Planning Report 11-2

Economic Evaluation of the Baldrige Performance Excellence Program

Albert N. Link
Department of Economics
University of North Carolina
at Greensboro

John T. Scott
Department of Economics
Dartmouth College

December 16, 2011

National Institute of
Standards and Technology
U.S. Department of Commerce

Economic Evaluation of the

Baldrige Performance Excellence Program

Albert N. Link
Department of Economics
University of North Carolina at Greensboro

John T. Scott
Department of Economics
Dartmouth College

December 16, 2011

CONTENTS

EXECUTIVE SUMMARY

This study estimates the net social value of the Baldrige Performance Excellence Program. It focuses specifically on a survey population of 273 applicants for the Malcolm Baldrige National Quality Award since 2006.

Using a counterfactual evaluation method, three categories of social benefits have been quantified from the responses of 45 Award applicants to a Web-based survey. These categories are:

- the counterfactual cost savings of the applicants because it was not necessary for them to incur the investment costs to achieve on their own the same level of benefits from their performance excellence strategies as they realized from the availability of the publicly funded Baldrige Performance Excellence Program,
- the gains to consumers from greater satisfaction from higher quality products because the Baldrige Criteria were available and used rather than the counterfactual alternative,[1] and
- the gains to the economy from saving scarce resources (because successful performance excellence strategies not only enable higher quality products or services but also lower the costs of providing them) because the Baldrige Criteria were available and used rather than the counterfactual alternative.[2]

The following table summarizes the evaluation findings from this study. Benefit-to-cost ratios (B/C) were calculated using alterative measures of benefits, and each category was separately compared to the entire operating cost of the Baldrige Performance Excellence Program.

[1] Economists call this a gain in consumer surplus associated with the availability of the Baldrige Criteria.
[2] Economists call this a gain in producer surplus associated with the availability of the Baldrige Criteria. These producer surplus gains result because the goods being supplied have higher value (as reflected in the willingness of consumers to pay more for them) and because performance excellence lessens the costs relative to what they otherwise would have been. Over time, competition erodes the producer surplus as prices fall and consumers gain more of the value from the increase in quality of products and services and the lower costs to achieve high quality.

Categories of Benefits	**B/C$_{n=45}$**	**B/C$_{\text{Baldrige Award Applicants}}$**
Counterfactual Implementation Cost Savings	1.3-to-1	3.0-to-1
Counterfactual Implementation Cost Savings + Gains from Consumer Satisfaction	46-to-1	107-to-1
Counterfactual Implementation Cost Savings + Gains from Consumer Satisfaction + Gains from Increased Value of Sales in Excess of Resource Costs	351-to-1	820-to-1

The benefit-to-cost ratio of 820-to-1—using only the benefits for the surveyed group of applicants for the National Quality Award since 2006 but using *all* of the social costs of the Baldrige Program—certainly supports the belief that the Baldrige Program creates great value for the U.S. economy.

The Baldrige Performance Excellence Program, with the imprimatur of national leadership and a prominent national award presented by the President, creates great value that could not be replicated by private sector actions alone.

I.
INTRODUCTION AND OVERVIEW OF THE BALDRIGE PERFORMANCE EXCELLENCE PROGRAM

Purpose of the Study[3]

This study evaluates the net social benefits of the Baldrige Performance Excellence Program (formerly the Baldrige National Quality Program and renamed in 2010). During the years 2007 through 2010, there were 322 applications for the Malcolm Baldrige National Quality Award. These 322 applications were from 273 firms and organizations; the 49 additional applications were repeat applications from some of the 273 firms and organizations. The 273 firms and organizations that applied for the Award from 2007 through 2010 were asked by the Program Office to participate in a study of the benefits they received through the Award application process. Specifically, each firm or organization was asked to complete a Web-based survey instrument. A total of 45 firms and organizations responded to the survey request—a response rate of 16.5%—and the results from an evaluation analysis based on those responses are discussed in this report.

History of the Baldrige Performance Excellence Program

Productivity in the non-farm U.S. economy fell in the early-1970s and then fell again in the early to mid-1980s.[4] Associated with these declines was the loss of world market shares by firms in many critical industries. In response, a number of economic policy initiatives were introduced in the early-1980s in an effort to reverse the downward productivity trend by stimulating innovative activities within firms. These initiatives included the Bayh-Dole Act of 1980 and the Stevenson-Wydler Innovation Act of 1980 to encourage technology transfer from universities and federal laboratories, respectively, to the private sector; the Economic Recovery and Tax Act of 1981 that contained provisions for a R&E tax credit; the Small Business Innovation Development Act of 1982 that established the Small Business Innovation Research (SBIR) Program; and the National Cooperative Research Act of 1984 that encouraged collaborative research activity among firms.

