# QUALITY ASSURANCE ELEMENTS IN PRODUCER PRICE INDEX DATA INITIATION

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This paper provides an overview of a modelled approach to quality control in the data initiation process implemented in the Bureau of Labor Statistics' (BLS) Producer Price Index (PPI) program. This model is generally applicable to directly collected statistical programs.

The data initiation process involves the initial introduction of a new sample unit into the index and not the subsequent monthly repricing activity, which is conducted by mail. The objectives of the Quality Control (QC) program are to assist in improving and controlling the quality of survey information obtained in the data initiation process. The cornerstone of the QC program is a Structured Schedule Review (SSR) system. This is a dependent review of the completed survey collection documents prepared by the BLS field representative (FR) with the computation and tabulation of error rates by type. No attempt is made to independently verify the submitted data.

Organizationally, the paper is divided into four sections. The first of these provides an overview of the data initiation process. The second section defines those quality assurance elements, both principles and parameters, applicable to ensuring fitness for use in a statistical survey. The third section outlines the major steps undertaken in the development of the QC model. The final section discusses the output uses of the QC system in terms of the Quality Assurance (QA) objectives of the system.

## I. OVERVIEW OF THE DATA INITIATION PROCESS

At its most basic level, the PPI is composed of individually sampled 4-digit Standard Industrial Classification (SIC) industry output indexes within the manufacturing and mining sectors of the economy. The first stage sampling involves probability proportionate to size selection of a representative sample of companies primary to the industry, which meet the economic definition of the firm. The data initiation process involves the subsequent activities of the individual field representatives in the Bureau's eight regional offices to initiate these sample units into the index. The initial goal of the process is to complete coverage for all mining and manufacturing industries and subsequently to perform sample rotation on a fixed schedule of industry areas already in publication.

FR activities, conducted by personal visit to the appropriate company officials, include the following:

1. Designation of the actual unit which most closely matches the assigned sample unit;
2. Description of basic characteristics of the actual unit in terms of survey parameters;
3. Selection of representative items for introduction into the index (the second stage sampling) using probability proportionate to size statistical procedures based on value of shipments;
4. Identification of unique physical characteristics and transaction terms of the selected items; and
5. Establishment of repricing procedures to secure updated price data by mail.

Given the above, it is evident that the FR has the central role in establishing index quality. Subsequent determinations of such things as quality adjustment or product substitution when items are modified or become obsolete, timely detection of misreported prices, etc. depend on the success of the FR.

As the selection of index items is also a FR function, the range of FR error encompasses both sampling and non-sampling error. Properly conducted, the data initiation effort secures an updated market basket of items and updated weights which reflect the net output of the industry. This will permit subsequent monthly index estimation for an expected period of seven to eight years, when resampling is conducted.

## II. QUALITY ASSURANCE ELEMENTS IN STATISTICAL SURVEYS

This chapter provides an overview of those quality assurance parameters and principles applicable to ensuring fitness for use (Juran and Gryna 1980) in a statistical survey. Fitness for use, a major objective of any statistical program, is defined as sufficient output quality to meet intended survey uses. The first section outlines the QA parameters and objectives that contribute to ensuring fitness for use. The second section provides an operational overview of how to attain the objective of control of the level of program quality. The third section discusses the process of achieving breakthrough to a higher level of quality, the objective of quality improvement.

### Quality Assurance Parameters and Objectives

The initial step in the design of an operational quality control system is specifying the parameters and objectives that will permit the attainment of the goal of ensuring fitness for use of survey data. The objectives, stated as QA principles, are bounded by the goal of the statistical program and the QA parameters. The following are the major QA principles governing the technical design of the QC system:

1. Self-control (Juran and Gryna 1980)—how well the FR avoids controllable errors; and
2. Quality Improvement (Juran and Gryna 1980) --how well management accomplishes survey design, specification and procedure modification to move to a higher level of performance.

