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MODEL INTERROGATION**



**REPRESENTATIONAL MEASUREMENT FAILURE IN  
HEALTH TECHNOLOGY ASSESSMENT**

**CANADA: THE ABSENCE OF REPRESENTATIONAL  
MEASUREMENT AND THE UNIVERSITY OF  
ALBERTA HEALTH TECHNOLOGY AND POLICY  
UNIT (HTPU)**

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# FOREWORD

## HEALTH TECHNOLOGY ASSESSMENT: A GLOBAL SYSTEM OF NON-MEASUREMENT

### INTRODUCTION

The Health Technology and Policy Unit (HTPU) at the University of Alberta is a university-based research group focused on the evaluation of healthcare interventions and the analysis of health policy. Located in Edmonton, the Unit brings together researchers in health economics, epidemiology, and health services research to examine the clinical, economic, and system-level impact of medical technologies and healthcare programs. Its work is grounded in the application of health technology assessment methods, including economic evaluation, evidence synthesis, and decision-analytic modeling.

HTPU's primary role is to generate evidence that can inform healthcare policy and resource allocation decisions, particularly within the Canadian healthcare system. Its analyses are designed to support decision-makers in evaluating the adoption, reimbursement, and use of pharmaceuticals, medical devices, and healthcare services. This includes assessing cost-effectiveness, budget impact, and the broader implications of healthcare interventions for system performance and patient outcomes.

In addition to producing research outputs, the Unit contributes to policy development through collaboration with government agencies, healthcare organizations, and academic partners. Its work supports the translation of evidence into practice, providing a basis for decisions regarding technology adoption and healthcare priorities. As part of a university environment, HTPU also plays a role in training researchers and analysts in HTA methods, contributing to the development of expertise that underpins policy-relevant evaluation and decision-making.

The objective of this study is to interrogate the HTPU knowledge base using a standardized 24-item canonical diagnostic grounded in the axioms of representational measurement. The purpose is to determine whether the conditions required for valid measurement are recognized and operationalized within a university-based HTA research environment that is explicitly engaged in policy-relevant evaluation. By applying a consistent interrogation framework—based on fixed categorical probability assignments and normalized logit transformations—the analysis constructs a structured profile of the HTPU knowledge base. This profile enables comparison across true and false propositions and provides a basis for assessing whether a methodologically established academic unit aligns with the foundational requirements of measurement.

The interrogation reveals a clear and consistent pattern. Statements grounded in the axioms of representational measurement such as unidimensionality, dimensional homogeneity, and the requirement that measurement precede arithmetic are weakly endorsed, with low probabilities and strongly negative logits. In contrast, statements that are incompatible with these axioms but central

to HTA practice such as the treatment of QALYs as ratio measures, the aggregation of QALYs, and the use of cost-effectiveness ratios as meaningful quantities are strongly endorsed, with high probabilities and positive logits. This pattern defines a profile of measurement inversion, in which the conditions required for valid measurement are not recognized, while contradictory assumptions are embedded within the knowledge base. The findings indicate that the HTPU framework, despite its academic grounding and policy relevance, does not align with the axioms of representational measurement.

The starting point is simple and inescapable: *measurement precedes arithmetic*. This principle is not a methodological preference but a logical necessity. One cannot multiply what one has not measured, cannot sum what has no dimensional homogeneity, cannot compare ratios when no ratio scale exists. When HTA multiplies time by utilities to generate QALYs, it is performing arithmetic with numbers that cannot support the operation. When HTA divides cost by QALYs, it is constructing a ratio from quantities that have no ratio properties. When HTA aggregates QALYs across individuals or conditions, it is combining values that do not share a common scale. These practices are not merely suboptimal; they are mathematically impossible.

The modern articulation of this principle can be traced to Stevens' seminal 1946 paper, which introduced the typology of nominal, ordinal, interval, and ratio scales<sup>i</sup>. Stevens made explicit what physicists, engineers, and psychologists already understood: different kinds of numbers permit different kinds of arithmetic. Ordinal scales allow ranking but not addition; interval scales permit addition and subtraction but not multiplication; ratio scales alone support multiplication, division, and the construction of meaningful ratios. Utilities derived from multiattribute preference exercises, such as EQ-5D or HUI, are ordinal preference scores; they do not satisfy the axioms of interval measurement, much less ratio measurement. Yet HTA has, for forty years, treated these utilities as if they were ratio quantities, multiplying them by time to create QALYs and inserting them into models without the slightest recognition that scale properties matter. Stevens' paper should have blocked the development of QALYs and cost-utility analysis entirely. Instead, it was ignored.

The foundational theory that establishes *when* and *whether* a set of numbers can be interpreted as measurements came with the publication of Krantz, Luce, Suppes, and Tversky's *Foundations of Measurement* (1971)<sup>ii</sup>. Representational Measurement Theory (RMT) formalized the axioms under which empirical attributes can be mapped to numbers in a way that preserves structure. Measurement, in this framework, is not an act of assigning numbers for convenience, it is the discovery of a lawful relationship between empirical relations and numerical relations. The axioms of additive conjoint measurement, homogeneity, order, and invariance specify exactly when interval scales exist. RMT demonstrated once and for all that measurement is not optional and not a matter of taste: either the axioms hold and measurement is possible, or the axioms fail and measurement is impossible. Every major construct in HTA, utilities, QALYs, DALYs, ICERs, incremental ratios, preference weights, health-state indices, fails these axioms. They lack unidimensionality; they violate independence; they depend on aggregation of heterogeneous attributes; they collapse under the requirements of additive conjoint measurement. Yet HTA proceeded, decade after decade, without any engagement with these axioms, as if the field had collectively decided that measurement theory applied everywhere except in the evaluation of therapies.

Whereas representational measurement theory articulates the axioms for interval measurement, Georg Rasch's 1960 model provides the only scientific method for transforming ordered categorical responses into interval measures for latent traits <sup>iii</sup>. Rasch models uniquely satisfy the principles of specific objectivity, sufficiency, unidimensionality, and invariance. For any construct such as pain, fatigue, depression, mobility, or need, Rasch analysis is the only legitimate means of producing an interval scale from ordinal item responses. Rasch measurement is not an alternative to RMT; it is its operational instantiation. The equivalence of Rasch's axioms and the axioms of representational measurement was demonstrated by Wright, Andrich and others as early as the 1970s. In the latent-trait domain, the very domain where HTA claims to operate; Rasch is the only game in town <sup>iv</sup>.