[3] We thank the Program Office for its help through providing institutional information and assisting in the data collection process.
[4] See Link and Siegel (2007) for a detailed discussion of the productivity slowdown.

Further, Congress declared as part of the Malcolm Baldrige National Quality Improvement Act of 1987 (P.L. 100-107) that:

> … the leadership of the United States in product and process quality has been challenged strongly (and sometimes successfully) by foreign competition, and our Nation's productivity growth has improved less than our competitors over the last two decades; … a national quality award program … in the United States would help improve quality and productivity by—
>
> (A) helping to stimulate American companies to improve quality and productivity for the pride of recognition while obtaining a competitive edge through increased profits,
>
> (B) recognizing the achievements of those companies which improve the quality of their goods and services and providing an example to others,
>
> (C) establishing guidelines and criteria that can be used by businesses, industrial, governmental, and other organizations in evaluating their own quality improvement efforts, and
>
> (D) providing specific guidance for other American organizations that wish to learn how to manage for high quality by making available detailed information on how winning organizations were able to change their cultures and achieve eminence.
>
> … [and] There is hereby established the Malcolm Baldrige National Quality Award …

The goal of the Malcolm Baldrige National Quality Improvement Act of 1987 was to enhance the competitiveness of U.S. businesses. Applicants for the Award originally represented three categories of U.S. firms: manufacturing firms, small businesses, and service sector firms.

The criteria for the Malcolm Baldrige National Quality Award have evolved over time. In 1997, the name for the Award Criteria was changed to the Criteria for Performance Excellence, and in 2010 the Program was renamed the Baldrige Performance Excellence Program.[5] The name of the award has remained the Malcolm Baldrige National Quality Award. The scope of the Program has also evolved. It was expanded to include health care and education organizations in 1999 and nonprofit/government organizations in 2006.

[5] "After 23 years as the 'Baldrige National Quality Program,' the nation's public-private partnership dedicated to performance excellence has decided to highlight that mission with a new name—the Baldrige Performance Excellence Program. 'Performance excellence' describes a focus on overall organizational quality, and for years, followers of the Baldrige Criteria for Performance Excellence have indicated that this term best reflects what makes Baldrige work." See, <http://www.nist.gov/baldrige/baldrige_100510.cfm>.

Table 1 shows the number of applicants, by year and by sector, for the Award.

Outline of the Report

The methodology used in this evaluation is overviewed in Section II, and the counterfactual evaluation method that is employed is discussed in detail. The process used to collect relevant benefit and cost data is described in Section III. The data used in the economic evaluation are presented in Section IV along with calculated benefit-to-cost ratios. Section V completes the report with a summary discussion of the findings, a comparison of the findings of this study to a previous 2001 evaluation study of the Program and other similar studies, and a brief concluding statement.

II.
EVALUATION METHODOLOGY

Traditional economics-based evaluation methods are frequently referenced to the research of Griliches (1958) and Mansfield et al. (1977). They pioneered the application of fundamental economic insight to the development of estimates of the private and social rates of return to investments in R&D. Streams of investment outlays through time—the costs—generate economic surplus through time—the benefits. Once identified and measured, these streams of costs and benefits are used to calculate rates of return, benefit-to-cost ratios, and other related metrics.

In a broad sense, the Baldrige Performance Excellence Program is a measurement-and-standards infrastructure R&D investment program. Publicly funded, publicly performed infrastructure R&D developed the Baldrige Criteria; continuing investments have occurred within the Program throughout the Baldrige Award process to measure business performance and apply the Criteria.

