OMB Control No. # 0693-0033 – NIST Generic Clearance for Program Evaluation Data Collections

ECONOMIC IMPACT ASSESSMENT OF THE STANDARD FOR THE EXCHANGE OF PRODUCT MODEL DATA (STEP) IN THE TRANSPORTATION MANUFACTURING AND ELECTRONIC INDUSTRIES – 2002-2010

FOUR STANDARD QUESTIONS

1. Explain who will be surveyed and why the group is appropriate to survey.

The Network Control Systems Group of the National Institute of Standards and Technology (NIST) is proposing to administer two questionnaires to key stakeholders in the transportation manufacturing and electronics industries. The first instrument will include questions aimed at end users or original equipment manufacturers (OEMs) and suppliers. The second instrument will be administered to software developers. Thus, stakeholders will receive only one questionnaire depending on their classification. This study evaluates the potential benefits of STEP in reducing interoperability costs for the exchange of product data in the transportation and electronics manufacturing industries. Members of these industries involved in product design and engineering have unique insights into the product data exchange problem. This is the target audience for the end-user questionnaire. Similarly members of the software industry who produce the software used in the design operations of the industries being evaluated for this study have insights into the state of STEP incorporation in CAD/CAM/CAE or PDM software.

The End User questionnaire is designed to elicit responses on the means of product data exchange as well as provide input on staff, systems support, data transfers, productivity, manual reentry and delay costs, which will be used in the computations for both the cost-accounting and economic surplus methodologies.

The Software Developer questionnaire is more qualitative in nature and captures that industry's involvement in STEP development as well as an evaluation of NIST's contributions to STEP's development.

2. Explain how the survey was developed including consultation with interested parties, pre-testing, and responses to suggestions for improvement.

Both instruments are largely based on the previous instruments employed in the 2002 NIST report titled "Economic Impact Assessment of the International Standard for the Exchange of Product Model Data (STEP) in Transportation Equipment Industries". Based on "previously approved" OMB questions, additional questions were needed to elicit responses for use in application of the economic surplus methodology (discussed in Section 4). Technical experts in those industries and the government (NIST) have reviewed the instrument for quality assurance purposes.

3. Explain how the survey will be conducted, how customers will be sampled if fewer than all customers will be surveyed, expected response rate, and actions your agency plans to take to improve the response rate.

Both instruments will be administered online via a neutral survey platform:
Software Developer - https://www.surveymonkey.com/s/QYR9DPF;

and End User: https://www.surveymonkey.com/s/QYYSQ29).

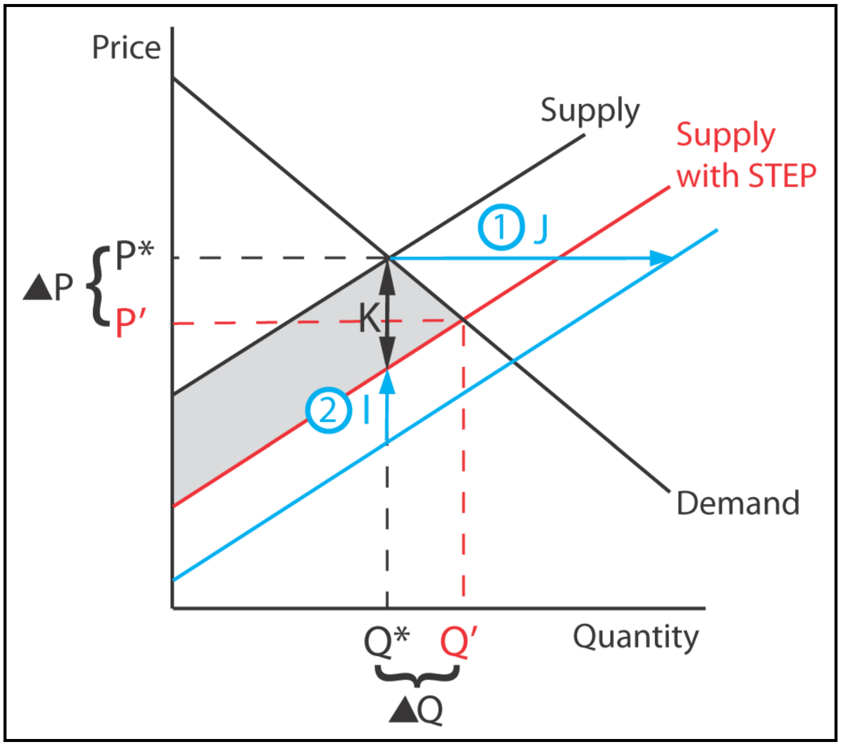
Email invitations to participate in the questionnaire will be sent to a list of possible respondents, with follow-up emails for those candidates that have not yet completed the questionnaire within one month. Based on the focus-group discussions we have conducted to-date, we anticipate a 75 percent response rate. Participants will be able to direct any questions they have to a toll free number and/or email address for assistance. The estimated time to complete the end user instrument is 60 minutes, whereas the expected time to complete the software developer instrument is 30 minutes. Participants will complete only one instrument.