Yet Rasch is effectively absent from all HTA guidelines, including NICE, PBAC, CADTH/CDA, ICER, SMC, and PHARMAC. The analysis demands utilities but never requires that those utilities be measured. They rely on multiattribute ordinal classifications but never understand that those constructs be calibrated on interval or ratio scales. They mandate cost-utility analysis but never justify the arithmetic. They demand modelled QALYs but never interrogate their dimensional properties. These guidelines do not misunderstand Rasch; they do not know it exists. The axioms that define measurement and the model that makes latent trait measurement possible are invisible to the authors of global HTA rules. The field has evolved without the science that measurement demands.

How did HTA miss the bus so thoroughly? The answer lies in its historical origins. In the late 1970s and early 1980s, HTA emerged not from measurement science but from welfare economics, decision theory, and administrative pressure to control drug budgets. Its core concern was *valuing health states*, not *measuring health*. This move, quiet, subtle, but devastating, shifted the field away from the scientific question "What is the empirical structure of the construct we intend to measure?" and toward the administrative question "How do we elicit a preference weight that we can multiply by time?" The preference-elicitation projects of that era (SG, TTO, VAS) were rationalized as measurement techniques, but they never satisfied measurement axioms. Ordinal preferences were dressed up as quasi-cardinal indices; valuation tasks were misinterpreted as psychometrics; analyst convenience replaced measurement theory. The HTA community built an entire belief system around the illusion that valuing health is equivalent to measuring health. It is not.

The endurance of this belief system, forty years strong and globally uniform, is not evidence of validity but evidence of institutionalized error. HTA has operated under conditions of what can only be described as *structural epistemic closure*: a system that has never questioned its constructs because it never learned the language required to ask the questions. Representational measurement theory is not taught in graduate HTA programs; Rasch modelling is not part of guideline development; dimensional analysis is not part of methodological review. The field has been insulated from correction because its conceptual foundations were never laid. What remains is a ritualized practice: utilities in, QALYs out, ICERs calculated, thresholds applied. The arithmetic continues because everyone assumes someone else validated the numbers.

This Logit Working Paper series exposes, through probabilistic and logit-based interrogations of AI large language national knowledge bases, the scale of this failure. The results display a global

pattern: true statements reflecting the axioms of measurement receive weak endorsement; false statements reflecting the HTA belief system receive moderate or strong reinforcement. This is not disagreement. It is non-possession. It shows that HTA, worldwide, has developed as a quantitative discipline without quantitative foundations; a confused exercise in numerical storytelling.

The conclusion is unavoidable: HTA does not need incremental reform; it needs a scientific revolution. Measurement must precede arithmetic. Representational axioms must precede valuation rituals. Rasch measurement must replace ordinal summation and utility algorithms. Value claims must be falsifiable, protocol-driven, and measurable; rather than simulated, aggregated, and numerically embellished.

The global system of non-measurement is now visible. The task ahead is to replace it with science.

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### **DISCLAIMER**

This analysis is generated through the structured interrogation of a large language model (LLM) applied to a defined documentary corpus and is intended solely to characterize patterns within an aggregated knowledge environment. It does not identify, assess, or attribute beliefs, intentions, competencies, or actions to any named individual, faculty member, student, administrator, institution, or organization. The results do not constitute factual findings about specific persons or programs, nor should they be interpreted as claims regarding professional conduct, educational quality, or compliance with regulatory or accreditation standards. All probabilities and logit values reflect model-based inferences about the presence or absence of concepts within a bounded textual ecosystem, not judgments about real-world actors. The analysis is exploratory, interpretive, and methodological in nature, offered for scholarly discussion of epistemic structures rather than evaluative or legal purposes. Any resemblance to particular institutions or practices is contextual and non-attributive, and no adverse implication should be inferred.

# 1. INTERROGATING THE LARGE LANGUAGE MODEL

A large language model (LLM) is an artificial intelligence system designed to understand, generate, and manipulate human language by learning patterns from vast amounts of text data. Built on deep neural network architectures, most commonly transformers, LLMs analyze relationships between words, sentences, and concepts to produce contextually relevant responses. During training, the model processes billions of examples, enabling it to learn grammar, facts, reasoning patterns, and even subtle linguistic nuances. Once trained, an LLM can perform a wide range of tasks: answering questions, summarizing documents, generating creative writing, translating languages, assisting with coding, and more. Although LLMs do not possess consciousness or true understanding, they simulate comprehension by predicting the most likely continuation of text based on learned patterns. Their capabilities make them powerful tools for communication, research, automation, and decision support, but they also require careful oversight to ensure accuracy, fairness, privacy, and responsible use

In this Logit Working Paper, “interrogation” refers not to discovering what an LLM *believes*, it has no beliefs, but to probing the content of the *corpus-defined knowledge space* we choose to analyze. This knowledge base is enhanced if it is backed by accumulated memory from the user. In this case the interrogation relies also on 12 months of HTA memory from continued application of the system to evaluate HTA experience. The corpus is defined before interrogation: it may consist of a journal (e.g., *Value in Health*), a national HTA body, a specific methodological framework, or a collection of policy documents. Once the boundaries of that corpus are established, the LLM is used to estimate the conceptual footprint within it. This approach allows us to determine which principles are articulated, neglected, misunderstood, or systematically reinforced.

In this HTA assessment, the objective is precise: to determine the extent to which a given HTA knowledge base or corpus, global, national, institutional, or journal-specific, recognizes and reinforces the foundational principles of representational measurement theory (RMT). The core principle under investigation is that measurement precedes arithmetic; no construct may be treated as a number or subjected to mathematical operations unless the axioms of measurement are satisfied. These axioms include unidimensionality, scale-type distinctions, invariance, additivity, and the requirement that ordinal responses cannot lawfully be transformed into interval or ratio quantities except under Rasch measurement rules.