These principles determine the output uses of the QC data and are the operational tools for attaining fitness for use. The form of the QC system is determined by the following 4 parameters:

1. Quality of Design (Juran and Gryna 1980)—

how well the conceptual design represents the user's needs;
2. Quality of Conformance (Juran & Gryna 1980)--how well the organization follows the survey specifications and procedures;
3. Quality Measurement--how well the product meets the design; and
4. Quality Audit (Juran & Gryna 1980)--how well the control processes are executed according to specifications.

The successful incorporation of the parameters into the QC system design ensures the flow of information necessary to achieve self-control and quality improvement. The parameters are the required pre-conditions for implementing a system that provides the potential to achieve the objectives. The objectives are achieved by effectively using the output information.

Steps for Achieving Control

Control is defined as maintaining an equilibrium state at an acceptable level of quality in the performance of a work process. The seven steps for achieving control provide an overview of the control process from development through achieving performance equilibrium in application. These steps are (Juran & Gryna 1980):

1. Choose the control subject--data initiation activities;
2. Choose the unit of measure--errors in sample unit (SU) initiation;
3. Set the standard value--six errors per SU;
4. Create the sensing device--dependent review process;
5. Conduct measurement--review and count errors using SSR:
6. Interpret the difference between the measure and the standard--diagnose sources of error for sub-standard performance; and
7. Act on the difference--undertake training to remove systematic errors.

The first four steps encompass the design phase which, if properly done, permit the conduct of the application steps. Once control is achieved, we can reevaluate the standard value in terms of its impact on the survey program's fitness for use.

Steps for Achieving Breakthrough

Breakthrough is defined as moving to a higher level of performance (quality improvement). The seven steps for achieving breakthrough provide insight into the impact of introducing QA into a program.

These steps are (Juran & Gryna 1980):

1. Breakthrough in attitude--awareness of the need for QA;
2. Pareto analysis--priortized study of error patterns;
3. Organization of steering and diagnostic arms--Quality Assurance Design Team and Data Collection Quality Control Oversight Committee;
4. Breakthrough in knowledge--diagnosis of sources of error from data analysis;
5. Breakthrough in cultural patterns--procedural changes through program staff working in the process;
6. Breakthrough in results--attain a higher level of performance; and
7. Control--re-establishing quality control.

Breakthrough moves us to a higher performance level. Once the new equilibrium state is reached we have the necessary measurements to evaluate initiation data in terms of fitness for use.

## III. DEVELOPMENT OF THE MODEL

Two assumptions underlie the development of the SSR system:

1. Survey quality is largely determined at the data initiation stage; and
2. Quality related problems are associated with various causes, such as faulty procedures, inadequate training, imprecise collection forms and/or uncontrolled operator errors, and require an SSR system to assist in diagnosing the source of error.

This led to a requirement for a rigorous QC design as the SSR system must be capable of narrowly diagnosing the ultimate cause of error. The attempt to develop such a powerful tool clearly demonstrated that construction of a model based on quality assurance parameters was necessary to meet this requirement.

Definition of the Scope of SSR

SSR permits the identification, recording and quantifying of both errors of omission and commission made in the recording of survey data on the required collection forms. As such, it only meets some of the basic objectives of a full QA program. Objectives not met by SSR include the following:

1. Evaluation of interview technique. This is best achieved by using SSR results with other dependent reviews such as observational interviews;
2. Evaluation of data collector effectiveness. This is best achieved by a combination of reinterviews and the tabulation of effectiveness measures from survey data (e.g. frequency of use of fallback procedures); and
3. Measurement of non-sampling error. This is best achieved by reinterviews and special quality measurement studies.

SSR is limited in its application to the identification, recording and quantifying of those errors in the submitted collection documents capable of being caught in a dependent review process. By adhering to this definition, SSR can become an objective and powerful tool that is highly useful in diagnosing and correcting a wide variety of program error sources while retaining a high degree of acceptance due to its objective and broad-based nature. It is broad-based in that the analysis of output data can strongly suggest the source of error, which could include problems in:

1. Forms design;
2. Collection manual procedures;
3. Operating procedures;
4. Survey specific/special procedures;
5. Training; and
6. Data collector ability or knowledge.

