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Re-Reading Deming's Fourteen Points in the Era of Data Science: Fourteen Questions for Vibrant Management of Statistical Information Systems

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Abstract for the Online Supplementary Material:

Key words: administrative record data; big data; incentives; integration of multiple data sources; matrix management; organic data; quality/risk/cost profiles; sample surveys; total survey error model; transparency, reproducibility, and replicability; use value and option value of public goods

Abstract: The printed version of this paper reviewed the landmark "Fourteen Points for Management" presented by W. Edwards Deming in his 1986 book *Out of the Crisis*. These points were anchored in the fundamental concepts of statistical variability, statistical control, practical improvements in underlying systems, and the critical importance of the human element in all areas of management. Much – but not all - of Deming's original exposition of his Fourteen Points occurred in the context of twentieth-century manufacturing. However, the printed version of the current paper suggested that those points align with some elements of fourteen fundamental questions about technical and managerial issues that arise in many large and complex organizations. These questions centered on:

(A) Systematic approaches to statistical variability and design that link stakeholder value with quality, risk, cost, and continuous improvement thereof; and related communications with a wide range of stakeholders (questions 1-6).

(B) Use of the framework from (A) to improve management structure and function, and to strengthen leadership of the organization (questions 7-10).

(C) The critical role of humans in all of their complexity (questions 11-14).

The printed paper suggested that these general questions may be of special interest to the statistical and data science community as it responds to extraordinary opportunities and challenges related to the production, dissemination, and use of high-quality statistical information. Some of the most notable opportunities and challenges arise from changes in the customary survey environment; increased availability of many non-survey data sources; and changes in stakeholder expectations regarding multiple dimensions of quality, risk, and cost of statistical information products and services.

The paper framed that discussion through schematic models for a "performance profile" vector $P = (P, R, C)$ of the properties of a statistical information production system, including sub-vectors for quality (Q), risk (R) and cost (C). For a system intended to produce estimates of a parameter vector θ, the schematic model is:

$$P_\theta(X, Z;\ \gamma) = g(X, Z;\ \gamma) + \ e_P \qquad (1)$$

where $g(\cdot)$ is a function of nominally known form; the vector

$$X = \left(X_{Stakeholders}, X_{Estimands}, X_{Sources}, X_{Dissemination},\ X_{Methodology}, X_{Technology}, X_{Management}\right)$$

represents nominally controlled design decisions; the vector Z describes relevant factors that are observed but not controlled, including societal conditions that may influence the environments for both data collection and data usage; e_P is an error term with mean zero and distribution function that may depend on X and Z; and γ is a parameter vector both for the mean function $g(X, Z;\ \gamma)$ and for the distribution of e_P.

For the multiple dimensions of value V_θ delivered to stakeholders by production and distribution of estimates of θ through a system with properties P , a complementary schematic model is:

$$V_\theta(P, X, Z;\ \alpha) = h(P, X, Z;\ \alpha) + \ e_V \qquad (2)$$

where $h(\cdot)$ is a function of nominally known form; e_V is an error term with mean zero and distribution function that may depend on P, X and Z; and α is a parameter vector for both the mean function $h(P, X, Z;\ \alpha)$ and the distribution of e_V.

For each of the principal fourteen questions, the supplementary statistical sub-questions are listed below:

Questions 1-6: Quality, Risk and Cost and Stakeholder Value, and Their Connections with Statistical Design and Operating Environments

Initial Question 1: "*Clear understanding of the organization's mission and vision.* Who are the primary stakeholders served by our organization; what are the stakeholder needs that we intend to address; and what are the durable guiding principles for meeting those needs?"

Statistical Sub-Questions: Data users; statistical information products and services; and guiding principles

Q 1.1: Who are our principal data users; what are their highest-priority needs for statistical information; what are the predominant features of the economic and societal context within which we should address those needs; how durable are those needs and contextual features; and to what extent can all of these questions be addressed through

models (1)-(2), either in broad schematic terms, or through formal characterization, measurement and modeling of *V, P, X* and *Z,* when feasible?

Q 1.2: To what extent are the stakeholder information needs identified in Q 1.1 focused primarily on, respectively, simple descriptive statistics; measures of association; prediction; causality; or outright perceived control of the underlying social and economic phenomena?