The Griliches/Mansfield model for calculating economic social rates of return is generally viewed as the traditional evaluation method to use when considering the impact of a publicly funded technology. However, following Link and Scott (1998, 2001, 2006, 2011a, 2011b), it is not the most appropriate model to use from a public accountability perspective and therefore it is

not employed in this study. Rather, the counterfactual evaluation method is implemented, and the evaluation question asked is:

> *What would the private sector have had to invest to achieve the same level of benefits as provided through the publicly funded Baldrige Performance Excellence Program?*[6]

When there are shortfalls in benefits, despite such investment with the goal of achieving the same level of benefits, the counterfactual evaluation method is expanded here to also include the gains in producer and consumer surplus associated with a firm or organization (hereafter, "firm" in the theoretical discussion in this section) implementing the Baldrige Criteria rather than incurring costs to establish performance excellence in the absence of the Baldrige Program.

Consider Figure 1, which shows a firm, with average cost AC and facing demand D, that sells its differentiated product or service in amount Q* at price P* in a market with other sellers.[7] In Figure 1, the area defined by the triangle ABP* represents consumer surplus. Producer surplus is represented by the rectangle P*BEF.

Consider Figure 2, which shows the same firm after it has implemented the Baldrige Criteria. The firm's demand has increased from D to D′ because of the firm's higher quality product, and its average cost has fallen from AC to AC′ because of more efficient operations. This firm's implementation of the Baldrige Criteria has created a net gain of HGJA in total surplus because of new consumer surplus and a net gain of JBEFKLG in total surplus because of new producer surplus.[8]

---

[6] This is the same evaluation question asked in Link and Scott's 2001 evaluation of the Baldrige National Quality Program, as discussed in Section V below.

[7] The market might have so many other sellers that there is no strategic interaction among them, and in that case such markets with differentiated products are called "monopolistically competitive" in the economics literature. If there are fewer competitors and strategic interaction, the economics literature typically describes the equilibrium price and output for the firm as an outcome in a Nash noncooperative equilibrium for price-setting oligopolists selling differentiated products. In either case, the depiction in Figure 1 is appropriate.

[8] The new consumer surplus is net of previously existing consumer surplus AJP*′. The new producer surplus is net of P*′JBP* which was previously existing consumer surplus and net of P*BEF which was producer surplus existing before the performance excellence program. The movement from P* to P*′ reflects the movement to the new profit-maximizing equilibrium after the implementation of the Baldrige Criteria.

Figure 2 depicts the annual effect resulting when the firm implements a performance excellence program using the Baldrige Criteria. Over time, other firms with competing differentiated products and efficient processes could erode the firm's profitability and hence the producer surplus. In long-run equilibrium, producer surplus may even be eliminated by price competition among the sellers of the general type of differentiated product or service, although the benefits to consumers of higher quality products of that type will increase as prices fall and numerous competitors offer the higher quality products, resulting in more consumer surplus as the producer surplus is competed away.

Therefore, given the social costs—the public and private costs to operate the Baldrige Performance Excellence Program—the counterfactual evaluation method is used to estimate the following public benefits of the Program. Those benefits are three:

1. the counterfactual cost savings as measured by what the private sector would have had to invest in its attempt to achieve the same level of benefits as provided through the publicly funded Baldrige Performance Excellence Program,
2. the annual shortfall from HGJA in Figure 2 given the alternative performance excellence programs developed by firms in the absence of the Baldrige Criteria (i.e., the annual gains in consumer surplus because the Baldrige Criteria were available rather than the counterfactual alternatives), and
3. the annual shortfall from JBEFKLG in Figure 2 given the alternative performance excellence programs (i.e., the annual gains in producer surplus because the Baldrige Criteria were available rather than the counterfactual alternatives).

In sum, the social benefits from the Program for a firm and its customers are the costs avoided that would have been incurred to establish performance excellence without the Baldrige Criteria (category 1 above) and the avoided shortfalls in consumer surplus and producer surplus when performance excellence has not been based on the Baldrige Criteria but instead based on the counterfactual alternative developed by a firm in the absence of the Program (categories 2 and 3 above).

III.
DATA COLLECTION PROCESS

Two sets of data are needed to implement the counterfactual evaluation method. The first set of data relates to the costs to operate the Baldrige Performance Excellence Program, and the second set relates to the three categories of benefits described above: the implementation costs (of performance excellence programs in the absence of the Baldrige Program) avoided by the private sector, the avoided shortfalls in the gains in consumer surplus, and the avoided shortfalls in the gains in producer surplus. The three categories of benefits—the avoided implementation costs and the avoided shortfalls in consumer and producer surplus gains—are costs avoided because of having the Baldrige Program rather than having to use the counterfactual alternatives to the Baldrige Criteria.

