W. Edwards Deming Memorial Lecture

Improving the Quality and Value of Statistical Information: Fourteen Questions Regarding Management

John L. Eltinge

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The views expressed here are those of the speaker and do not necessarily represent the policies of the United States Census Bureau.

Overview

I. Context – Memorials, Deming & Quality – 14 Points

II. Quality and Management Issues for Statistical Information Products and Services

III. Integration of Multiple Data Sources

IV. Fourteen Questions
- Linking value with quality/risk/cost
- Improving management structure & function
- Emphasizing the human element

I. Context – Memorial Lectures

1. Honor predecessors and their work

2. Reconsider elements of that work:
   Context, fundamentals and details

3. Extend their insights into new areas:
   technical challenges & societal impact

I. Context – Dr. William Edwards Deming

I. Context – Dr. W. Edwards Deming

His Century (1900-1993) and Work

1. Industrial growth & organizational changes

2. Size and scope of government
   - Changing relationships among government, citizens, economy and the field of science

I. Context: Dr. Deming's Management Focus

1. Flowed primarily from experiences with quality improvement in manufacturing

2. Also informed by sample surveys, statistical auditing, government operations (Deming & Stephan, 1940; Deming, 1950, 1960)

I. Dr. Deming – Management Focus (2)

3. Perspective on management filtered largely through concepts of sampling variability (control charts; more complex samp and expt designs)

4. Focus management attention on concepts:
   - State of statistical control
   - Special and common causes
   - Improving the system

I. Context – Industrial Quality Management

Out of the Crisis (1986), *The New Economics* (1994), other materials and lectures

Succinct summaries:

“Fourteen Points”

“System of Profound Knowledge”

I. Context – Today's Lecture

1. Explore some current opportunities and challenges for production, dissemination and use of high-quality statistical information (esp integration of multiple data sources)

2. Draw selectively from several fields

3. Apply underlying concepts from "14 Points"
   → 14 Questions on Management

II. Quality and Management Issues for Statistical Information Products and Services

General mission for rigorous statistical organizations:

Production of high-quality statistical information products and services on a sustainable and cost-effective basis

II. Statistical Information - Definitions

"High-quality statistics" – criteria

Accuracy (main technical focus)

Relevance, Timeliness, Comparability,

Coherence, Accessibility, Granularity

Brackstone (1999), CNSTAT (2017b), others

II. Statistical Information - Products

- Tabular publications, graphs, maps

- Microdata releases

- In-depth modeling results (per Commission on Evidence-Based Policymaking, 2017)

II. Statistical Information: "Rigorous Statistical Organization"

- Mission: quality, sustainability, cost

- High degree of transparency on data sources, methodology, (some) quality characteristics

- Culture of objectivity, professionalism, scientific rigor, realistic balance (CNSTAT, 2017a; Statistics Canada; UNSD)

II. Information: Changing Environment

Expand data sources & tools (beyond surveys):

- "Non-designed data" ("organic data" "big data": Groves, 2012; Couper, 2013; CNSTAT, 2017b)
- Modeling, data management

Changing expectations on privacy, granularity of information, "evidence-based policymaking"

II. Information: Changing Environment

Broader societal reconsideration of the nature of (statistical) information:

- Linkage of value with quality, cost, risk, credibility, accountability, access

- Resource allocation: amounts, mechanisms

- Nature of “public goods”

II. Statistical Information: Response to Changing Environment

Productive response will require:

- Extend rich body of research & practice

- Invest – serious, sustained, targeted

- Re-affirm and apply core principles of quality and integrity

III. Integration of Multiple Data Sources

Two Examples:

Example A ("append microdata"): Link survey data with unit-level admin/commercial records

- cf. CNSTAT report on Consumer Expenditure Survey

Goals: Reduce cost (expenditures, burden), improve quality, esp for high-cognitive load items

III. Multiple Data Sources (continued)

Example B ("backbone and bridge"):