Q 1.3: What are the principal statistical information products and services that we intend to produce in addressing the needs identified in Q 1.1 – 1.2; and what are the additional production capabilities that we intend to have in response to potential changes in those needs?

Q 1.4: What are the durable guiding principles to address stakeholder needs for high-quality information on a cost-effective and sustainable basis; anchored in rigorous and nuanced application of statistical concepts and practices; aligned with legal and regulatory requirements related to privacy-protection, as well as open-data and open-government policies; calibrated with realistic assessment of current and prospective revenue streams and market forces; and also informed by different approaches to the design, production and use of statistical information in the form of public goods?

Q 1.5: What are accessible ways in which to use visualization tools to help participants represent and explore the fundamental features of stakeholder subpopulations; their needs for statistical information; the space of feasible statistical information products and services intended to address those needs; and related core institutional values, as considered in Q 1.1 – 1.4?

Initial Question 2: "Linkage of stakeholder value with quality, risk, and cost. To what extent, and in what ways, can we characterize, measure, model and control stakeholder value and its linkage with realistic measures of quality, risk and cost?"

Statistical Sub-Questions: Value in the space defined by stakeholder information needs, performance profiles, design features and environmental conditions

Q 2.1: What are practical ways in which we can characterize, measure and model both use value and option value conveyed to a given set of stakeholders by a specific set of statistical information products, possibly within the context of model (1)-(2)?

Q 2.2: What are practical methods to assess option value attributable to, respectively, (a) a given suite of statistical information products and services with a specified performance profile *P*, in a future moment that has environmental conditions *Z*; and (b) a

methodological or technological capability to produce additional such products and services on demand?

Q 2.3: To what extent are case-specific value patterns identified in Q 2.1 – Q 2.2 dominated by, respectively, fundamental features of a given vector of estimands θ, and conceptual nuances thereof; one particular dimension of data quality (e.g., relevance, accuracy, comparability or granularity); or one particular dimension of cost or risk?

Q 2.4: For cases of Q 2.3 in which the "accuracy" dimension of quality is considered predominant, what are realistic ways in which to assess the value conveyed to stakeholders through formal inference (e.g., presentation of a point estimate and an associated confidence set or credible set) that accounts for only some components of variability, and essentially conditions on other components?

Q 2.5: Similarly, what are realistic ways in which to assess the degradation in stakeholder value incurred through p-hacking or other phenomena associated with the reproducibility crisis; and what are some ways in which additional dimensions of data quality (e.g., point-estimation bias, comparability, and interpretability, as well as ecological-fallacy issues arising from some analyses of aggregate data) should be considered in expanded discussion of the reproducibility crisis?

Q 2.6: To what extent would established methods for elicitation of utility functions (e.g., in some areas of Bayesian statistics) provide a satisfactory approach to the preceding questions?

Q 2.7: For a given application area, what are the principal design features X and environmental factors Z associated with stakeholder value identified in the preceding questions and described in model (2)?

Q 2.8: To what extent are the above-mentioned value patterns heterogeneous across stakeholder groups and data products; and what are the implications of that heterogeneity for practical decisions on development and production?

Q 2.9: To what extent do the preceding questions require different approaches when one is considering the value of statistical information related to small or historically under-measured subpopulations?

Initial Question 3: "Models that can connect quality, risk and cost with underlying design and environmental factors. What are practical ways in which we can characterize, measure, model and control systems that link quality, risk, and cost measures with design features X and environmental factors Z?"

Statistical Sub-Questions: In keeping with Deming's emphasis on understanding all aspects of statistical variability in systems: exploration of empirical information on model (1); and interpretation and limits thereof

Q 3.1: For specified dimensions of P in model (1), what are the predominant predictor variables within X and Z; and are there important interaction terms among the design variables X or between the design variables X and the environmental variables Z, thus indicating that decisions about a given design setting may best be made conditionally?

Q 3.2: For specified dimensions of P in model (1), is the surface of P relatively flat in neighborhoods of the current design setting X and the current environmental variables Z, thus indicating that the "local" system performance is relatively insensitive to modest changes in X and Z?

Q 3.3: For a specified dimension of P in model (1), what are the values of R^2 or other measures of goodness-of-fit; do those results vary substantially over different neighborhoods of X and Z; and what do those empirical results imply about prospects for local prediction of, or control over, system performance?