Annual program costs, from 1988 through 2010, were provided by the Program Office and are reported in Table 2 in 2010 dollars ($2010). Because the survey respondents are all Award applicants, an additional cost was considered in the evaluation analysis. Specifically, the following question was asked about the costs of applying for the Award:[9]

> *If your organization has been an Award applicant, what was the total monetary cost (fully burdened and in current dollars) to your organization to obtain, understand, collect relevant information, and comply with the Baldrige Award or state application requirements?*
>
> *Approximately between $_____ and $_____(in current dollars) per year over the year(s) ____to _____.*

The 273 firms and organizations that applied for the Malcolm Baldrige National Quality Award over the years 2007 through 2010 (and generated the 322 applications) were asked by the Program Office to participate in a study of the benefits they received through the Award application process. Specifically, each organization was asked to complete a Web-based survey

[9] The mean value reported on this survey question, and on those that follow, was used in the evaluation analysis.

instrument.[10] A total of 45 organizations responded to the survey request—a response rate of 16.5%. Benefits were calculated using survey information obtained from the 45 firms and organizations that responded completely or partially to the survey.

The counterfactual cost savings, as measured by what the private sector would have had to invest in an attempt to achieve the same level of benefits as provided through the publicly funded Baldrige Performance Excellence Program, were obtained from responses to the following survey question:

> Please consider the following hypothetical or counterfactual situation. Assume the Baldrige Criteria and related processes had not been available, and as a result your organization could not have used the Baldrige Criteria or related criteria to perform an organizational performance self-assessment or submit an award application to receive feedback on organizational performance from a panel of trained Baldrige examiners. We would like to know how much your organization would have had to spend in the absence of the Baldrige Criteria or related criteria, and over what years, to achieve the same level of expertise in performance excellence that your organization now has.
>
> Counterfactual Cost Savings
> *In the absence of the Baldrige Performance Excellence Program—and therefore without the information and assistance that it provides about performance excellence assessments and therefore with the need to incur expenditures to develop and acquire such knowledge and assistance from other sources—what expenditures (fully burdened and in current dollars) would your organization have incurred to achieve the same level of expertise in performance excellence that you now have?*
>
> *Approximately between $_____ and $_____(in current dollars) per year over the years _____ to _____.*

The avoided shortfalls (of what would be obtained with the counterfactual effort to replace the Baldrige Criteria from what was obtained with the Baldrige Criteria) in consumer surplus and producer surplus were measured from responses to the following survey questions:[11]

[10] The survey instrument was designed by Link and Scott; RTI International administered the Web-based survey.
[11] Recall, for the counterfactual evaluation method, the consumer surplus benefits and producer surplus benefits of the Baldrige Program are not the areas HGJA and JBEFKLG identified in the figures (those *would* be the benefits in the traditional Griliches/Mansfield approach) but instead the shortfalls from those areas if the counterfactual replacement of the Baldrige Program is used rather than the Program itself.

Above, you estimated, in the hypothetical or counterfactual situation without the Baldrige Criteria or related criteria for guidance, the additional costs that your organization would have incurred to achieve same level of expertise in performance excellence that your organization has now achieved using these criteria. However, even with such additional effort, if performance excellence were achieved in the absence of the Baldrige Criteria, customers may have undervalued the products and services of your organization and investors may have not recognized as fully the performance excellence achieved. Or, possibly, despite efforts to achieve the same level of performance excellence, there would have been a performance shortfall without the Baldrige Criteria to guide organizational self-assessment and improved performance. This question allows you to quantify any such shortfalls in quality performance that would have been experienced in the hypothetical situation where your organization had not had the Baldrige Criteria or related criteria and instead used the substitution of additional efforts to make up for the loss of the Criteria to organize the management of performance excellence.