Restating the above discussion in terms of QA elements, it becomes clear that an SSR system provides varying degrees of effectiveness in meeting the QA objectives. Also, it is clear that the SSR system cannot take a functional form that satisfies all the QA parameters. Figure 1. summarizes the effectiveness of the SSR system toward achieving the various QA elements.

Figure 1. QA Effectiveness of the SSR System

| QA Element | SSR System Effectiveness |
|---|---|
| Parameter | |
| Quality of Design | Low |
| Quality of Conformance | Medium |
| Quality Measurement | Medium |
| Quality Audit | High |
| Objective | |
| Self-Control | High |
| Quality Improvement | Medium |

Quality of Design, which may well be a critical objective to the organization, is barely addressed by a dependent review system. However, such a dependent review system is extremely effective in establishing self-control because it gives the central role to the schedule reviewer and provides useful diagnostic information to other program staff. This is extremely useful toward achieving a program-wide breakthrough in attitude, the first and most difficult of the 7 steps for achieving quality improvement.

## Specification of the Model: Quality of Conformance

Defining major objectives--A meaningful conceptual framework is needed to relate similar types of errors in order to diagnose the scope of the problem, the cause of the problem, and the suggested solution to the problem. Trial and error strongly indicate that without such a framework many of the SSR form and ouput objectives cannot be met. The framework serves as the bridge between the input and output sides by structuring the outputs (aggregation tree) and providing guidance in defining the inputs (type of error definitions) so that the inputs translate directly and unambiguously into highly useful output formats. Without postulating a model, the user is faced with numerous unrelated data points (error rates for each type of error).

The model should be process-based and reflect the goals and objectives of the process. The goal of data initiation is to secure required survey specific information in an appropriate format. The objectives of the process are survey specific. In the PPI data collection process they are:

1. Sample unit/reporting unit identification;
2. Proper use of statistical techniques in item selection and specification;
3. Adequate product specification;
4. Transaction terms specification;
5. Repricing procedures specification; and
6. Documentation.

The objectives of the initiation process are the major error categories of the output listing and the basic framework of the model. By defining each type of error from the SSR form so that it maps into one and only one output category, one can directly translate input data into a meaningful output format. An aggregation tree can be created by extending the process to define sub-objectives of the collection process. The type of error definitions on the SSR review form become descriptive statements of what errors were committed in attempting to meet the various sub-objectives. Additionally, this provides a methodology to move up the tree and calculate an error per schedule rate (total number of errors committed in initiating one sample unit).

Defining the standard--To complete the structure of the model (the bottom of the aggregation tree) the type of error definitions listed on the reviewers' error capture form must reflect violations of survey procedures and specifications. Initially, this requires specifying a set of standards upon which to base the error definitions. Data collection standards encompass all written collection instructions, including data collection manuals, operating instructions and collection form instructions. This reliance on written specifications ensures the objectivity of the SSR system.

Quality of conformance equation By adhering to the following formula in constructing the individual type of error definitions, quality of conformance is imbedded in the model:

$$\text{Type of Error} \cong \text{Violation of one survey collection procedure or specification} \Longrightarrow \text{Quality of Conformance}$$

The other requirement in defining type of error is that each error maps into one and only one of the 6 major error categories.

Aggregation tree structure of the model--At the bottom of the tree are the universe of types of errors reflecting violations of survey procedures and specifications. These map into various aggregation levels and therefore enable the diagnosis of the scope of the problem in terms of survey procedures up through sub-objectives and major objectives of the data collection process.

Design criteria--Specification of its internal logic completes the model. The criteria are an explicit statement of the model's logic. This allows evaluation of the efficacy of the model prior to its finalization.

### Quality Measurement (QM)

The SSR system only partially reflects this QA parameter. It permits unambiguous error determination, but does not yield a methodology for assigning QM values to the errors. Therefore, the term Quality Measurement is used in the restrictive sense of measuring only against quality of conformance.

In order to operationalize the model, to meaningfully measure quality of conformance, additional considerations apply.