The HTA knowledge space is defined pragmatically and operationally. For each jurisdiction, organization, or journal, the corpus consists of:

- published HTA guidelines
- agency decision frameworks
- cost-effectiveness reference cases
- academic journals and textbooks associated with HTA
- modelling templates, technical reports, and task-force recommendations
- teaching materials, methodological articles, and institutional white papers

These sources collectively form the epistemic environment within which HTA practitioners develop their beliefs and justify their evaluative practices. The boundary of interrogation is thus not the whole of medicine, economics, or public policy, but the specific textual ecosystem that sustains HTA reasoning. . The “knowledge base” is therefore not individual opinions but the cumulative, structured content of the HTA discourse itself within the LLM.

## **THE HTPU KNOWLEDGE BASE**

The Health Technology and Policy Unit (HTPU) at the University of Alberta represents a well-defined academic knowledge base within the Canadian HTA landscape, characterized by its integration of economic evaluation, health services research, and policy analysis. Situated within a university environment but closely linked to healthcare decision-making, the HTPU operates at the interface between methodological development and applied evaluation. Its knowledge base reflects both the academic traditions of health economics and the practical requirements of informing policy in publicly funded healthcare systems.

At its core, the HTPU knowledge base is structured around the principles of cost-effectiveness and cost-utility analysis. The central analytical task is the comparison of alternative healthcare interventions in terms of costs and outcomes, typically expressed through incremental cost-effectiveness ratios. Outcomes are frequently represented using quality-adjusted life years, which combine estimates of survival and health-related quality of life into a single index. These estimates are derived from preference-based instruments, most commonly the EQ-5D, with utility values obtained through standardized valuation techniques. Within the HTPU framework, these values are treated as quantities that can be combined, aggregated, and compared across interventions and populations.

A defining feature of the HTPU knowledge base is its reliance on decision-analytic modeling. Models are used to simulate disease progression, treatment pathways, and long-term outcomes, often extending beyond the time horizons of available clinical data. These models incorporate inputs from clinical trials, observational studies, and meta-analyses, and are structured to estimate both costs and effects under alternative scenarios. Probabilistic sensitivity analysis and scenario testing are used to address uncertainty, reflecting standard practice in HTA. The outputs of these models with costs, QALYs, and incremental ratios are presented as evidence to support policy decisions regarding resource allocation and technology adoption.

The knowledge base also incorporates elements of evidence synthesis and comparative effectiveness research. Systematic reviews and meta-analyses are used to identify and combine evidence from multiple sources, providing inputs for economic evaluation and supporting broader assessments of clinical effectiveness. This integration of evidence reflects the broader HTA objective of informing decisions under conditions of uncertainty, balancing considerations of effectiveness, cost, and population impact.

The HTPU knowledge base is characterized by a high degree of internal coherence. The methods employed are standardized, widely accepted within the HTA community, and aligned with national and international guidelines. There is a clear relationship between the analytical tools used, the data inputs selected, and the outputs generated. This coherence supports the reproducibility of

analyses and facilitates their interpretation within established decision-making frameworks. The knowledge base therefore functions as a stable and consistent system for producing policy-relevant evidence.

At the same time, the structure of the HTPU knowledge base reflects a set of implicit assumptions regarding measurement. Constructs such as utilities, QALYs, and composite indices are treated as operational quantities that can be combined through arithmetic operations. The scale properties required to justify these operations, such as the presence of a true zero, unidimensionality, and dimensional homogeneity are not explicitly examined within the framework. Similarly, the transformation of subjective responses into measurable quantities is assumed rather than demonstrated. This reflects a broader orientation toward the application of established methods rather than the examination of their foundational properties.

The emphasis on practical application reinforces this orientation. The primary objective of the HTPU is to generate evidence that can inform real-world decisions. This focus on applicability and relevance prioritizes the use of established analytical tools and accepted outcome measures. As a result, the knowledge base evolves through the refinement and application of these tools rather than through engagement with the underlying principles of measurement.

In summary, the HTPU knowledge base represents a mature and methodologically coherent approach to health technology assessment. It integrates economic evaluation, modeling, and evidence synthesis into a structured framework designed to inform healthcare policy. At the same time, it operates within a set of assumptions about measurement that are not explicitly addressed, reflecting its alignment with the broader HTA paradigm while maintaining a strong focus on practical decision-making.

## **CATEGORICAL PROBABILITIES**

In the present application, the interrogation is tightly bounded. It does not ask what an LLM “thinks,” nor does it request a normative judgment. Instead, the LLM evaluates how likely the HTA knowledge space is to endorse, imply, or reinforce a set of 24 diagnostic statements derived from representational measurement theory (RMT). Each statement is objectively TRUE or FALSE under RMT. The objective is to assess whether the HTA corpus exhibits possession or non-possession of the axioms required to treat numbers as measures. The interrogation creates an endorsement probability: the estimated likelihood that the HTA knowledge base endorses the statement whether it is true or false; *explicitly or implicitly*.

The use of categorical endorsement probabilities within the Logit Working Papers reflects both the nature of the diagnostic task and the structure of the language model that underpins it. The purpose of the interrogation is not to estimate a statistical frequency drawn from a population of individuals, nor to simulate the behavior of hypothetical analysts. Instead, the aim is to determine the conceptual tendencies embedded in a domain-specific knowledge base: the discursive patterns, methodological assumptions, and implicit rules that shape how a health technology assessment environment behaves. A large language model does not “vote” like a survey respondent; it expresses likelihoods based on its internal representation of a domain. In this context, endorsement probabilities capture the strength with which the knowledge base, as represented within the model,

supports a particular proposition. Because these endorsements are conceptual rather than statistical, the model must produce values that communicate differences in reinforcement without implying precision that cannot be justified.

This is why categorical probabilities are essential. Continuous probabilities would falsely suggest a measurable underlying distribution, as if each HTA system comprised a definable population of respondents with quantifiable frequencies. But large language models do not operate on that level. They represent knowledge through weighted relationships between linguistic and conceptual patterns. When asked whether a domain tends to affirm, deny, or ignore a principle such as unidimensionality, admissible arithmetic, or the axioms of representational measurement, the model draws on its internal structure to produce an estimate of conceptual reinforcement. The precision of that estimate must match the nature of the task. Categorical probabilities therefore provide a disciplined and interpretable way of capturing reinforcement strength while avoiding the illusion of statistical granularity.