- "Backbone": administrative record sets
- "Bridge": supplementary sample surveys to calibrate definitions; determine "domain sizes" in multiple-frame extensions

Longstanding cases: Current Employment Survey
Small domain estimation (Rao and Molina, 2015)

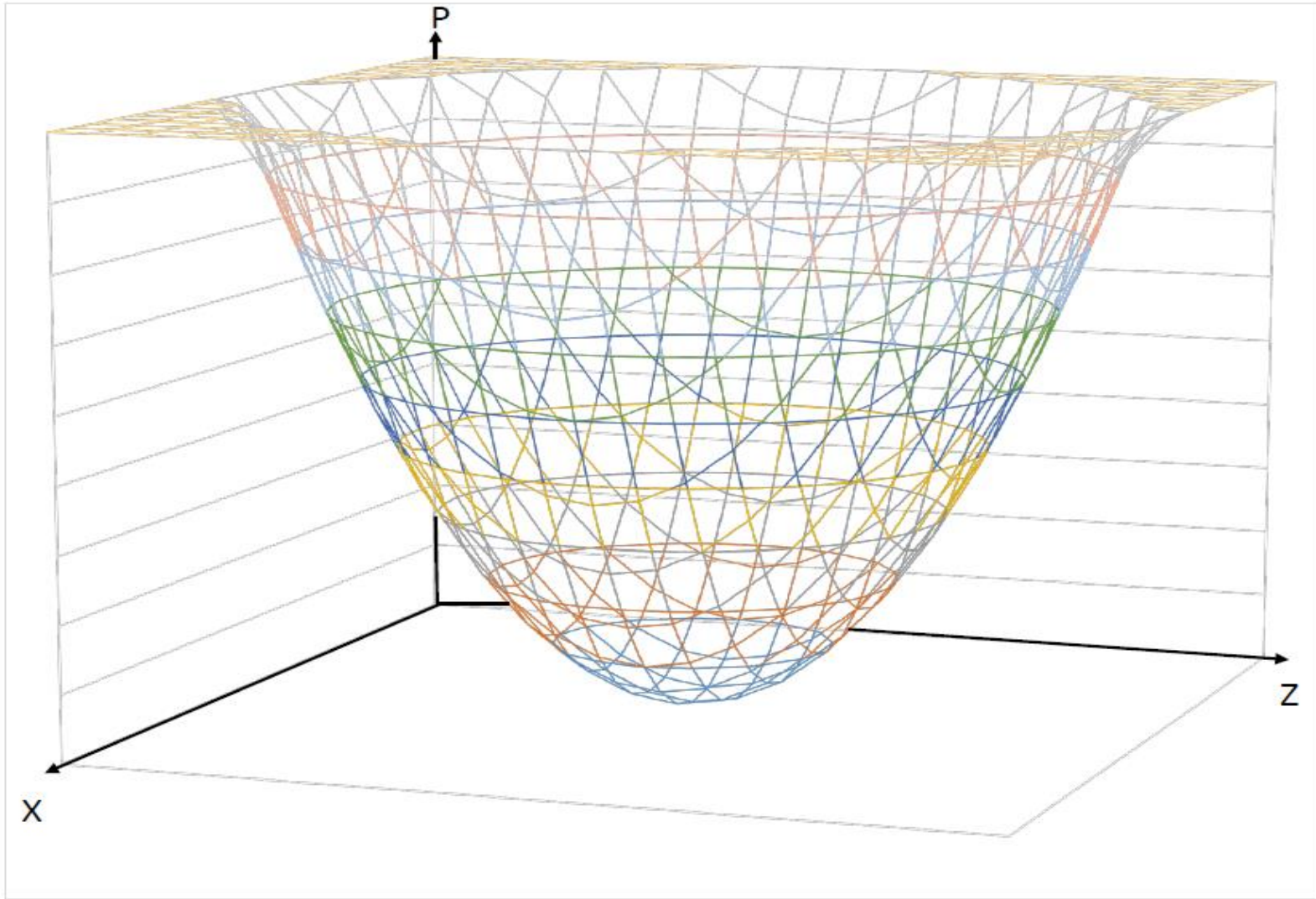
III. Multiple Data Sources (continued)

Evaluation & integration of multiple sources?