Consumer Surplus

Because a key aspect of quality performance is ensuring customer satisfaction, it is expected that the value customers place on your organization's products or services increased because of performance improvement efforts. Because of the competition your organization faces, customers' willingness to pay for the products or services of your organization will typically exceed what they actually do pay. If the Baldrige Criteria or criteria based on them had not been available as a guide, and instead your organization had incurred the costs for improvement as reported in Question II.1 above, as a percentage of your organization's total sales/revenues or the appropriate analogous measure, what would have been the approximate reduction annually in the excess amount (beyond what they actually paid) in your customers' collective willingness to pay for your organization's products or services because improvement took place in the absence of the Baldrige Criteria? Please mark the most appropriate answer:

0% 5%-10% 10%-20% 20%-30% 30%-40% 40%-50%
50%-60% 60%-70% 70%-80% 80%-90% 90%-100% other__%

Producer Surplus

If your organization had not had the Baldrige Criteria as a guide, and instead had incurred the costs for quality improvement as reported in Question II.1 above, as a percentage of your organization's total sales/revenues or the appropriate analogous measure (for example, for a health care organization, revenues might include third party reimbursements, or for an organization in education the tuition fees and grants, or for a public school perhaps simply the annual budget, or for a charitable organization the donations and grants it receives, and so forth), what would have been the shortfall in annual earnings before interest and taxes (or the most appropriate analogous measure reflecting the difference between revenues and costs for your organization) for your organization because improvement took place in the absence of the Baldrige Criteria? Please mark the most appropriate answer:

0% 5%-10% 10%-20% 20%-30% 30%-40% 40%-50%
50%-60% 60%-70% 70%-80% 80%-90% 90%-100% other __%

IV.
ESTIMATION OF NET SOCIAL BENEFITS

Benefits and Costs

One method, and clearly the most conservative method, for calculating the net social benefit associated with the Baldrige Performance Excellence Program is to employ a cluster approach.[12] A cluster approach to evaluation compares the benefits for a sample of identified private-sector benefit recipients from the population of potential benefit recipients to the total operating costs of the publicly funded, publicly performed program. Stated differently, a cluster analysis approach in effect assumes that the subset of affected parties for which benefit information is available is the entire population of affected parties.

In addition to the pronounced conservative (i.e., downward biased) basis from using the cluster approach focused on only the applicants for the Baldrige National Quality Award, an even more conservative measure of social benefits associated with the Baldrige Performance Excellence Program would be to use for the cluster of applicants only the sum of implementation cost savings (category 1 above) obtained from the sample of 45 survey respondents. Thus, a decidedly lower bound estimate of benefits associated with the Baldrige Performance Excellence Program is the ratio of the present value of implementation cost savings from the 45 survey respondents to the present value of total Program operating costs. Below we present evaluation metrics using only implementation cost savings as well as metrics adding the consumer and producer surplus benefits.

The present value of total Program operating costs is derived from Table 2. Each annual value of operating costs, in 2010 dollars ($2010), is referenced forward to 2010 by a 7 percent real rate.[13]

[12] Ruegg and Jordan (2011) advocated a cluster approach for the evaluation of the retrospective benefit-cost studies of technologies developed from the Department of Energy's (DOE's) Office of Energy Efficiency and Renewable Energy (EERE). Ruegg and Jordan argue that one can compare the benefits for a cluster of technologies funded by EERE to the entire EERE budget in an effort to obtain a lower bound on a measure of net social benefits.

[13] The use of a 7 percent real rate corresponds to the guidelines set forth by the OMB (1992) in Circular A-94: "Constant-dollar benefit-cost analyses of proposed investments and regulations should report net present value and other outcomes determined using a real discount rate of 7 percent." Rather than discounting all operating costs to 1988, the first year of data on costs, and similarly discounting all benefits to 1988, we chose to bring all values forward for ease of interpretation.

See column (3) of Table 3. Also included in column (4) of Table 3 is the present value of application costs.

The present value of counterfactual cost savings, in $2010, is similarly calculated by referencing forward annual counterfactual cost savings to 2010 by a 7 percent rate. See Table 4.

Regarding the calculation of the shortfalls avoided in consumer surplus and producer surplus from responses to the respective questions above, it is assumed that both are social benefits of the Baldrige Program that should be accounted for, and it is assumed that both begin in the year that the firm applied for the Baldrige Award. See Table 5. However, as explained in the earlier discussion, over time producer surplus is expected to decline because of market competition. Here, we conservatively assume that profits persist for 5 years, declining by 20 percent of the base year each year until in year 6 producer surplus equals 0.[14]

Ratio of Benefits to Costs

For the sample of 45 Award applicants, the ratio of all social benefits to social costs is calculated as the ratio of (1) the sum of the present value (PV) of counterfactual implementation cost savings plus the present value of shortfalls avoided in consumer surplus plus the present value of shortfalls avoided in producer surplus to (2) the sum of the present value of total operating costs plus the present value of application costs:

$$B/C_{n=45} = (\text{PV Counterfactual Implementation Cost Savings} + \text{PV Counterfactual Avoided Shortfalls in Consumer Surplus} + \text{PV Counterfactual Avoided Shortfalls in Producer Surplus}) / (\text{PV Total Operating Costs} + \text{PV Application Costs})$$

And, based on the survey data from only the cluster of respondents, the ratio of social benefits to social costs is:

$$B/C_{\text{Baldrige Award Applicants responding to the survey, n=45}} = 351\text{-to-}1.$$

[14] For those firms for which producer surplus began in year 2007 or later, the straight line depreciation is truncated in year 2010.