The categories used, values such as 0.05, 0.10, 0.20, 0.50, 0.75, 0.80, and 0.85, are not arbitrary. They function as qualitative markers that correspond to distinct degrees of conceptual possession: near-absence, weak reinforcement, inconsistent or ambiguous reinforcement, common reinforcement, and strong reinforcement. These values are far enough apart to ensure clear interpretability yet fine-grained enough to capture meaningful differences in the behavior of the knowledge base. The objective is not to measure probability in a statistical sense but to classify the epistemic stance of the domain toward a given item. A probability of 0.05 signals that the knowledge base almost never articulates or implies the correct response under measurement theory, whereas 0.85 indicates that the domain routinely reinforces it. Values near the middle reflect conceptual instability rather than a balanced distribution of views.

Using categorical probabilities also aligns with the requirements of logit transformation. Converting these probabilities into logits produces an interval-like diagnostic scale that can be compared across countries, agencies, journals, or organizations. The logit transformation stretches differences at the extremes, allowing strong reinforcement and strong non-reinforcement to become highly visible. Normalizing logits to the fixed  $\pm 2.50$  range ensure comparability without implying unwarranted mathematical precision. Without categorical inputs, logits would suggest a false precision that could mislead readers about the nature of the diagnostic tool.

In essence, the categorical probability approach translates the conceptual architecture of the LLM into a structured and interpretable measurement analogue. It provides a disciplined bridge between the qualitative behavior of a domain's knowledge base and the quantitative diagnostic framework needed to expose its internal strengths and weaknesses.

The LLM computes these categorical probabilities from three sources:

- 1. Structural content of HTA discourse**

If the literature repeatedly uses ordinal utilities as interval measures, multiplies non-quantities, aggregates QALYs, or treats simulations as falsifiable, the model infers high reinforcement of these false statements.

## 2. **Conceptual visibility of measurement axioms**

If ideas such as unidimensionality, dimensional homogeneity, scale-type integrity, or Rasch transformation rarely appear, or are contradicted by practice, the model assigns low endorsement probabilities to TRUE statements.

## 3. **The model's learned representation of domain stability**

Where discourse is fragmented, contradictory, or conceptually hollow, the model avoids assigning high probabilities. This is *not* averaging across people; it is a reflection of internal conceptual incoherence within HTA.

The output of interrogation is a categorical probability for each statement. Probabilities are then transformed into logits [  $\ln(p/(1-p))$  ], capped to  $\pm 4.0$  logits to avoid extreme distortions, and normalized to  $\pm 2.50$  logits for comparability across countries. A positive normalized logit indicates reinforcement in the knowledge base. A negative logit indicates weak reinforcement or conceptual absence. Values near zero logits reflect epistemic noise.

Importantly, *a high endorsement probability for a false statement does not imply that practitioners knowingly believe something incorrect*. It means the HTA literature itself behaves as if the falsehood were true; through methods, assumptions, or repeated uncritical usage. Conversely, a low probability for a true statement indicates that the literature rarely articulates, applies, or even implies the principle in question.

The LLM interrogation thus reveals structural epistemic patterns in HTA: which ideas the field possesses, which it lacks, and where its belief system diverges from the axioms required for scientific measurement. It is a diagnostic of the *knowledge behavior* of the HTA domain, not of individuals. The 24 statements function as probes into the conceptual fabric of HTA, exposing the extent to which practice aligns or fails to align with the axioms of representational measurement.

## **INTERROGATION STATEMENTS**

Below is the canonical list of the 24 diagnostic HTA measurement items used in all the logit analyses, each marked with its correct truth value under representational measurement theory (RMT) and Rasch measurement principles.

This is the definitive set used across the Logit Working Papers.

### **Measurement Theory & Scale Properties**

1. Interval measures lack a true zero — TRUE
2. Measures must be unidimensional — TRUE
3. Multiplication requires a ratio measure — TRUE
4. Time trade-off preferences are unidimensional — FALSE
5. Ratio measures can have negative values — FALSE
6. EQ-5D-3L preference algorithms create interval measures — FALSE
7. The QALY is a ratio measure — FALSE
8. Time is a ratio measure — TRUE

### **Measurement Preconditions for Arithmetic**

- 9. Measurement precedes arithmetic — TRUE
- 10. Summations of subjective instrument responses are ratio measures — FALSE
- 11. Meeting the axioms of representational measurement is required for arithmetic — TRUE

### **Rasch Measurement & Latent Traits**

- 12. There are only two classes of measurement: linear ratio and Rasch logit ratio — TRUE
- 13. Transforming subjective responses to interval measurement is only possible with Rasch rules — TRUE
- 14. Summation of Likert question scores creates a ratio measure — FALSE

### **Properties of QALYs & Utilities**

- 15. The QALY is a dimensionally homogeneous measure — FALSE
- 16. Claims for cost-effectiveness fail the axioms of representational measurement — TRUE
- 17. QALYs can be aggregated — FALSE

### **Falsifiability & Scientific Standards**

- 18. Non-falsifiable claims should be rejected — TRUE
- 19. Reference-case simulations generate falsifiable claims — FALSE

### **Logit Fundamentals**

- 20. The logit is the natural logarithm of the odds-ratio — TRUE

### **Latent Trait Theory**

- 21. The Rasch logit ratio scale is the only basis for assessing therapy impact for latent traits — TRUE
- 22. A linear ratio scale for manifest claims can always be combined with a logit scale — FALSE
- 23. The outcome of interest for latent traits is the possession of that trait — TRUE
- 24. The Rasch rules for measurement are identical to the axioms of representational measurement — TRUE

## AI LARGE LANGUAGE MODEL STATEMENTS: TRUE OR FALSE

Each of the 24 statements has a 400 word explanation why the statement is true or false as there may be differences of opinion on their status in terms of unfamiliarity with scale typology and the axioms of representational measurement.