- Multiple dimensions: quality, risk and cost

- Extend customary def of “design”

- “Stat control” & “common & special causes”?


P
X
Z

III. Multiple Sources – Quality - 1

Qualitative features: timeliness, relevance, comparability, coherence, accessibility

Quantitative features: "accuracy" via extension of "total survey error" models (e.g. Biemer et al, 2017):

- Population coverage, linkage errors & entity resolution, definitional errors, incomplete data; est errors (Lohr & Raghunathan,2017; Elliott & Valliant, 2017, Meng, 2018)

III. Multiple Sources – Quality - 2

For each dimension, distinguish between:

- Indicator for specific degradation event

  Ex: Missing observation j for unit i

- Resulting impact on performance (modeled)

  Ex: Inflation in mean squared error of $\hat{\theta}$

III. Multiple Data Sources – Risk

Focus here: Identifiable system-level events that degrade sustainability: Probability of event? Impact?

Survey events:

Programming failure, disclosure, “break in series”:

Multiple-source event: Loss or undetected change in administrative or commercial source

Modeling: Hazard function

III. Multiple Data Sources – Cost

Survey event: Specific collection, infrastructure –

- Cash expenditure – direct collection, systems
- Respondent burden

Multiple-source event: More expenditures

- Specific systems for capture and integration of administrative and commercial sources
- Contingencies for risk management

III. Multiple Sources – Environment

Uncontrolled environmental factors Z:

- Impact on quality, risk and cost?

Example A ("append"):
consent-to-link affected by public trust

Example B ("backbone and bridge"):
regulations, market strategy affect pop coverage

III. Multiple Sources – Design

Traditional methodological "design"

- Optimize (improve?) specific quality measure, conditional on cost

Ex: P = Sampling error variance

Stratum boundaries, sampling rates

Ex: P = Nonsampling error (bias, MSE)

- Instrument design, mode choice

III. Design – Extended Definition

Design decisions = Targeted resource allocation:

account for observable environmental factors Z

to deliver a specified performance profile (quality, risk, cost)

for a given parameter vector θ and user group

III. Design – Resource Allocation

High-quality statistical work is inherently capital intensive (mostly intangible capital)

Examples of resource (capital) investments:

- Data sources (due diligence, negotiations)
- Methodology & technology – defined broadly
- Production systems
- Mgmt: skills, standards, stakeholder relations
- Research & development to improve

Design: Operating Space Defined by

Target parameters θ

Data users with schematic value function

$$V = g_\theta(Quality, Risk, Cost;\ \gamma) + err$$

$Z =$ Environment (observed, uncontrolled)

$$X = \left(X_{Source}, X_{Method}, X_{System}, X_{Admin}\right)$$

= Design vector (resource decisions)

III. Multiple Data Sources (continued)

Recurring question: Realistic capacity to capture and use empirical information to inform management decisions – value, quality, risk and cost?

Humility in assessing available empirical information

"Walk humbly with our data" – Kott & Liao (2014)

- CEP (2017) "humility"; Tukey (1986), Hogan (2018)
- Broader "zone of competence" caution for all