Q 3.4: To what extent, and at what cost, is it feasible to obtain near-contemporaneous measures of (and possibly forecasts of) the environmental vector Z, especially for Z terms that are relatively volatile, and for which some dimensions of P are notably sensitive?

Q 3.5: What are the predominant costs (including both direct and indirect components of cost) incurred by the organization as it makes specified changes in the design vector X; and what are time lags and constraints that are important for efforts to make those changes?

Q 3.6: To what extent are changes in the nominal design settings X subject to slippage over time; what are important predictor variables related to that slippage; and what are realistic ways in which to monitor, reduce and reverse that slippage?

Q 3.7: Within the context considered by the preceding sub-questions, to what extent does the statistical organization consider empirical results on model (1) to be only descriptive or predictive in nature; or instead to provide substantial indications of causation or the potential for outright control of P through contemporaneous knowledge of Z and timely adjustments in X?

Q 3.8: To what extent can the statistical organization use initial empirical results on model (1) (which may be only descriptive or predictive in nature) to identify a design setting X^* that may produce an improved performance profile P; and then use confirmatory experiments to evaluate the distribution of P with the design setting X^* and current environmental conditions Z?

Q 3.9: To what extent, and in what ways, are certain features of model (1) relatively homogeneous within certain groups of estimands θ, and certain groups of statistical information production designs, in ways that are somewhat analogous to the transferability of intra-cluster correlation coefficients discussed in the literature on design effects?

Q 3.10: Specifically for the "accuracy" dimension of quality, what are ways in which to produce realistic evaluations, balanced across multiple estimands θ and a range of environmental conditions Z, of the improvement in point-estimation and inferential performance provided through the use of refined data science methods (relative to simpler statistical modeling methods)? Illustrative examples would include comparison of data-driven vs. simple rule-based classification procedures; or comparison of response-propensity-based weighting developed through random-forest vs. standard parametric logistic regression approaches.

Q 3.11: Specifically for the "quality" dimensions other than "accuracy" (relevance, comparability, cross-sectional and temporal granularity, punctuality, interpretability and accessibility): To what extent do these dimensions involve some components that are inherently qualitative in nature, and other components that are potentially quantifiable, e.g., through a predictive model?

Q 3.12: Specifically for the "relevance," "comparability" and "interpretability" dimensions of quality, what are realistic ways in which to characterize, measure and model the effects attributable to substantial changes in a current statistical product suite and production system; or attributable to introduction of a fundamentally new statistical product? Both of these cases may require some components of empirical information not readily available from evaluation of previously developed statistical information production systems.

Q 3.13: Specifically for the "cost" dimensions of the overall performance profile P: To what extent do current accounting and management-information systems provide (admittedly observational) data on the predominant fixed- and variable-cost factors, and related predictor variables, in forms that support (a) rigorous modeling of cost functions; (b) timely action in response to important changes in cost structures, or changes in resource availability; and (c) feedback to identify changes in the accounting and management-information systems that could substantially improve the inputs for (a) and (b)?

Q 3.14: In the overall measurement and management of costs for statistical information production systems, what is the relative importance of intangible capital (including all related components of initial fixed costs, depreciation patterns, and related uncertainties); and especially the intangible-capital components related (a) the skills of all of our

colleagues; (b) related forms of institutional capital; and (c) statistical methodology considered, respectively, as a form of public goods, or as a form of proprietary intellectual property?

Q 3.15: In exploration of the full suite of cost components incurred by stakeholders outside of the statistical information organization, what are realistic measures of respondent burden that go beyond simple counts of questions or time expended, and include, e.g., consideration of cognitive burden as reduced through increased use of administrative records; and or as increased by, e.g., consent-to-link questions or change in context effects? This can be especially important for cases in which we may use non-survey data sources to supplement, or replace, data from survey responses.

Q 3.16: Similarly, what are realistic measures of costs incurred by stakeholders in their access to, and use of, specific statistical information products and services, including, e.g., fixed and variable costs incurred through specific access, data management and analysis tasks, as well as related costs in learning to use the required access systems, and applicable metadata?

Q 3.17: What are realistic approaches to the early diagnosis and mitigation of systemic risks, including risks incurred through the use of "complex and tightly coupled systems" associated with the acquisition, evaluation, integration and use of multiple data sources?