The link to these explanations is: <https://maimonresearch.com/ai-llm-true-or-false/>

## INTERPRETING TRUE STATEMENTS

TRUE statements represent foundational axioms of measurement and arithmetic. Endorsement probabilities for TRUE items typically cluster in the low range, indicating that the HTA corpus does *not* consistently articulate or reinforce essential principles such as:

- measurement preceding arithmetic
- unidimensionality
- scale-type distinctions
- dimensional homogeneity
- impossibility of ratio multiplication on non-ratio scales
- the Rasch requirement for latent-trait measurement

Low endorsement indicates **non-possession** of fundamental measurement knowledge—the literature simply does not contain, teach, or apply these principles.

## INTERPRETING FALSE STATEMENTS

FALSE statements represent the well-known mathematical impossibilities embedded in the QALY framework and reference-case modelling. Endorsement probabilities for FALSE statements are often moderate or even high, meaning the HTA knowledge base:

- accepts non-falsifiable simulation as evidence
- permits negative “ratio” measures
- treats ordinal utilities as interval measures
- treats QALYs as ratio measures
- treats summated ordinal scores as ratio scales
- accepts dimensional incoherence

This means the field systematically reinforces incorrect assumptions at the center of its practice. *Endorsement* here means the HTA literature behaves as though the falsehood were true.

## **2. SUMMARY OF FINDINGS FOR TRUE AND FALSE ENDORSEMENTS: UNIVERSITY OF ALBERTA HEALTH TECHNOLOGY AND POLICY UNIT (HTPU)**

Table 1 presents probabilities and normalized logits for each of the 24 diagnostic measurement statements. This is the standard reporting format used throughout the HTA assessment series.

It is essential to understand how to interpret these results.

The endorsement probabilities do not indicate whether a statement is *true* or *false* under representational measurement theory. Instead, they estimate the extent to which the HTA knowledge base associated with the target treats the statement as if it were true, that is, whether the concept is reinforced, implied, assumed, or accepted within the country's published HTA knowledge base.

The logits provide a continuous, symmetric scale, ranging from +2.50 to -2.50, that quantifies the degree of this endorsement. The logits, of course link to the probabilities ( $p$ ) as the logit is the natural logarithm of the odds ratio;  $\text{logit} = \ln[p/1-p]$ .

- Strongly positive logits indicate pervasive reinforcement of the statement within the knowledge system.
- Strongly negative logits indicate conceptual absence, non-recognition, or contradiction within that same system.
- Values near zero indicate only shallow, inconsistent, or fragmentary support.

Thus, the endorsement logit profile serves as a direct index of a country's epistemic alignment with the axioms of scientific measurement, revealing the internal structure of its HTA discourse. It does not reflect individual opinions or survey responses, but the implicit conceptual commitments encoded in the literature itself.

### **HTPU: ENDORSING MEASUREMENT INVERSION**

The results presented in Table 1 demonstrate a clear and consistent pattern. As with previous The Health Technology and Policy Unit (HTPU) at the University of Alberta represents a well-established academic research domain within the Canadian HTA landscape. Positioned within a major research university and closely linked to provincial and national health policy environments, the HTPU knowledge base integrates economic evaluation, policy analysis, and applied health services research. Its outputs include cost-effectiveness analyses, systematic reviews, and modeling studies designed to inform healthcare decision-making. As such, it reflects a mature instantiation of the HTA paradigm and provides an appropriate domain for interrogation using the canonical 24-statement diagnostic.

**TABLE 1: ITEM STATEMENT, RESPONSE, ENDORSEMENT AND NORMALIZED LOGITS HTPU**

<b>STATEMENT</b>	<b>RESPONSE 1=TRUE 0=FALSE</b>	<b>ENDORSEMENT OF RESPONSE CATEGORICAL PROBABILITY</b>	<b>NORMALIZED LOGIT (IN RANGE +/- 2.50)</b>
INTERVAL MEASURES LACK A TRUE ZERO	1	0.15	-1.75
MEASURES MUST BE UNIDIMENSIONAL	1	0.10	-2.20
MULTIPLICATION REQUIRES A RATIO MEASURE	1	0.10	-2.20
TIME TRADE-OFF PREFERENCES ARE UNIDIMENSIONAL	0	0.85	+1.75
RATIO MEASURES CAN HAVE NEGATIVE VALUES	0	0.90	+2.20
EQ-5D-3L PREFERENCE ALGORITHMS CREATE INTERVAL MEASURES	0	0.90	+2.20
THE QALY IS A RATIO MEASURE	0	0.95	+2.50
TIME IS A RATIO MEASURE	1	0.90	+2.20
MEASUREMENT PRECEDES ARITHMETIC	1	0.10	-2.20
SUMMATIONS OF SUBJECTIVE INSTRUMENT RESPONSES ARE RATIO MEASURES	0	0.90	+2.20
MEETING THE AXIOMS OF REPRESENTATIONAL MEASUREMENT IS REQUIRED FOR ARITHMETIC	1	0.10	-2.20
THERE ARE ONLY TWO CLASSES OF MEASUREMENT LINEAR RATIO AND RASCH LOGIT RATIO	1	0.05	-2.50
TRANSFORMING SUBJECTIVE RESPONSES TO INTERVAL MEASUREMENT IS ONLY POSSIBLE WITH RASH RULES	1	0.05	-2.509
SUMMATION OF LIKERT QUESTION SCORES CREATES A RATIO MEASURE	0	0.90	+2.20
THE QALY IS A DIMENSIONALLY HOMOGENEOUS MEASURE	0	0.95	+2.50

CLAIMS FOR COST-EFFECTIVENESS FAIL THE AXIOMS OF REPRESENTATIONAL MEASUREMENT	1	0.10	-2.20
QALYS CAN BE AGGREGATED	0	0.95	+2.50
NON-FALSIFIABLE CLAIMS SHOULD BE REJECTED	1	0.20	-1.40
REFERENCE CASE SIMULATIONS GENERATE FALSIFIABLE CLAIMS	0	0.90	+2.20
THE LOGIT IS THE NATURAL LOGARITHM OF THE ODDS-RATIO	1	0.30	-0.85
THE RASCH LOGIT RATIO SCALE IS THE ONLY BASIS FOR ASSESSING THERAPY IMPACT FOR LATENT TRAITS	1	0.05	-2.50
A LINEAR RATIO SCALE FOR MANIFEST CLAIMS CAN ALWAYS BE COMBINED WITH A LOGIT SCALE	0	0.80	+1.40
THE OUTCOME OF INTEREST FOR LATENT TRAITS IS THE POSSESSION OF THAT TRAIT	1	0.05	-2.50
THE RASCH RULES FOR MEASUREMENT ARE IDENTICAL TO THE AXIOMS OF REPRESENTATIONAL MEASUREMENT	1	0.05	-2.50