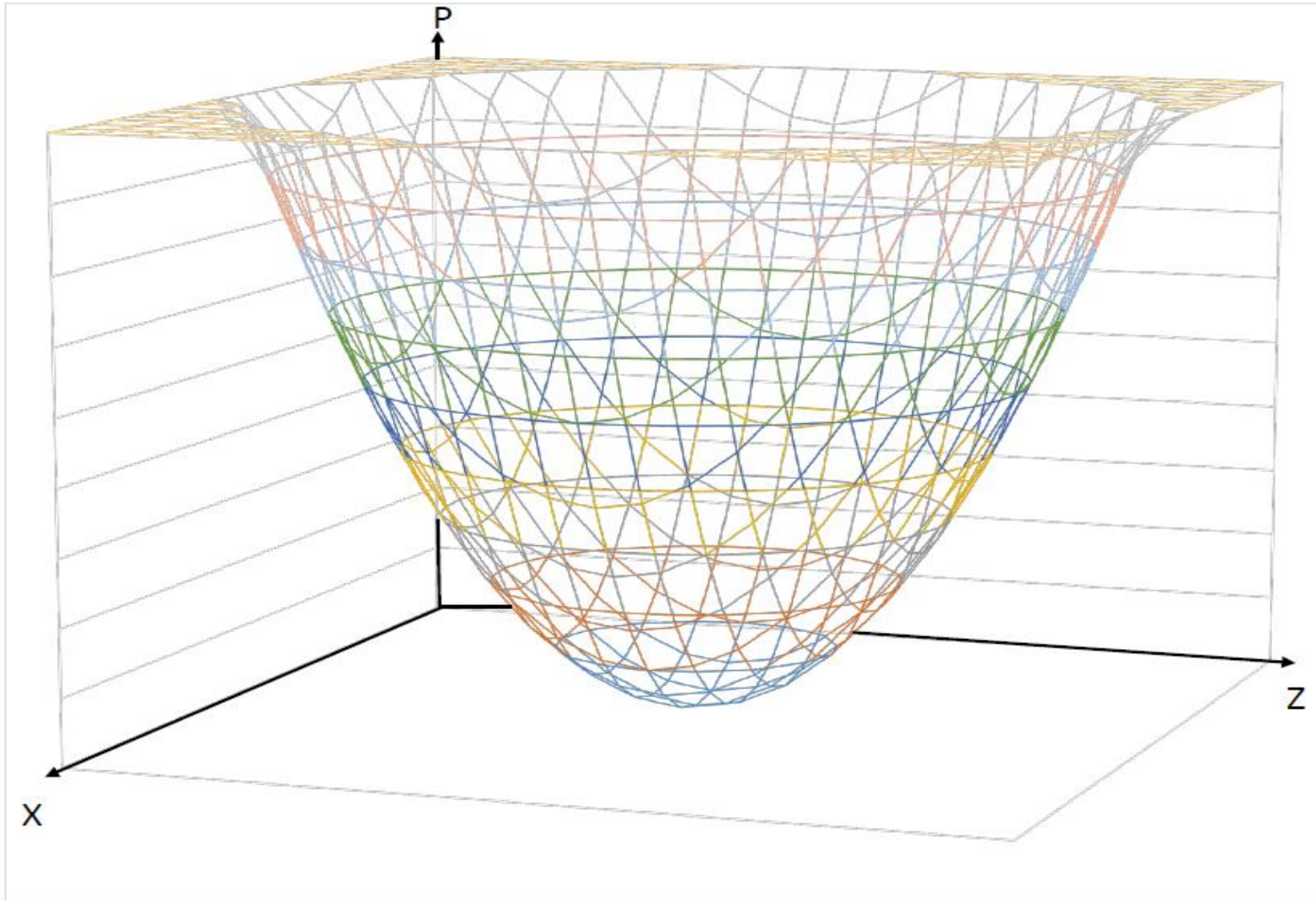
III. Design (continued)

Schematic model: "Performance profile" vector

$$P = (Quality, Risk, Cost) = f_\theta(X, Z;\ \beta) + e$$

e = residual effects (uncontrolled, unobserved)

ß = parameters of "performance surface," dispersion


P
Z
X

III. Design (continued)

Qualitative questions on $P = f_\theta(X, Z;\ \beta) + e$

- (Local) surfaces for *P*: stable "bowl"? Sharp ridge?
- Simple dominant main effects of *X, Z*? Interactions?
- Constraints on choice of *X?* Known or predicted?
- Predictive quality (R^2 , variants)? Improve w/more *Z*?
- Realistic & timely control over *X* (slippage)?
- "Optimization" - condition on elements of P, X, Z?