Q 3.18: In the work with characterization, measurement, modeling and management of multiple dimensions of quality, risk and cost described in Question 3, what are some practical methods to address the effects of scale, scope and complexity, prospectively defined with respect to increases in the number, type and heterogeneity of data sources; the numbers of variables and units reflected in the data; the complexity of the models employed; related aggregation effects; dependencies and other constraints among design factors; the size, heterogeneity and network structure of the principal groups that will use the resulting statistical information products; and volatility of these features over time?

Q 3.19: To what extent is the approach considered in Q 3.1 – Q 3.18 complicated by cases in which some dimensions of X have only a very small number of discrete settings that are feasible, e.g., the choice of survey response modes; or choices among a small number of administrative record data sources?

Initial Question 4: "Building on the modeling framework of Question 3 to identify practical insights and guidance on trade-offs. What are practical ways in which we can use modeling results to explore and manage trade-offs among multiple dimensions of quality, risk, cost, and stakeholder value?"

Statistical Sub-Questions: Use cases, thresholds, and uncertainty

Q 4.1: For specific areas of work in the integration of multiple data sources, what are some high-profile use cases that shed light on crucial trade-offs, especially in modification of the suite of statistical information products; supplementation of surveys with non-survey data; use of specialized surveys to address coverage or item-specification issues in administrative record data; combined use of survey and non-survey data to expand and refine the suite of small domain estimates and other statistical information products; expansion of customary risk-utility analyses of disclosure avoidance, to consider multidimensional surfaces that describe trade-offs among risk (privacy-loss budget), utility and stakeholder costs; and in related decisions on features of our product lines, e.g., calibration of punctuality criteria with the degree of temporal volatility of specific key estimands θ_t?

Q 4.2: Because quality, risk, cost and stakeholder value for the use cases in Q 4.1 tend to involve several important multivariate dimensions, to what extent can we frame trade-off decisions through, respectively, reduced-dimensional optimization approaches; or satisficing approaches based on specified threshold requirements for the predominant dimensions?

Q 4.3: What are realistic ways in which trade-off decisions are affected by uncertainty in the characterization, measurement, and modeling of some important dimensions of quality, risk, cost and stakeholder value; and what are some practical sensitivity analyses to quantify those effects of uncertainty?

Q 4.4: What are practical ways in which to use the sensitivity analyses from Q 4.3 to identify the most important areas in which trade-off decisions would be improved through additional empirical information on quality, risk, cost and stakeholder value?

Q 4.5: For cases involving limited empirical information on quality, risk and cost for some data sources, what are practical ways in which to obtain realistic guidance on trade-offs by: (a) using prior-elicitation methods to obtain some indications regarding that limited information; and (b) integrating available empirical information on quality, risk and cost, along with the prior information from (a) and the utility-function information from Q 2.6?

Q 4.6: For the high-priority use cases highlighted in Q 4.1, does the approach summarized in Q 4.2-4.5 provide enough structure to guide truly actionable decisions on trade-offs; or is it advisable to consider fundamentally different approaches that involve more localized design options, or otherwise highly restricted decisions, e.g., decisions only on addition of one more prospective administrative record data source; or addition of only one more group of statistical information products?

Q 4.7: In light of the uncertainties and costs inherent in all of the measurement and modeling efforts considered in Q 1 – Q 4, what are realistic ways to determine when these efforts have reached a point of diminishing returns in producing realistic improvements for a given statistical information production system?

Initial Question 5: "Design of systems to enhance adaptability and innovation. What are the practical ways in which our organization can design its systems to be reasonably robust and adaptable in light of changing environmental factors that can have important effects on value, quality, risk and cost profiles; and to make major innovations in our product lines and production processes when necessary?"

Statistical Sub-Questions: Adaptation (data-driven changes in the design vector X) and innovation for incremental and fundamental improvements; and evaluation of related performance trajectories

Q 5.1: In work with the capture and integration of multiple data sources, what are areas in which one may extend concepts and approaches developed previously for adaptive and responsive survey methodology?

Q 5.2: Building on the results of Q 3 – Q 4, what are realistic methods to modify our statistical information production systems in ways that will address fundamental changes in features of our prospective data sources; in environmental conditions Z; or in underlying methodological and technological capabilities, as reflected in the functional form, error distribution and parameters of model (1)?

