencing guidelines and parole policy, our conclusions might differ.

Are Assumptions Important?

Of course, assumptions are important. Different assumptions can yield conflicting implications. Different assumptions can convey different interpretations. Different assumptions can yield different theories. Sometimes, the theory and subsequent testing reveals that an assumption is always necessary for accurate predictions. The point is not whether assumptions are important; the point is how to evaluate assumptions when a theory has many assumptions. There is considerable evidence that evaluating theories based on their ability to predict is better than evaluations based on more subjective criteria such as realism. It is easy to prove that realistic assumptions are neither necessary nor sufficient for good theory (see the examples in Shugan 2007a).

As another example, consider the assumption that market price levels reflect underlying quality levels. This fundamental assumption is consistent with the theory of efficient markets. Modern finance has found this assumption useful because it helps predict market behavior. However, the assumption would probably be dysfunctional in a bargaining context when yielding to a higher price would usually not result in any gain in quality. It is impossible to test the realism of the assumption outside the context of a specific theory.

Finally, deductive proofs remain valuable. Proofs requiring strictly fewer conditions are better, ceteris paribus. Models with less onerous data or computational requirements are better, ceteris paribus. Proofs allowing many different conditions rather than only one are better, ceteris paribus. However, these proofs merit recognition because they enhance the understanding of already tested theories or provide building blocks for future theories, not because of realism. Moreover, it is tragic to reject a theory because of one distasteful assumption that eventually proves unnecessary for the theory.

Should Authors Justify Individual Assumptions?

Most requests for justification merely request speculation. When journals ask about the consequences of eliminating assumptions, any answer short of a new proof is simply speculation. Journals should not publish speculation unless it is identified as such. Otherwise, journals risk their fragile credibility.

Does Eliashberg-Shugan (1997) Contradict Shugan (2007a)?

No, Eliashberg-Shugan (1997) is a highly cited peer-reviewed article that survived the review process. This article is consistent with my editorial (Shugan 2007a) but also includes justification for some assumptions as requested by the very diligent review team. The article's idea is that one can differentiate between different theories of critical reviews (whether critics influence or just predict) based on when the reaction to the review occurs. For example, if film critics influence a box office, then a test of that theory is whether box office results change most when the review first appears. There is no doubt that critical reviews influence some individuals, but the research question concerns whether the reviews influence aggregate box

office. Here is a perfect example of when it is possible to find that all individuals are influenced to some degree (i.e., the noninfluence assumption at the individual level is unrealistic), but the impact of word of mouth completely overwhelms critical reviews at the aggregate box office level (i.e., market level).

Final Thoughts About Theory Testing and Disliked Assumptions

In 2008, financial markets were in crisis. Having the correct explanatory theory might help identify the appropriate remedies. One prevalent assumption was that corrupt Wall Street executives caused the crisis, and that assumption inspired many theories that implied various remedies, all involving government intervention. The corruption assumption seems realistic; after all, many people believe worse of these executives. However, the corruption theory makes testable predictions including numerous indictments and convictions unless the government is also corrupt. If the government is corrupt (which makes intervention problematic), the corruption theory might predict that the news media would reveal widespread corruption and identify the violated laws. Moreover, the corruption theory would also predict a crisis every period (or, at least, ongoing crises) because corruption is ongoing. Finally, the corruption theory would predict that unempathic Ebenezer Scrooge-like executives would be loath to make loans to help the poor, particularly those with bad credit. Judging theories requires an objective evaluation of the predictive ability of the theory and not the popularity of the assumptions. Competing theories based on changes in the legal environment, accounting rules, regulations, or market environments might better predict future crises. At least, a complete explanatory theory would predict both when and why.

For example, testing explanatory theories for the U.S. Great Depression in the 1930s involved more rigor and potential falsification (Friedman and Schwartz 1963). Adjunct tests involved predictions for other depressions. Unlike the theory of greed, which seems relatively invariant over time, alternative theories use economic factors that vary over time (e.g., money supply, tariffs, or government spending) and use factors that vary over time (versus factors that do not vary over time) to predict events. A theory seeking to predict change must make different predictions at different points in time.

Conclusion

Do not confuse theory testing with the objectives of a theory. Whether the objectives are descriptive, predictive, normative, or something else, validation requires valid predictions rather than subjective critique of the assumptions on realism or any other opinionated criteria. When advocating an explanation, it is best to provide evidence that the explanation predicts better than alternative explanations. The ability to predict might not be sufficient, but it is necessary at least at some level of confidence. It seems difficult to trust an explanation that is unable to make verifiable predictions. Other points made in this comment include:

- The editorial (Shugan 2007a) makes no argument that predictive research is better than explanatory research.
- The editorial (Shugan 2007a) only argues that evaluating theories on the realism of their assumptions is too subjective, opinionated, and unscientific. It does not argue that assumptions are unimportant. Assumptions are important because they can help build theories. Moreover, predictive testing might reveal that some assumptions are necessary and some are not.
- This comment defines assumptions as sufficient conditions, but other definitions are also possible. Each theory determines when each assumption must hold and to what degree. The theory's domain determines whether the assumptions are realistic and whether another set of assumptions will do as well.
- Some assumptions are certainly inadmissible based on the requirements of logic, not realism.
- Requiring realistic assumptions (beyond predictive accuracy) risks the rejection of all disliked but correct theories. There is considerable evidence that subjective opinions have inhibited past theory advancement in science, technology, and medicine.
- Theories restrict the regions where assumptions must hold and to what degree, so testing an assumption in isolation puts an unnecessary burden on the assumption (i.e., that it must approximate perceived reality everywhere). Sometimes the theory and subsequent testing reveals that an assumption is always necessary for accurate predictions; however, that conclusion follows assessment of predictive accuracy and does not precede it.
- More realistic assumptions alone are not better and merely risk overfitting irrelevant details in reality.
- Abstraction is an important benefit severely diminished by obsession with realism.
- Do not require authors to justify assumptions with pure speculation.
- Eliashberg-Shugan (1997) is consistent with Shugan (2007a).
- Denounce journals that reject models with insightful new implications because the assumptions are too simple or merely disliked.

Wrong theories yield some wrong predictions. For example, a theory that people are broccoli produces correct predictions (people are mortal) and incorrect predictions (people are biennial).

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