Smart Math Saves Time and Improves Communication

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1. INTRODUCTION:
Why consider upfront design of mathematical organization and sequence?

Federal agencies collecting information from regulated communities have the responsibility under the Paperwork Reduction Act (PRA) to inform the public of the industry burden associated with the information collection. To this end, burden estimates encompass, "…the total time, effort, or financial resources expended by persons to generate, maintain, retain, disclose, or provide information to or for a federal agency." Analysts at federal agencies routinely develop burden estimates that must consider and reflect a variety of information collection conditions including the level at which the information is organized and reported (e.g. per site), the amount and type of information reported, the type of staff responsible for reporting, and the time frame over which reporting occurs.

Methods for estimating burden can have more than one possible formulation given the fundamental laws of mathematics, which include the communicative, associative, and distributive laws. For new information collections, burden estimate methodology can implement the heuristics and design principles presented in this paper to prevent future problems. However, the easiest way to illustrate such potential problems is to examine results from less robust designs—and show how using Smart Math addresses problems. For example, it is not unusual to need to modify burden estimates based on changes in policy. However, in the event that key estimates central to a methodology are adjusted without attention to the whole system of estimates, trouble ensues. Such changes can occur without attention to important key methodological principles, including: internal consistency, parsimony, and transparency. The results can be sub-optimal, especially where:

- categories of respondents are numerous and overly specific,
- origins of estimates cannot be quantitatively identified or verified, and
- burden estimation methods have progressed on a piecemeal basis.

In this paper, the authors have observed overly complex methodology and potentially internally inconsistent estimates. Better designs are provided with problems prevented using Smart Math techniques, including: algebraic simplification, definition of per-submission unit of analysis to consolidate multi-scale activity-level burdens into a unified scale, and management of temporal effects. The benefits of using Smart Math are associated with the objective production of more accurate, robust, and intuitive estimates delivered in a timely manner in a variety of policy/regulatory contexts. As an additional benefit, the estimates often provide useful metrics for communication and back-of-the envelope estimates. Moreover, the cost of generating and maintaining estimates is reduced because Smart Math simplifies reporting presentations with fewer report tables and less work during quality control procedures. Therefore, burden reports offer greater integrity and reliability, with improvements in transparency plus sustained cost savings.

Studies used in this paper are drawn from reports of burden estimates by the US Environmental Protection Agency (EPA). EPA routinely collects information from industry across multiple time intervals (i.e, episodic, annual, biennial, etc) as part of its mission to protect human health and the environment. Data collections at EPA may support surveys, permit applications, questionnaires, regulatory requirements established by rulemaking, and reports. Examples of such collections at EPA include annual reporting on routine and accidental chemical releases, periodic pesticide registrations, and one-time, annual, and occasional submission of records and reports related to topics such as refrigerant releases during refrigerant recovery, recycling, and reclamation. For any collection where information is to be obtained from more than nine respondents, EPA must prepare an Information Collection Request (ICR) identifying the estimated burden and cost to affected respondents. ICRs must be approved by the Office of Management and Budget (OMB) before data can be collected, and thereafter renewed every three years. Also, economic analyses (EAs) supporting rulemakings that mandate data collection must estimate incremental burden and cost to affected respondents. Note that the applications of Smart Math apply broadly to EPA ICRs, and Economic Analyses (EAs) with associated preambles, as well as to similar documents at other agencies subject to PRA.

Given the examples in this report, and as a matter of context on ICR format, please note that EPA uses a handbook developed to help analysts prepare ICRs. This guidance identifies the activities that should be considered when developing the ICR including rule familiarization, compliance determination, form completion, and recordkeeping.

The handbook includes an established outline for how labor and non-labor burden and costs should be estimated and presented in the ICR Supporting Statement. Within labor costs, the handbook also identifies the major categories of managerial, technical, clerical labor.

Based on multiple experiences with methodology revisions in ICR renewals and EAs in EPA's Office of Pollution Prevention and Toxics, the authors employ two key questions: 1) What is the simplest and easiest way to calculate burden? and 2) How can the Agency best provide clearly defined and consistent estimates? Key strategies for Smart Math implementation include:

1) *Simplify with Algebraic Reduction*: as opposed to using repetitious component calculations,

2) *Define Per-Submission Unit of Analysis:* with a focus on the respondent perspective; as a likely follow-on, consolidate multi-scale activity-level burdens into a unified scale,

3) *Avoid Potential Internal Inconsistencies*: with assessment of relationships between burden estimates for interrelated subpopulation categories, and implementation of ratio or other models, and

4) *Manage Temporal Effects*: with attention to timing issues and periodicity differences between reporter submission activities and ICR renewal needs.

This paper discusses these four strategies supported by simple examples in Section 2: Background and Basic Heuristics. In Section 3, two case studies that are complex examples of applying Smart Math are presented. Conclusions, including benefits and long-term implications, are discussed in Section 4.