Q 5.3: What are cost-effective and robust methods to adapt our statistical information production systems to address fundamental changes in stakeholder needs and priorities for statistical information, leading to major changes in the product lines and supporting production processes, e.g., large expansion in the production of highly granular information; or in estimation of population parameters that are fundamentally different from those that we produced previously?

Q 5.4: What are realistic ways in which to set priorities for investing in changes described in Q 5.1-Q 5.3; to determine the extent to which those high-priority changes require methodologies and technologies that are, respectively, groundbreaking, or relatively routine applications of established practice; and to produce wholistic evaluations of the prospective impact on crucial system features that may arise from the priority changes?

Q 5.5: What are realistic ways in which to measure the trajectories of the performance vector P as a given body of innovative statistical methodology and technology – and usage therof - matures from initial ideas, through prototypes, and into full-scale production? In some, but not all, cases, those trajectories would reflect improvements in

P, but the existence and magnitudes of such improvements would warrant empirical evaluation. Also, in some cases there may be special interest in comparing the prospective trajectories of *P* that may arise from, respectively, (a) the application of relatively mature methodological and technological capabilities (sometimes known as "off the shelf" or "last mile" applications); or (b) innovations that require deeper forms of research and development, and that may involve longer timelines, larger investments, and greater uncertainties regarding outcomes and prospective mid-course adjustments.

Q 5.6: What are practical ways in which to use results from Q 3, Q 4, Q 5.5, and other analyses to design efficient proof-of-concept and pilot studies that can inform initial work with system improvements; adjustments to the design in response to changes in environmental factors *Z*, in resource availability, or constraints on *X*; or development of fundamentally new statistical information products and services?

Q 5.7: For innovations expected to lead to substantial reductions in cost or risk, or to substantial improvement in the value delivered to key stakeholders, does the statistical organization have practical ways in which to translate these benefits into discretionary resources that can be re-invested in additional improvement efforts?

Initial Question 6: "Communication on quality, risk, cost, value, and changes therein, in forms that are clear, realistic and credible for internal and external stakeholders. What are realistic approaches for clear, responsible, and credible communication and negotiation with all relevant stakeholders (both internal and external) regarding important features of, and decisions on, quality, risk, cost, and stakeholder value, and on related changes?"

Statistical Sub-Questions: Nuanced, credible and transparent communication and negotiation in environments of incremental change, uncertainty, and dynamic innovation

Q 6.1: In listening to current and prospective data users, what are some notable narratives that they employ in describing their needs for statistical information; the ways in which they use that information for their own substantive work; and the ways in which they perceive and interpret related measures of data quality, risk and cost?

Q 6.2: What are practical ways in which the narratives from Q 6.1 may offer insights into some important strengths and limitations of schematic models (1) and (2), and related customary methodological approaches to management of quality risk, and cost; and thus help to anchor communication of the conceptual and technical work outlined in Q 1-5 in ways that are credible and resonate with both internal and external stakeholders?

Q 6.3: What are realistic numerical, graphical and narrative methods to convey overall patterns of system performance – and important exceptions that may be especially

challenging - that are inherently empirical and case-by-case in nature; and to do this in a way that draws stakeholders into further constructive engagement, within the context defined by Q 6.1-6.2?

Q 6.4: In stakeholder communication and negotiation related to properties of statistical information systems, and related to acquisition of particular non-survey data sources, what are practical, objective and transparent ways in which to account for components of uncertainty and ambiguity that are inherent to the system; to make clear the related limits on extrapolation from available data; to communicate realistically about distinctions between properties of early prototypes and full-scale production systems; to describe related institutional policies, decisions, and conditioning thereof; and to reduce inefficiencies and other issues that arise from information asymmetries, conceptual blurring, last-mover phenomena, and other problematic aspects of negotiations?

Q 6.5: For both internal and external stakeholders, what are communication approaches to ensure that all participants understand, within the context defined by models (1) and (2) for statistical information production, realistic options for multiple types of innovation for products and processes, including "sustaining innovations" and "disruptive innovations"; and related requirements for carefully targeted changes in the design features X?