4. Describe how the results of the survey will be analyzed and used to generalize the results to the entire customer population.

Both instruments will capture potential cost savings by the inclusion of questions focused on measuring cost reductions due to avoidance, mitigation and delay costs. These responses will be tabulated across industries. Published summary statistics will not identify individual firms. To approximate the total benefits to industry, we measure the total employment of firms sampled relative to total employment in industry and weight calculations accordingly. This extrapolation will enable us to calculate industry wide benefits.

To implement the economic surplus methodology, we pose questions relating to relative production costs and productivity changes. As illustrated below, the use of STEP can be viewed as a technological improvement, resulting in a rightward shift of the supply curve. However, there are undoubtedly some costs to implement this technology, **I**, resulting to a leftward shift of the supply curve compared to the condition that would prevail if adoption of STEP related technological improvements were costless. The objective is then to compute **K**, which represents the net rightward shift of the supply curve. In the course of this analysis, we will use proportions, which have the benefit of having no units. While neither **J**, **K**, **I**, nor Δ**Q** are observed, they will be estimated in the analysis that follows.

Figure 1



<u>**Computing j**</u>

The first step is to compute j, the proportional-shift parameter. By definition,

$$J = \Delta YtH \text{ and } Y = Q/H$$

where ΔY represents the productivity gain from STEP (total increase in production per employee-hour), t is the adoption rate, or the fraction of employee-hours in the new technology, Q is the quantity produced, and H is the total number of employee hours. Thus, using proportions, we have

$$j = \frac{J}{Q} = \frac{\Delta Yt}{Y}$$

where Y is the average per-unit production (total production per employee-hour). We are measuring the total increase in quantity produced as a proportion of the total quantity.

Computing c

Second, the per-unit cost to implement STEP must be computed. The per-unit adoption cost parameter c, can be written as

$$c = \frac{I}{P} = \frac{\Delta Ct}{YP}$$

All variables are defined as before and ΔC now represents the cost of implementing STEP per employee-hour, whereas P is the price of the product. Thus, we have the total increase in production costs as a proportion of the observed product price.

Computing k

We now just need to know the elasticity of supply, ε, in order to compute the net shift in the supply curve k. The elasticity of supply ε, captures the percentage change in quantity supplied due to a one percent change in price

$$\varepsilon = \frac{\frac{\Delta Q}{Q}}{\frac{\Delta P}{P}}$$

This elasticity will be estimated from a literature review of the industry. The formula is derived in detail in the **Appendix**

$$k = \frac{K}{P} = \left[\frac{JP}{\varepsilon QP}\right] - \frac{I}{P} = \left(\frac{j}{\varepsilon}\right) - c$$

It is clear that the less elastic supply is, the larger the gains from STEP.

Computing ΔQ

In order to calculate the social gains from STEP, we also need to know the total increase in production. In addition to the elasticity of supply, we also require the elasticity of demand, e. The change is derived in detail in the **Appendix** and is given as

$$\Delta Q = \frac{Qe\varepsilon k}{e + \varepsilon}$$

where Q is the actual quantity produced.