Requirement for error definition--Three requirements govern the error concept if the SSR system is to successfully meet operational criteria.

a. Error definitions must be based on objective sources, in this case the survey standards discussed in the previous page.
b. The error definitions must be consistently applied by different reviewers (uniformity in error classification).
c. Only direct errors should be counted. If the commission of error A caused subsequent mistakes in a causal chain relating

to survey instructions, only the first error is counted.

Ordinal error rate—The SSR system must yield a set of output numbers which allow meaningful comparisons of performance across types of errors and sub-objectives, and over time or across FR's or regional offices. A process of normalization achieves this at the most aggregate level of errors per schedule (sample unit) and per major objective. This is accomplished by normalizing on the relevant size variable, which is the number of items selected for introduction into the index. (Non-productive schedules are tabulated separately for output purposes.) Error rates at the less aggregate levels are calculated either on a per schedule basis when applicable or on a per item basis, both expressed as decimals. This yields a percentage number of how often that type of error can be expected to be committed per sample unit or per item. Therefore, only the initial commission of a unique type of error is counted and not any repetitions.

The above discussion can be summarized in a quality measurement equation as follows:

Definition of Error Requirements
1. Based on Objective Source ⟶ Ordinal
2. Consistent in Application ⟶ Error
3. Counts Only Direct Errors Rate

Quality Audit

In order to ensure the integrity of the SSR system in operation, an audit mechanism is required. This is the third QA parameter relevant to the system. The objectives of the audit are as follows:

1. To provide consistency measures for reviewers and the review process;
2. To provide feedback to the regional reviewers;
3. To provide overall confidence measures for the review process to management; and
4. To provide feedback on systemic problems in the collection process.

Feedback requirements resulting from the audit are as follows:

1. Thorough documentation of substantive error;
2. Sense of the magnitude of reviewer failure to identify error; and
3. Identification of subject areas requiring additional training.

## IV. SSR OBJECTIVES

The preceding sections of the paper referred to the input side of developing an SSR system. This would ensure a system which is operationally sound and statistically powerful. It is the output uses of the data, however, that allow achievement of the QA objectives of the system.

Establishing Self-Control

The system assists in realizing this goal in two respects:

1. By providing diagnostically powerful and precise data in the identification of the scope and magnitude of the problem; and
2. By according the central role in the system to the regional office reviewer, generally the first-line supervisor of the field representative.

Figure 2. illustrates this. The national

Figure 2.--Establishing Self-Control

| ITEM | FR A | | FR B | | FR C | | R O | | NATIONAL TARGET GROUP | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 12/83 | 3/84 | 12/83 | 3/84 | 12/83 | 3/84 | 12/83 | 3/84 | 12/83 | 3/84 |
| DISAGGREGATION PARAMETERS . . . . . . . | .30 | .10 | .40 | — | .60 | .20 | .43 | .10 | .20 | .20 |
| NUMBER OF QUOTES ENTRY WRONG/ CHANGE NOT MADE . . . . . . . . | — | — | .10 | — | — | — | .03 | — | — | .05 |
| INCLUDED ITEM INELIGIBLE FOR DISAGGREGATION . . . . . . . . . . | .10 | — | .20 | — | .20 | .10 | .17 | .03 | .05 | .05 |
| REFERENCE PERIOD CHANGE NOT EXPLAINED. . . . . . . . . . . . | — | .10 | — | — | — | — | — | .03 | .05 | — |
| DID NOT FOLLOW SAMPLE A/B DESIGNATION. . . . . . . . . . . . | .20 | — | — | — | .10 | .10 | .10 | .03 | .05 | .05 |
| APPLIED DEPENDENT/INDEPENDENT DISAGGREGATION INCORRECTLY . . . | — | — | .10 | — | .30 | — | .13 | — | .05 | .05 |

target group (NTG) is comprised of all FR's currently in a state of self-control, that is, prolonged performance equal or superior to the established error per schedule standard. The output listings permit comparison to this performance level in order to diagnose FR or Regional Office (RO) weaknesses. After appropriate remedial action is taken, time series analysis indicates the effectiveness of the remedial measures.