Q 6.6: Do statistical information organizations encounter some aspects of stakeholder communication and negotiation that share features of "wicked problems" identified in the public policy literature (e.g., in which stakeholder groups include "multiple parties, conflicting in values and interests" and "neither the problem itself nor the possible effective solutions are clearly known to the decision-makers in question"); and if so, does integration of that literature with models (1)-(2) lead to practical suggestions about ways in which to address such problems?

Questions 7-10: Management Structure and Function

Initial Question 7: "Internal organizational roles and responsibilities. What organizational structures and allocation of resources, along with decision-making authority and responsibility, will enhance timely, efficient, and responsible decision-making and organizational control?"

Statistical Sub-Questions: Use of organizational structures for robust and efficient management of models (1) and (2), tuned to the nature and pace of underlying changes

Q 7.1: In keeping with literature on project management, matrix management, and subsidiarity, what are organizational structures that allow technical specialists (e.g., subject-matter experts, statisticians, data scientists, methodologists, computer scientists and project managers) to have well-defined areas of responsibility, authority and agency in which they have comparative advantage to address specified goals and tasks?

Q 7.2: In considering Q 7.1, what are important distinctions between preferred organizational structures for cases in which, respectively:

- stakeholder information needs, environmental factors Z , feasible options for the design factors X, and models (1) and (2), all are relatively stable, and thus the statistical organization is focused primarily on operations, maintenance, and incremental continuous improvement; or

- some or all of the above-mentioned features are changing quickly, and thus the statistical organization is focusing on major changes in product suites and production processes?

Initial Question 8: "Explicit and implicit incentives for internal and external stakeholders. How do we ensure that our explicit and implicit incentives, and related management processes, are consistent with long-term success in meeting our organization's goals; and in reinforcing expectations of individual, institutional and scientific integrity?"

Statistical Sub-Questions: Incentives for data users, data providers and internal stakeholders.

Q 8.1: What are realistic incentives for internal technical and managerial personnel to use the management structure from Q 7 to collaborate in ways that are aligned coherently with the value and performance-profile criteria highlighted in Q 2-3; with trade-offs considered in Q 4; with the need for structured adaptation discussed in Q 5; and with communication efforts described in Q 6?

Q 8.2: What are realistic incentives for external providers of administrative records or other non-survey data to provide high-quality data and metadata in timely and cost-effective forms, through, e.g., payments or other direct benefits to the data provider; other benefits to their constituent group; legal or regulatory mandates; commitments regarding data protections and related liability issues; and general appeals for data philanthropy?

Q 8.3 Within the context of dissemination of statistical information in the form of public goods, and building on ideas from Q 4, what are realistic incentives for external data users to engage constructively with the statistical organization through, e.g., exploration of their priorities for data use, including challenging trade-offs among multiple dimensions of quality, risk and cost; transparent and reproducible curation of data and code for future use by other stakeholders; and compliance with resource-sharing and confidentiality-protection rules within restricted-data-access environments?

Q 8.4: What are realistic incentives that can help to foster an institutional culture of evidence-based communication and negotiation about the production, dissemination and use of statistical information, in keeping with the criteria in Q 6 above; and thus, to

increase stakeholders' nuanced understanding of the strengths and limitations of our statistical information production systems?

Q 8.5: What are realistic ways in which to align the above-mentioned incentives with timely information flow and feedback mechanisms based on models (1) and (2)?

Initial Question 9: "Investments in focused, robust, and durable organizational change. What are realistic ways in which our organization can allocate efficiently the full suite of resources needed to foster carefully focused, robust, and durable organizational change, including changes in target markets and product focus; and in technical and managerial processes?"

Statistical Sub-Questions: Building on the technical results from Q 5 to identify necessary changes in organizational structure and function required to implement high-priority investments in evaluation, acquisition and integration of multiple data sources; and in expansion of statistical information product suites to meet changing stakeholder needs

Q 9.1: Are there features of the organizational structure and function from Q 7 that would produce substantial inefficiencies or risks in the implementation of technical or managerial adaptations and innovations considered in Q 5, and thus may warrant substantial changes?

Q 9.2: What are the predominant costs and risks that would likely be incurred through the prospective organizational changes identified in Q 9.1; and what are realistic ways in which to manage those costs and risks?

Initial Question 10: "Practical definitions of managerial and technical leadership. What characteristics are most important for managerial and technical leadership within our organization?"