2. BACKGROUND AND BASIC HEURISTICS

This section explains the fundamentals in applying Smart Math to burden estimate analysis. The key strategies stated above are used to organize the discussion. Examples in this section and for the case studies in the following sections are drawn from burden reports for EPA's programs including the Toxics Releases Inventory (TRI), and the Notices of Activity (NOAs) for the TSCA Inventory, and TSCA section 4 testing).[1]

For discussions of this section, examples are drawn from the recent information collection called "Notices of Activity," which provide an updated status indicator in the TSCA Inventory. The TSCA Inventory is a compilation of chemical substances manufactured (including imported) or processes in the US. The purpose of the Inventory is to define, for the purpose of TSCA, what chemical substances exist in U.S. commerce. At any point in time subsequent the initial reporting effort in 1977, substances not included on the Inventory are considered to be new substances that are subject to the Premanufacture Notification (PMN) requirements which provide a mechanism for adding the new chemicals to the TSCA inventory, once commenced.

In June 2016, Congress passed the Frank R. Lautenberg Chemicals Safety for the 21st Century Act which established additional requirements for maintenance of the TSCA Inventory. These requirements included a "mass reporting" effort to identify chemical substances active in commerce for a ten-year lookback period ending June 2016, with provisions for updates. In the first part of the mass reporting effort, manufacturers were required to submit NOAs (termed "Start-up Reporting – Phase I" in economics documents).

To reference some burden estimate terminology: activity-based unit burden estimates are provided as fundamental building blocks for burden analysis. An activity may be broad—such as recordkeeping for a comprehensive submission, or specific—such as providing information for a single data element, in which case the burden assigned includes time for preparation (including calculation) plus time to enter the information on a form or via electronic format. An example from the NOA, Form A in Figure 1. The informational benefit of an activity-level unit burden rests in its face validity: Does this amount of time sound reasonable for the effort required to complete the task? Is this estimate a reasonable representation of the average conditions for which universe estimates will be used to scale to the total burden estimate?

Table 1: Activity-Level Unit Burden Example — Notice of Activity (NOA) Form A

Activity-Level Unit Burdens for NOAs During Start-up, Phase I (Manufacturers) Reporting					
Activity	**Unit of Analysis**	**Managerial Burden (hours)**	**Technical Burden (hours)**	**Clerical Burden (hours)**	**Activity-Level Unit Burden (hours)**
Chemical Name and Identifier	Chemical	0.000	0.083	0.000	0.083

Source: EPA, 2017

In contrast, the total burden estimate is used to assess the magnitude of the burden for the overall information collection effort (e.g. Submission and Recordkeeping burdens for all NOAs), on an annual basis.

[1] TRI authority under EPCRA section 313 (42 USC 11023**)**, NOA authority under TSCA section 8(b), (15 USC 2607(b)), and Section 4 Testing authority under TSCA section 4(a) (15 USC 2603).

Simplify With Algebraic Reduction

In conducting methodology revisions that apply Smart Math, the division between unit burden per response and universe estimates is an important one. Note that it is best to develop calculation procedures for these two constructs separately before multiplying them together to get total burden, as illustrated in Figure 1. Oftentimes, multiple variants of the calculation in Figure 1 are presented according to subpopulations or according to different activities with differing units of measure. Examples in this paper show that the alternative approach of building a consolidated version of the unit burden term and applying it the to a minimum number of subpopulations prevents errors, as well as produces useful communication metrics. The organizing principle displayed in Figure 1 is consistently used in applications of Smart Math presented in this paper. Note that that Figure 1 also presents a dimensional analysis, as a useful tool to employ when addressing scaling issues, as shown in the next section.

Figure 1: Separate Development of Unit Burden and Universe Estimates

Estimate	**Submission Unit Burden**	X	**Universe of Submissions from Reporters**	=	**Total Burden for the Information Collection**
Dimensional Analysis	Hours/ Submission		Count of Submissions		Hours

Assess Levels of Information and Define Per-Submission Unit of Analysis

There are often intervening factors that influence the aggregation of activity-level unit burdens to per-response and total burden estimates, as required in documents associated with PRA requirements. For the purposes of this paper, the authors recommend organizing the analyses in terms of the respondent's "per-submission" requirements and then converting to "per-response" and "per-respondent" bases.

The definition of per-submission unit of analysis flows directly from the assessment of levels of information. Regarding levels of information and activity, once the per-submission unit of analysis is defined, multiple levels of information and activity (e.g., per-site and per chemical) are easy to accommodate conceptually and mathematically, using scaling techniques—more specifically, applying a "roll-up" calculation.

With Smart Math, the per-submission unit burden occurs at the level of information at which unit burden estimates may be communicated prior to aggregating to total burden. Referring back to Figure 1, the per-submission unit burden is the consolidated unit burden. The examples below show how assessing levels of information leads to a purposefully defined per-submission unit of analysis and also to a good metric for use in burden estimates and communications.