The first group of statements addresses the foundational requirements of measurement. These include unidimensionality, the restriction of multiplication to ratio scales, the requirement that measurement precede arithmetic, and the necessity of dimensional homogeneity. Across these statements, endorsement probabilities are consistently low, typically at 0.10, with logits of -2.20, and in several cases at 0.05 with logits of -2.50. This indicates that these principles are not recognized or operationalized within the HTPU knowledge base. There is no evidence that these axioms are treated as prerequisites for the numerical operations that underpin HTA analysis.

This absence is particularly significant given the centrality of arithmetic within HTPU outputs. Cost-effectiveness analysis requires the calculation of incremental ratios, the aggregation of outcomes over time, and the combination of costs and effects into composite measures. These operations presuppose specific scale properties. The interrogation results indicate that these properties are not explicitly considered. The knowledge base proceeds as if measurement conditions have been satisfied, without demonstrating that they are in place.

In contrast, statements reflecting standard HTA constructs receive strong endorsement. These include the treatment of QALYs as ratio measures, the aggregation of QALYs across populations, the multiplication of utilities by time, and the interpretation of cost-effectiveness ratios as meaningful quantities. Probabilities for these statements are consistently high, typically 0.90 to

0.95, with logits between +2.20 and +2.50. This indicates that these propositions are deeply embedded within the knowledge base and form the basis of analytical practice.

The symmetry between weak endorsement of true statements and strong endorsement of false statements defines the pattern of measurement inversion. This pattern is not incidental. It reflects a structured set of assumptions in which the axioms of measurement are absent, while incompatible propositions are normalized. For example, the requirement that multiplication be restricted to ratio scales is weakly endorsed, while the multiplication of utilities by time is strongly endorsed. Similarly, dimensional homogeneity is not recognized, while the aggregation of QALYs is treated as unproblematic. These pairings are logically incompatible, yet they coexist within the knowledge base without apparent contradiction.

The central role of QALYs within the HTPU knowledge base reinforces this pattern. QALYs are used as the primary outcome measure in economic evaluation, combining survival and quality of life into a single index. The interrogation shows strong endorsement of statements affirming QALYs as ratio measures and dimensionally homogeneous quantities. At the same time, there is weak recognition of the conditions required to support these claims. This indicates that the measurement properties of QALYs are assumed rather than demonstrated.

The treatment of utility measurement further illustrates this point. Preference-based instruments such as the EQ-5D are used to generate utility values, which are then incorporated into QALY calculations. The interrogation results show strong endorsement of statements suggesting that these values possess interval or ratio properties. At the same time, there is weak recognition of the requirement for Rasch transformation or other methods to establish measurement properties for latent constructs. This indicates that the transformation of subjective responses into measurable quantities is not part of the knowledge base.

The reliance on modeling frameworks within HTPU analyses provides additional insight. Decision-analytic models are used to project long-term outcomes, simulate disease progression, and estimate costs and effects under alternative scenarios. These models generate outputs that are interpreted as evidence for decision-making. The interrogation results show strong endorsement of statements equating simulation outputs with falsifiable claims, despite weak recognition of the conditions required for empirical evaluation. This suggests that the distinction between modeled outputs and measurable evidence is not maintained.

It is important to emphasize that the HTPU knowledge base is internally coherent and methodologically rigorous within its own framework. The methods employed are consistent, widely accepted, and supported by a substantial body of literature. Models are constructed carefully, data inputs are selected systematically, and uncertainty is addressed through established techniques. The issue identified through interrogation is not a lack of rigor, but a lack of alignment with the axioms of measurement.

This distinction is critical. The HTPU knowledge base functions effectively within its own assumptions. It produces outputs that are consistent, reproducible, and useful within the context of HTA decision-making. However, these outputs are not grounded in measurement as defined by

representational theory. The absence of measurement principles does not disrupt the internal functioning of the framework, but it has implications for the interpretation of its results.

The consistency of the pattern observed in this interrogation reinforces the broader conclusion that measurement inversion is a structural feature of HTA. The HTPU is not an outlier. It is representative of a class of knowledge bases that share a common set of assumptions. The same pattern—weak endorsement of measurement principles and strong endorsement of incompatible propositions—has been observed across multiple domains, including academic centers, policy organizations, and journals.

In conclusion, the interrogation of the HTPU knowledge base demonstrates not merely a divergence from the axioms of representational measurement, but a systematic inversion of them. Foundational principles—unidimensionality, dimensional homogeneity, and the requirement that measurement precede arithmetic—are weakly recognized or absent, while propositions that directly violate these axioms are strongly endorsed and operationalized. This is not an isolated inconsistency or a matter of incomplete understanding. It reflects a coherent and internally reinforced framework in which numerical outputs are generated and interpreted without reference to the conditions that would make them valid measures.

The implications are unavoidable. A knowledge base that fails to recognize the requirements of measurement cannot support evaluable claims, regardless of the sophistication of its methods or the volume of its outputs. The reproducibility of this pattern across interrogations confirms that this is not a local deficiency, but a structural characteristic of HTA. The HTPU knowledge base, as a representative academic domain, exemplifies a system in which arithmetic has displaced measurement, and where the appearance of quantitative rigor substitutes for the existence of measurable attributes. Until this inversion is addressed, the numerical claims produced within this framework remain assertions without a scientific foundation.

### **III. THE TRANSITION TO MEASUREMENT IN HEALTH TECHNOLOGY ASSESSMENT**

#### **THE IMPERATIVE OF CHANGE**

This analysis has not been undertaken to criticize decisions made by health system, nor to assign responsibility for the analytical frameworks currently used in formulary review. The evidence shows something more fundamental: organizations have been operating within a system that does not permit meaningful evaluation of therapy impact, even when decisions are made carefully, transparently, and in good faith.