In this example, the entire PPI staff of a regional office was performing in a sub-standard manner within the major objective of Statistical Techniques in Item Selection and Specification. The table shows problems in understanding the general rules governing the probability proportionate to size item selection technique. Subsequent measurement after remediation indicates a breakthrough in the performance level. The error rate of all FR's and the RO is less than that of the national target group, where it had been more than twice the rate previously. The four subcategories reflect the specific survey procedures governing the sub-objective of Disaggregation Parameters. They appear as types of errors on the SSR review form. If the reduced RO error rate of 10% in March 1984, or a similar value not exceeding the NTG rate of 20%, is maintained in subsequent time periods, then the RO and its FR's have attained self-control in terms of this subobjective of the collection process. (Self-control is defined as the avoidance of operator-controllable errors.)

Achieving Quality Improvement

Quality improvement (breakthrough) is defined as moving to a new equilibrium level at a higher level of performance. Implicit in this process is the identification and reduction in management controllable errors. Within the boundaries of the SSR system, this means accomplishing clarification or expansion in survey procedures, improvement or expansion in training, and/or improvement in forms design as identified by analysis of the output listings.

Figure 3. illustrates how the process is accomplished.

In this type of analysis we are looking for patterns of error with relatively high error rates in comparison to other sub-objectives. The asterisked type of error categories show such patterns across most of the eight regional offices. Management can readily narrow the probable causes of these problems and, with little additional research, identify the source and then recommend appropriate remedial action. Quality improvement occurs when the remedial action is implemented and results in reducing or eliminating these management controllable errors. As a component of these displayed error rates reflects operator (FR) error, quality improvement will not result in zero error rates. Quality improvement would be manifested by lower overall error rates in the error category in future measurement periods and by a breaking of the pattern that encompassed most population members.

SUMMARY

The general model presented in this paper results in a QC system which efficiently meets a wide array of user needs. When viewed from the top, the model follows the work process approach

Figure 3.--Achieving Quality Improvement

| ITEM | RO A | RO B | RO C | RO D | RO E | RO F | RO G | RO H | NATL. |
|---|---|---|---|---|---|---|---|---|---|
| PRODUCT CATEGORIZATION. . . . . . . . . | .14 | .34 | .22 | .25 | .05 | .33 | .31 | .18 | .22 |
| APPROPRIATE CHECKLIST CATEGORY COMPLETION . . . . . . . . . . . . . | .08 | .31 | .17 | .16 | .02 | .33 | .28 | .18 | .19 |
| USED WRONG CATEGORY . . . . . . . | — | — | .06 | — | — | .15 | .06 | — | .03 |
| * DIDN'T USE APPLICABLE NA CATEGORY . | .06 | .25 | .11 | .06 | .02 | .08 | .03 | .08 | .08 |
| * DIDN'T USE APPLICABLE NON-NA CATEGORY . . . . . . . . . . . . . | .03 | .06 | — | .09 | — | .10 | .19 | .11 | .07 |
| OTHER PRODUCT CATEGORIZATION REQUIREMENTS . . . . . . . . . . . | .06 | .03 | .06 | .09 | .02 | — | .03 | — | .03 |
| INCONSISTENT WITH DISAGGREGATION. . | .03 | — | .03 | .09 | — | — | — | — | .02 |
| PRODUCT DESCRIPTION WRONG . . . . . | .03 | .03 | .03 | — | .02 | — | .03 | — | .02 |

* SUGGESTS NEED FOR IMPROVED TRAINING, PROGRAM OVERVIEW AND/OR FORMS DESIGN.

which has been associated with industrial models. When viewed from the bottom of the aggregation tree, it embeds the quality of conformance parameter in the system by defining types of errors to be violations of survey procedures. Thus, the SSR system does not lose any power beyond the limitations inherent in a dependent review process. The model's validity and usefulness is predicated on the objective of measuring the quality of conformance.

## NOTES AND REFERENCES

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