III. Design – "Statistical Control"

"Common and special causes"

- One specific bad *outcome* (high missingness count, cost over-run): Attribute to inherent variability; poor model fit (low R^2);change in Z; slippage in X

- Continuous improvement: Better X control? Change nominal X (move on P surface)? How fast? Formally adaptive/responsive?

IV. Fourteen Questions

Deming's Original 14 Points (some overlap)

A. Systematic approaches to link stakeholder value with quality, risk, cost & continuous improvement (1-5)

B. Use framework from (A) to improve management structure and function (9-12)

C. Human condition – all its complexity (6-8; 13-14)

IV.A. Value, Quality, Risk and Cost

Question 1: To what extent, and in what ways, can we characterize, measure, model & control:

1.a. Stakeholder value and its linkage with realistic measures of quality, risk and cost?

1.b. Linkage of quality, risk and cost measures with design factors X and environmental factors Z?

IV.A Value, Quality, Risk and Cost - 2

Ex A ("append"): substantial value from reduction in burden, MSE?

Ex B ("backbone and bridge"): concrete uses from "more granular" estimates?

Try utility- and prior-elicitation methods developed in Bayesian framework?

(e.g.,. O'Hagan et al, 2005; Garthwaite, 2010)

IV. “Use Value” and “Option Value”

1. “Use value”– from specific well-defined use
   (e.g., CPI to adjust Social Security & contracts)

2. “Option value” – value from possible future use
   (Weisbrod, 1964; Arrow & Fisher, 1974; others)

   a. Estimands: Special variables, subpopulations

   b. Estimator robustness - model failures, outliers

IV. Fourteen Questions – Quality – 1

Question 2: In the integration of multiple data sources, what are practical ways to build **quality** into the product (& production system)?

Specific criteria context-dependent: users & uses

- Challenging with heterogeneous user base

IV. Fourteen Questions – Risk

Question 3: What are realistic approaches to the early diagnosis and mitigation of **systemic risks** in integration of multiple data sources?

Ex A ("append"): single- and multiple-points-of-failure in data acquisition and linkage

Ex B: Excessive complexity of "backbone and bridge" creates "complex and tightly coupled systems" that produce "normal accidents" per Perrow (1999)

IV. Fourteen Questions – Cost

Question 4: What are realistic ways to assess **total cost** of capture and integration of multiple data sources to produce high-quality statistical information on a sustainable basis?

Examples A and B:

- Fixed & variable cost terms, including risk mgmt
- Depreciation of (intangible) capital investments, accounting for multiple-source uncertainties on duration & magnitude of use & maintenance?

IV. Fourteen Questions – Robustness

Question 5: Practical ways to lead the statistical organization to be reasonably robust and adaptable to changing Z with important effects on value/quality/risk/cost profiles?

Ex A & B: Realistic culture to evaluate & act on:

- Leading indicators of changes in Z?
- Local surface(s) P around current Z?

IV. Fourteen Questions – Improve Management

B. Use of the framework from (A) to produce fundamental improvements in management structure and function (cf. points 9-12)

Observation: All nontrivial systems require management engagement & judgement

– No perfect "autopilot" system design X

IV. Management: Intangible Capital

Question 6: How do we improve investments in intangible capital: characterization, measurement, modeling and management?

Example B: Negotiation on data sources
(new or more refined)

Special challenges: Intellectual property;
operations on a cash basis; ROI measured?

IV. Management: Information & Control

Question 7: Organizational structure - and allocation of decision-making authority & responsibility – for timely and efficient information flow and operational control?