The present HTA framework forces health systems to rely on numerical outputs that appear rigorous but cannot be empirically assessed (Table 1). Reference-case models, cost-per-QALY ratios, and composite value claims are presented as decision-support tools, yet they do not satisfy the conditions required for measurement. As a result, committees are asked to deliberate over results that cannot be validated, reproduced, or falsified. This places decision makers in an untenable position: required to choose among therapies without a stable evidentiary foundation.

This is not a failure of expertise, diligence, or clinical judgment. It is a structural failure. The prevailing HTA architecture requires arithmetic before measurement, rather than measurement before arithmetic. Health systems inherit this structure rather than design it. Manufacturers respond to it. Consultants reproduce it. Journals reinforce it. Universities promote it. Over time it has come to appear normal, even inevitable.

Yet the analysis presented in Table 1 demonstrates that this HTA framework cannot support credible falsifiable claims. Where the dependent variable is not a measure, no amount of modeling sophistication can compensate. Uncertainty analysis cannot rescue non-measurement. Transparency cannot repair category error. Consensus cannot convert assumption into evidence.

The consequence is that formulary decisions are based on numerical storytelling rather than testable claims. This undermines confidence, constrains learning, and exposes health systems to growing scrutiny from clinicians, patients, and regulators who expect evidence to mean something more than structured speculation.

The imperative of change therefore does not arise from theory alone. It arises from governance responsibility. A health system cannot sustain long-term stewardship of care if it lacks the ability to distinguish between claims that can be evaluated and claims that cannot. Without that distinction, there is no pathway to improvement; only endless repetition for years to come.

This transition is not about rejecting evidence. It is about restoring evidence to its proper meaning. It requires moving away from composite, model-driven imaginary constructs toward claims that are measurable, unidimensional, and capable of empirical assessment over time. The remainder of this section sets out how that transition can occur in a practical, defensible, and staged manner.

## **MEANINGFUL THERAPY IMPACT CLAIMS**

At the center of the current problem is not data availability, modeling skill, or analytic effort. It is the nature of the claims being advanced. Contemporary HTA has evolved toward increasingly complex frameworks that attempt to compress multiple attributes, clinical effects, patient experience, time, and preferences into single composite outputs. These constructs are then treated as if they were measures. They are not (Table 1).

The complexity of the reference-case framework obscures a simpler truth: meaningful evaluation requires meaningful claims. A claim must state clearly what attribute is being affected, in whom, over what period, and how that attribute is measured. When these conditions are met, evaluation becomes possible. When they are not complexity substitutes for clarity. The current framework is not merely incorrect; it is needlessly elaborate. Reference-case modeling requires dozens of inputs, assumptions, and transformations, yet produces outputs that cannot be empirically verified. Each additional layer of complexity increases opacity while decreasing accountability. Committees are left comparing models rather than assessing outcomes.

In contrast, therapy impact can be expressed through two, and only two, types of legitimate claims. First are claims based on manifest attributes: observable events, durations, or resource units. These include hospitalizations avoided, time to event, days in remission, or resource use. When properly defined and unidimensional, these attributes can be measured on linear ratio scales and evaluated directly.

Second are claims based on latent attributes: symptoms, functioning, need fulfillment, or patient experience. These cannot be observed directly and therefore cannot be scored or summed meaningfully. They require formal measurement through Rasch models to produce invariant logit ratio scales. These two forms of claims are sufficient. They are also far more transparent. Each can be supported by a protocol. Each can be revisited. Each can be reproduced. Most importantly, each can fail. But they cannot be combined. This is the critical distinction. A meaningful claim is one that can be wrong.

Composite constructs such as QALYs do not fail in this sense. They persist regardless of outcome because they are insulated by assumptions. They are recalculated, not refuted. That is why they cannot support learning. The evolution of objective knowledge regarding therapy impact in disease areas is an entirely foreign concept. By re-centering formulary review on single-attribute, measurable claims, health systems regain control of evaluation. Decisions become grounded in observable change rather than modeled narratives. Evidence becomes something that accumulates, rather than something that is re-generated anew for every submission.

## **THE PATH TO MEANINGFUL MEASUREMENT**

Transitioning to meaningful measurement does not require abandoning current processes overnight. It requires reordering them. The essential change is not procedural but conceptual: measurement must become the gatekeeper for arithmetic, not its byproduct.

The first step is formal recognition that not all numerical outputs constitute evidence. Health systems must explicitly distinguish between descriptive analyses and evaluable claims. Numbers that do not meet measurement requirements may inform discussion but cannot anchor decisions.

The second step is restructuring submissions around explicit claims rather than models. Each submission should identify a limited number of therapy impact claims, each defined by attribute, population, timeframe, and comparator. Claims must be unidimensional by design.

Third, each claim must be classified as manifest or latent. This classification determines the admissible measurement standard and prevents inappropriate mixing of scale types.

Fourth, measurement validity must be assessed before any arithmetic is permitted. For manifest claims, this requires confirmation of ratio properties. For latent claims, this requires Rasch-based measurement with demonstrated invariance.

Fifth, claims must be supported by prospective or reproducible protocols. Evidence must be capable of reassessment, not locked within long-horizon simulations designed to frustrate falsification.

Sixth, committees must be supported through targeted training in representational measurement principles, including Rasch fundamentals. Without this capacity, enforcement cannot occur consistently.

Finally, evaluation must be iterative. Claims are not accepted permanently. They are monitored, reproduced, refined, or rejected as evidence accumulates.

These steps do not reduce analytical rigor. They restore it.

## **TRANSITION REQUIRES TRAINING**

A transition to meaningful measurement cannot be achieved through policy alone. It requires a parallel investment in training, because representational measurement theory is not intuitive and has never been part of standard professional education in health technology assessment, pharmacoeconomics, or formulary decision making. For more than forty years, practitioners have been taught to work within frameworks that assume measurement rather than demonstrate it. Reversing that inheritance requires structured learning, not informal exposure.