Computing Social Gains

The total gains from STEP, which incorporate the benefit to consumers, is given by

$$SG = kPQ - \left(\frac{1}{2}\right) kP\Delta Q$$

The second term in this equation is a correction term for the increase in quantity (we are conducting an *ex-post* study).

Computing Costs

These costs include the total fixed costs of research and may be aggregated if they cannot be broken down by industry. These research costs are incurred by NIST and other public agencies, software developers and manufacturers.

Summary

Once an acceptable discount rate is chosen, we can compute the present value of the benefits as well as the costs and hence, the net present value of STEP. Additionally, we can compute the benefit-to-cost ratio and the social rate of return. The latter rate is that which equates the present value of costs to the present value of benefits.

Following the extrapolation approach outlined in the cost-accounting methodology, these responses will be compiled by industry and will be generalized to represent overall industry patterns.

Additionally, both questionnaires will contain qualitative questions, which will provide more general feedback on product data exchange. These responses will be reviewed and summarized as a whole and by industry. Individual firm responses will be kept confidential. These findings will be included in the final report, which once approved by NIST, will become publicly available.

Appendix

Derivation of Formulas for Economic Surplus Methodology

Derivation of k

From Figure 1, given the slope of the supply curve b_s, K can be defined as

$$K = Jb_s - I$$

The elasticity of supply ε, captures the percentage change in quantity supplied due to a one percent change in price, and can be rewritten in terms of the slope of the supply curve as follows

$$\varepsilon = \frac{\frac{\Delta Q}{Q}}{\frac{\Delta P}{P}} = \left(\frac{\Delta Q}{\Delta P}\right)\left(\frac{P}{Q}\right) = \left(\frac{1}{b_s}\right)\left(\frac{P}{Q}\right)$$

With some rearranging, the slope of the supply curve b can now be rewritten as

$$b_s = \varepsilon\left(\frac{Q}{P}\right)$$

and more algebra demonstrates Kcan now be written as

$$K = \left[\frac{JP}{\varepsilon Q}\right] - I$$

Working with proportions, we divide by the price which yields

$$k = \frac{K}{P} = \left[\frac{JP}{\varepsilon QP}\right] - \frac{I}{P} = \left(\frac{j}{\varepsilon}\right) - c$$

Derivation of ΔQ

Let the supply and demand curves be linear. The equilibrium price is that such that quantity supplied is equal to quantity demanded. This is found by solving the following

$$a_s + b_s P = a_d + b_d P$$

which yields

$$P = \frac{a_s - a_d}{b_d - b_s}$$

The new equilibrium price following the rightward shift of the supply curve is found by solving the following equation

$$a_s + b_s(K + P') = a_d + b_d P'$$

which gives

$$P' = \frac{a_s - a_d + b_s K}{b_d - b_s}$$

So

$$\Delta P = P - P' = \frac{a_s - a_d}{b_d - b_s} - \frac{a_s - a_d + b_s K}{b_d - b_s} = \frac{-b_s K}{b_d - b_s} = \frac{b_s K}{b_d + b_s}$$

and

$$\Delta Q = Q - Q' = (a_d + b_d P) - (a_d + b_d P') = b_d \Delta P = \frac{b_d b_s K}{b_d + b_s}$$

Note that the elasticity of demand can be represented as

$$e = \frac{\frac{\Delta Q}{Q}}{\frac{\Delta P}{P}} = \left(\frac{\Delta Q}{\Delta P}\right)\left(\frac{P}{Q}\right) = \left(\frac{1}{b_d}\right)\left(\frac{P}{Q}\right)$$

and given some rearranging, the slope of the demand curve can be written as

$$b_d = e\left(\frac{Q}{P}\right)$$

This implies

$$\Delta Q = \frac{\left(\frac{eQ}{P}\right)\left(\frac{\varepsilon Q}{P}\right)K}{\frac{eQ}{P} + \frac{\varepsilon Q}{P}} = \frac{\left(\frac{Q}{P}\right)e\varepsilon K}{e + \varepsilon} = \frac{Qe\varepsilon K}{e + \varepsilon}$$