For example, in TSCA Inventory NOA-Form A, [2] some information is required for the site, such as site name and recordkeeping; and some information is required according to chemical, for one or more chemicals manufactured at the site. In short, the underlying structure of the information being collected involves multiple levels of information, with measures that have different units of analysis.

Defining the per-submission unit of analysis is typically best done by considering the perspective of the reporter under the conditions of the submission. How does the transaction or collection of transactions make sense from the reporter's perspective? In the NOA example, a typical submission is a company-level report that provides

[2] See Appendix for sample Notice of Activity Form A.

information on one or more chemicals. Therefore, the per-submission unit of analysis is at the company level with the understanding that information for some average number of chemicals is involved.

Combining activity-level burdens for companies and chemicals to formulate a per-submission unit burden requires scaling considerations. This roll-up calculation also requires knowledge of the reporting universe: How many chemicals, on average are reported on a NOA Form A? Based on readily available information, an estimated average of eighteen chemicals per company are predicted. Therefore, for the NOA Form A, the company-level activity burdens are counted once (e.g. company name and address), and the chemical level activity burdens (e.g. chemical name and identifier as shown in Table 1) are counted 18 times. Table 2 presents the unit burden for the submission in accord with the principle presented Figure 1 – one consolidated unit burden to be applied to the population of companies submitting a NOA Form A. In PRA terms, the submission corresponds to a single response, making the number of responses equal to the number of submissions. Similarly, with one NOA Form A submitted per company for one or more chemicals, the number of respondents is also equal to the number of submissions.

Often the outcome of the above exercise produces useful metrics for concise communication in management presentations and for back-of-the envelope estimates. As shown in Table 2, using NOA average conditions for Form A submission unit burden provides a means to focus on the bottom line per-submission impact of 14.930 hours while at the same time highlighting the average conditions—such as the fact that the average company reports on 18 chemicals.

Table 2: Per-Submission Unit Burden — NOA Form A Example

Notice of Activity (NOA): Average Unit Burden Per Multi-Chemical Submission for Phase I Start-Up Conditions		
Activity	**Unit of Analysis**	**Unit Burden per Submission (Hours)**
Rule Familiarization	Per Company	4.00
Multi-chemical Compliance Determination (18 chemicals)	Per Company	1.994
Multi-Chemical Form Completion (18 chemicals)	Per Company	8.811
Recordkeeping	Per Company	0.125
Total, Average Unit Burden per Company		**14.930**

Source: EPA, 2017

Remove Potential Internal Inconsistencies via Modeling

Some systems of burden estimates can become overly detailed and complex. Note that the base activity-level unit burden estimates are subjective measures. Therefore, high degrees of precision are not available for distinguishing activity burden under base conditions from activity burden under most differing conditions identified as important to the analysis. At a minimum, the practice of deriving additional activity-level unit burdens outside of base conditions produces over-specificity and/or creates a false sense of precision;[3] under the worst possible circumstances, the practice creates internal inconsistences between the sets of unit burdens and within total burden estimates.

Another way of thinking about the problem is in terms of reporter subpopulations. The greater the number of subpopulations with differing conditions, the greater the likelihood for internal inconsistency. Internal inconsistencies result from over-reliance on the analyst's ability to precisely differentiate the absolute values of detailed estimates between reporter subpopulations.

Consider a base population of experienced reporters and a secondary subpopulation of new reporters. It makes sense to estimate burden for the two groups separately—we know that certain tasks or types of tasks take longer the first time you go through them. Therefore, it is not unusual to put together an overall estimate reflective of a reporting universe comprised of new and experienced reporters. However, keep in mind that when we develop the base set of estimates for the experienced reporters, we are dealing with a set of subjective measures. Therefore, high degrees of precision are not available for distinguishing the differences between activities for new and experienced reporter burden, say on a data-element by data-element basis. Figure 2 presents two options for handling this scenario. On the left-hand-side is the more complicated approach, with separate estimates for every element of activity-level burden. On the right-hand-side is a simple solution that avoids potential internal consistencies. The simple solution retains the

base set of detailed subjective estimates, but applies an overarching factor to obtain an estimate for the secondary subpopulation at a higher level of aggregation. The factor, here called the First-Time Factor, or FTF, is a ratio model that provides a useful metric for understanding the new reporter burden relative to experienced reporters.

[3] For example, in the TRI RBBM development document, the authors state that highly specified estimates are not necessarily more precise (and hence not necessarily more accurate) than less specified estimates. "In the context of TRI's uncalibrated estimates, increasing specificity (i.e., adding variables) adds complexity without necessarily increasing precision." EPA concludes that neither TRI's pre-2011 nor revised methodologies require additional specificity (EPA, 2011-see pg 7).