Statistical Sub-Questions: Leadership to navigate the landscape defined by models (1)-(2), and related dynamics; and to foster an institutional culture to support that navigation by all participants

Q 10.1: Do managerial and technical leaders foster a shared strategic vision aligned with the above-mentioned issues; demonstrate a high degree of sincere and well-informed intellectual curiosity about a wide range of issues of practical importance for that vision; incorporate into that vision a nuanced understanding of the strengths and limitations of technical approaches to issues that include fundamentally non-technical societal features; and have strong skills in delegation and networking for vibrant implementation of all important aspects of that vision, with emphasis on the complementary insights and roles of the above-mentioned professions?

Q 10.2: Do managerial and technical leaders foster an institutional culture that engages in depth with the opportunities, challenges, constraints and uncertainties inherent in the design, development, implementation, and management of statistical information products and production systems; strikes a truly inspiring, healthy and dynamic balance of optimism and realism; and avoids the unproductive extremes of unwarranted certitude nor unreasonably detailed "paralysis of analysis"?

Q 10.3: Per the examples outlined in Question 3, do the managerial and technical leaders have the skill profile and discretionary resource base to design and implement procedures to make productive use of windfalls that occur; and, conversely, to respond in a resilient way to unexpected setbacks, like the loss of certain non-survey data sources; increases in cost structures; decreases in discretionary resources; losses of key personnel; or changes in the external operating environment?

Q 10.4: Do the managerial and technical leaders carry out their work in a way that reinforces the importance of public stewardship, and individual, institutional and scientific integrity, in the production, dissemination and use of statistical information; and recognizes the competing utility functions of many legitimate internal and external stakeholders, who have highly variable information needs, time horizons, resource bases, and degrees of expertise in subject matter and scientific areas?

Questions 11-14: The Human Element

Initial Question 11: "Fostering a culture of collaboration focused on positive-sum outcomes. What are some practical steps we can take to focus our organization on collaborative system-design and management approaches for *positive-sum outcomes,* ensuring robustness against natural human limitations and environmental factors?"

Statistical Sub-Questions: Fostering collaboration among multiple professions to improve the performance profile P and stakeholder value V

Q 11.1: In addressing especially challenging versions of the issues identified in Q 1 – Q 10, what are practical ways to gather and integrate insights from applicable professions, e.g., data scientists, statisticians, methodologists, subject matter experts, and specialists in legal, regulatory and management areas; to give open-minded and realistic consideration to both conventional and highly creative approaches to that integration; and to ensure that discussions from these perspectives are anchored in a shared commitment to improve outcomes as reflected in models (1)-(2)?

Q 11.2: In addressing serious problems that can arise in statistical information production, do team members have a balanced approach that includes the needed immediate responses; and also includes subsequent root-cause-analyses that lead to proportionate and durable improvements for the full system reflected in (1)-(2), within the context of the trade-offs outlined in Q 4?

Q 11.3: Per the discussion in Dillman (1996), do team members who address Q 11.1 – 11.2 approach system evaluation and improvement from the balanced and nuanced perspectives of both a "research culture" and an "operations culture"?

Q 11.4: What are ways in which the culture of collaboration in statistical organizations (including balanced consideration of multiple stakeholder perspectives; long learning curves; and deep networks of engagement among colleagues in all of the above-mentioned areas) can be impacted by changes in the overall work environment (e.g., hybrid telework/in-person workspaces, and patterns of relatively of relatively frequent changes in employment); and what are realistic ways in which to address the positive and negative aspects of those impacts, e.g., through changes in work assignments, training, meeting structure, time management, use of telecommunications capabilities, and leadership reinforcement of core institutional values?

Initial Question 12: "Addressing barriers to constructive, respectful, and enthusiastic engagement. What are practical steps that we can take within our organization to support constructive, respectful, and enthusiastic engagement that is essential to professional satisfaction?"

Statistical Sub-Questions: Realistic diagnosis of, and constructive engagement with, barriers, uncertainties and disagreements that arise frequently in the operations and institutional culture of large statistical organizations, especially within governmental contexts.

Q 12.1: In addressing unfunded mandates, audit requests and regulatory requirements, what are realistic ways to develop responses that will enhance contributions to the statistical organization's core mission, and performance under models (1)-(2), to the extent feasible?