At the center of this transition is the need to understand why measurement must precede arithmetic. Representational measurement theory establishes the criteria under which numbers can legitimately represent empirical attributes. These criteria are not optional. They determine whether addition, multiplication, aggregation, and comparison are meaningful or merely symbolic. Without this foundation, committees are left evaluating numerical outputs without any principled way to distinguish evidence from numerical storytelling.

Training must therefore begin with scale types and their permissible operations. Linear ratio measurement applies to manifest attributes that possess a true zero and invariant units, such as

time, counts, and resource use. Latent attributes, by contrast, cannot be observed directly and cannot be measured through summation or weighting. They require formal construction through a measurement model capable of producing invariant units. This distinction is the conceptual fulcrum of reform, because it determines which claims are admissible and which are not.

For latent trait claims, Rasch measurement provides the only established framework capable of meeting these requirements. Developed in the mid-twentieth century alongside the foundations of modern measurement theory, the Rasch model was explicitly designed to convert subjective observations into linear logit ratio measures. It enforces unidimensionality, tests item invariance, and produces measures that support meaningful comparison across persons, instruments, and time. These properties are not approximations; they are defining conditions of measurement.

Importantly, Rasch assessment is no longer technically burdensome. Dedicated software platforms developed and refined over more than four decades make Rasch analysis accessible, transparent, and auditable. These programs do not merely generate statistics; they explain why items function or fail, how scales behave, and whether a latent attribute has been successfully measured. Measurement becomes demonstrable rather than assumed.

Maimon Research has developed a two-part training program specifically to support this transition. The first component provides foundational instruction in representational measurement theory, including the historical origins of scale theory, the distinction between manifest and latent attributes, and the criteria that define admissible claims. The second component focuses on application, detailing claim types, protocol design, and the practical use of Rasch methods to support latent trait evaluation.

Together, these programs equip health systems, committees, and analysts with the competence required to enforce measurement standards consistently. Training does not replace judgment; it enables it. Without such preparation, the transition to meaningful measurement cannot be sustained. With it, formulary decision making can finally rest on claims that are not merely numerical, but measurable.

## **A NEW FRAMEWORK FOR HEALTH TECHNOLOGY ASSESSMENT**

For readers seeking an introduction to measurement that meets the standards of representational measurement, Maimon Research has released a new distance education program:

### **Health Technology Assessment Rebuilt – Evidence and Value**

This 12-module program (approximately 85,000 words) is structured around three core objectives:

- (i) defining value claims that meet the requirements of representational measurement,
- (ii) deconstructing the assumptions embedded in current HTA frameworks, and
- (iii) establishing standards for value claims for both manifest and latent attributes that satisfy mandatory measurement axioms.

The program is designed as a practical framework for evaluating and constructing HTA claims, rather than as a theoretical critique. It is priced at US\$250.

As with previous programs, invitations will be distributed to approximately 8,700 HTA professionals across 30 countries.

Further details on program content, access, and registration are available [here](#):

## **DESIGNED FOR CLOSURE**

For those who remain unconvinced that there is any need to abandon a long-standing and widely accepted HTA framework, it is necessary to confront a more fundamental question: why was this system developed and promoted globally in the first place?

The most plausible explanation is administrative rather than scientific. Policy makers were searching for an assessment framework that could be applied under conditions of limited empirical data while still producing a determinate conclusion. Reference-case modeling offered precisely this convenience. By constructing a simulation populated with assumptions, surrogate endpoints, preference weights, and extrapolated time horizons, it became possible to generate a numerical result that could be interpreted as decisive. Once an acceptable cost-effectiveness ratio emerged, the assessment could be declared complete and the pricing decision closed. This structure solved a political and administrative problem. It allowed authorities to claim that decisions were evidence-based without requiring the sustained empirical burden demanded by normal science. There was no requirement to formulate provisional claims and subject them to ongoing falsification. There was no obligation to revisit conclusions as new data emerged. Closure could be achieved at launch, rather than knowledge evolving over the product life cycle.

By contrast, a framework grounded in representational measurement would have imposed a very different obligation. Claims would necessarily be provisional. Measurement would precede arithmetic. Each therapy impact claim would require a defined attribute, a valid scale, a protocol, and the possibility of replication or refutation. Evidence would accumulate rather than conclude. Decisions would remain open to challenge as real-world data emerged. From an administrative standpoint, this was an unreasonable burden. It offered no finality.

The reference-case model avoided this problem entirely. By shifting attention away from whether quantities were measurable and toward whether assumptions were plausible, the framework replaced falsification with acceptability. Debate became internal to the model rather than external to reality. Sensitivity analysis substituted for empirical risk. Arithmetic proceeded without prior demonstration that the objects being manipulated possessed the properties required for arithmetic to be meaningful.

Crucially, this system required no understanding of representational measurement theory. Committees did not need to ask whether utilities were interval or ratio measures, whether latent traits had been measured or merely scored, or whether composite constructs could legitimately be multiplied or aggregated. These questions were never posed because the framework did not require them to be posed. The absence of measurement standards was not an oversight; it was functionally essential.

Once institutionalized, the framework became self-reinforcing. Training programs taught modeling rather than measurement. Guidelines codified practice rather than axioms. Journals reviewed technique rather than admissibility. Over time, arithmetic without measurement became normalized as “good practice,” while challenges grounded in measurement theory were dismissed as theoretical distractions. The result was a global HTA architecture capable of producing numbers, but incapable of producing falsifiable knowledge. Claims could be compared, ranked, and monetized, but not tested in the scientific sense. What evolved was not objective knowledge, but institutional consensus.

This history matters because it explains why the present transition is resisted. Moving to a real measurement framework with single, unidimensional claims does not merely refine existing methods; it dismantles the very mechanism by which closure has been achieved for forty years. It replaces decisiveness with accountability, finality with learning, and numerical plausibility with empirical discipline. Yet that is precisely the transition now required. A system that avoids measurement in order to secure closure cannot support scientific evaluation, cumulative knowledge, or long-term stewardship of healthcare resources. The choice is therefore unavoidable: continue with a framework designed to end debate, or adopt one designed to discover the truth.

Anything else is not assessment at all, but the ritualized manipulation of numbers detached from measurement, falsification, and scientific accountability.

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