- Aligns with “breaking down barriers”
- Crucial: Comparative advantage conveyed by specific skill mix, information base & controls? Changes as methodology matures?

IV. Management: Incentives - 1

Observation:

Deming's critique of "quotas and management by numbers" flowed from his objection to a naïve focus on specific outcomes (and the resulting perverse incentives and impact on morale), distracting from the core leadership task of improving the system

IV. Management: Incentives - 2

Question 8: How do we ensure that our explicit and implicit incentives, and related management processes, are consistent with long-term success in the realistic integration of multiple data sources, when appropriate?

Ex A & B: Trade-offs for “shared software”?

Fixed budget: reduce current production to fund transition to multiple sources?

IV. Management: Intellectual and Operational Cultures

Question 9: Norms and practices to foster a culture of mutually respectful and enthusiastic engagement and responsible risk-taking by data providers, methodology, research, operations, management, support & data users?

- cf. Deming (1986) “pride of workmanship” and Dillman (1996) – “research” vs. “operations”

IV. Fourteen Questions: Human Condition

C. Critical role of humans, and talents and leadership thereof (points 6-8; 13-14)

Frequent Deming term: “problems of people”

Dominant effects on essentially all aspects of management (even nominally “technical”)

IV. Human Condition (continued)

Humans: highly creative *and contentious*, especially at the intersection of:

- Representative government
- Free markets
- Multiple professional fields
- Rapidly changing economic, social and technological conditions

IV. Human Condition: Training

Question 10: Realistic approaches to training in new areas of methodology, technology and data sources, ensuring integration with substantive knowledge and legacy operations?

Ex A: Expert in health-surveys - train in linkage for electronic health records?

IV. Human Condition: Education & Self-Improvement

Question 11: What practical steps can a rigorous statistical organization take to help all colleagues thrive as professionals?

Characteristics: “know how to learn” & “robust”

Approaches: formal education, developmental assignments, intentional focus on human capital

IV. Human Condition – Leadership – 1

Deming's point 7: "Adopt & Institute Leadership"

1. Critiques of standard management approaches reflect deeper phenomenon:
   Humans, society, markets & organizations are profoundly imperfect

2. But they can improve

3. Leadership: improvement *and* humility

IV. Human Condition – Leadership – 2

Question 12: What characteristics are most important for managerial and technical leadership of a rigorous statistical organization?

Ex A & B: Build organizational consensus

- Expectations on quality/risk/cost/value
- Distinguish core values (enhance) and details (communicate & manage changes)

IV. Human Condition: Positive-Sum Focus

Question 13: How to focus statistical-information organizations on ***positive-sum outcomes,*** and robustness against natural human limitations, through improved institutional goals, management structures, information flow, and incentive systems?

- cf. “drive out fear”

IV. Human Condition: Public Goods

Question 14: To what extent, and in what ways, does the integration of multiple data sources require us to reconsider – or re-affirm – the "public goods" aspects of broadly disseminated statistical information?

cf. "data philanthropy" and public-private partnerships (e.g., Groves & Neufeld, 2017)

V. Conclusions - 1

Opportunity: Expansion of Scientifically Rigorous Statistical Information Products and Services (Esp Integration of Multiple Data Sources)

- Deming's Focus on Quality & Management Offers Important Insights

- Fourteen Questions on Management

V. Conclusions - 2

High-Quality Statistical Information:

- Data users and uses: value
- Balance quality, risk and cost
- What we know & don't know
- Practical implementation: Role of leadership

V. Conclusions - 3

Any Discussion of Management:

Critical role of the human condition: (individually and in community)

Values, relationships, passions, joys, creativity, sorrows, gratitude, dignity, grace

Thank You!

John L. Eltinge

Assistant Director for Research

and Methodology

U.S. Census Bureau

John.L.Eltinge@census.gov