Q 12.2: What are practical ways in which to foster an institutional culture in which responsible and nuanced dissents about design and operations, and related responses to stakeholder priorities and environmental conditions:

- are stated and explored in efficient and actionable terms based on evaluation of known features of *P, V* and *Z*, on the strengths and limitations of empirical results available for these terms, and on related stakeholder needs for statistical information;

- distinguish carefully between technical and managerial issues on which reasonable participants can disagree, and fundamental issues of individual, institutional and scientific integrity that must be aligned with the core values of the organization;

- respect and account responsibly for differences in institutional and intellectual cultures, communication styles, and personalities of individual participants, while retaining focus on the core issues emphasized in Q 1 – Q 11; and thus

- contribute to an institutional culture of practical, respectful, collaborative and lively management of quality, risk, cost and stakeholder value, and related contingency planning?

Q 12.3: What are practical ways in which important technical issues and contingencies identified through dissent in Q 12.2 can contribute to concrete improvements in design and operations (e.g., refinement of information on crucial aspects of (1)-(2); exploration of additional realistic options for the design *X*; strengthening of information on environmental conditions *Z*; and enhancement of paradata capture and operational control) for greater adaptability and robustness of the statistical information production system?

Initial Question 13: "Training to adapt to changes. What are realistic approaches to training our colleagues in new areas of technical and managerial practice, especially in rapidly changing areas, thus enhancing practical integration of new methods with substantive knowledge and legacy operations?"

Statistical Sub-Questions: Training to enhance collaboration among methodologists, data scientists, statisticians, computer scientists, subject-matter experts and specialists in legal, regulatory and administrative areas.

Q 13.1: What are some practical use cases that can help us identify expanded training in tools and fundamental concepts of data science and computer science that will be most important for mid-career methodologists and statisticians to strengthen capabilities in the integration of multiple data sources to improve current statistical information production, and to develop fundamentally different products; and similarly for expanded training in statistics and data science to help computer scientists strengthen capabilities to navigate complex trade-offs among multiple sources of uncertainty?

Q 13.2: What are some practical ways in which expanded training in legal, regulatory and management issues can help statisticians, data scientists, methodologists and computer scientists to engage constructively with administrative constraints and uncertainties, and related unfunded mandates that can become especially important as we expand the use of multiple data sources; and develop a wide range of new statistical information products and services?

Q 13.3: What are some practical ways in which expanded training in statistics, data science and computer science can help legal, regulatory and management professionals to engage constructively in development and implementation of statistical information production systems?

Q 13.4: What are some realistic approaches that can help supervisors to develop a nuanced and actionable understanding of the ways in which training in the above-mentioned areas can help them and their colleagues address high-priority needs of the statistical organization, and thus ensure that this training is brought to bear on those needs in a timely way?

Initial Question 14: "Help colleagues thrive as professionals. What practical steps can our organization take to help all colleagues thrive as professionals?"

Statistical Sub-Questions: Empowerment of colleagues for expansion of skills into new areas; and for highly creative and dynamic development of options for system improvement and new statistical information products.

Q 14.1: For colleagues who have deep expertise in historically important technical areas (e.g., sample design, questionnaire design and specific production-level surveys), what are ways in which to build on that expertise in revising – or completely re-inventing - legacy survey-based statistical information systems to: include non-survey data; expand use of record linkage and modeling; and enhance the suite of fundamentally new data products?

Q 14.2: Conversely, for colleagues with principal technical skills in data science and computer science, what are ways in which to provide exposure to the conceptual and operational elements of legacy survey production environments that: (a) reflect fundamental and persistent features of stakeholder information needs and related issues with operational constraints and multiple sources of uncertainty; and (b) are likely to persist in new production based on integration of multiple data sources and extensive modeling?

Q 14.3: In addressing the issues summarized in Q 1 – 13, and within the context of realistic constraints and general guidelines from senior management, are our colleagues empowered to explore a wide range of options, and are they provided with a reasonable level of resources for iterative and responsible exploration of those options, with appropriate and timely feedback loops?

Q 14.4: In all of the areas required for successful production of high-quality statistical information, do we have efficient, transparent and timely processes for balanced

allocation of resources (including intangible capital, as well as tangible assets) for, respectively, (a) current production operations; and (b) expansion of product suites, improvement of production systems, and related areas of professional development?

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