To generalize to the survey population of the 273 Baldrige applicants, the benefits of the preceding benefit-to-cost ratio and the application costs portion of the costs can be multiplied by the ratio of the total sales of the survey population of all 273 applicants to the total sales of the sample of 45 responding applicants (that sales ratio equals 3.563).[15] Thus, the ratio of social benefits to social costs for the population of all Baldrige award applicants surveyed is:

$$B/C_{\text{Baldrige Award Applicants}} = (B_{n=45} \times 3.563) / (\text{Total Program Operating Costs} + (\text{Application Costs}_{n=45} \times 3.563)) = 820\text{-to-}1.$$

Table 6 compares these benefit-to-cost ratios for the cluster of 45 respondents and the generalization to the survey population of 273 applicants, which are based on all categories of benefits, to ratios calculated using subcategories of benefits. From an economic perspective, all benefit categories should be considered, but for purposes of comparison to related evaluation analyses, the other benefit-to-cost ratios are useful, especially the ratios calculated using only implementation cost savings.

A More Disaggregated Analysis

As discussed above with reference to the expanded scope of the Program in 1999 and again in 2006 (see Table 1), we disaggregated the 45 responses by applicant sector. Twenty-five of the responding 45 applicants listed their primary sector of activity: 5 from education, 13 from health care, and 7 from manufacturing.

In an exploratory manner, given the small sector samples, we calculated a benefit-to-cost ratio, by sector. For benefits, we considered the sum of the present value of implementation cost savings plus the present value of the avoided shortfalls in consumer and producer surplus; for costs, we considered the sum of the present value of total operating costs for the Award Program plus the present value of the application costs for the sample of sectorial respondents. Finally, we extrapolated these ratios to the survey population of all Award applicants, by sector. This

[15] This extrapolation from the sample to the population assumes that the sample of respondents is representative of the population of surveyed applicants.

analysis resulted in a benefit-to-cost ratio for the education sector of 119-to-1, for the health care sector of 456-to-1, and for the manufacturing sector of 357-to-1.

We refrain from generalizing from these calculations about the relative importance of the Baldrige application process to different sectors because of the limited number of responses, by sector. However, our findings do suggest that the net benefits to the Program as reported in Table 6 are not specific to any one sector but reflect benefits realized across all of the sectors.

V.
DISCUSSION

As reported in Table 6, even the most conservative (i.e., downward biased) estimates for the benefit-to-cost ratios show substantial benefits for the Baldrige Program. All of the ratios in Table 6 compare benefits for selected subsets of beneficiaries and categories of benefits to all of the Program costs. Were one to completely ignore consumer and producer surplus benefits, the ratio of just the category of social benefits for avoided implementation costs to social costs (including all of the Program's operating costs) for the survey population of applicants since 2006 is 3.0-to-1. Adding to the social benefits only the shortfalls in consumer surplus, under what might be viewed as a heroic assumption that producer surplus is competed away immediately, yields a ratio of social benefits to social costs of 107-to-1.

The most inclusive benefit-to-cost ratio of 820-to-1, which is the most economically sound in terms of categories of benefits considered, is still conservative for two important reasons. First, the calculation of the ratio is based on the conservative cluster approach that compares all of the social costs of the Baldrige Program to only the social benefits for the surveyed applicants for the Baldrige Award.[16] And second, the calculation assumes that the producer surplus created by the use of the Baldrige Criteria to establish performance excellence is eroded quite rapidly by competition.[17]

[16] As Link and Scott (2001) showed, many firms utilize the Baldrige Criteria that never apply for the Award.
[17] Theory and evidence (see Mueller, 1977, 1986) in the economics literature about industrial organization shows that the profitability of firms that establish competitive advantages persists over time. Indeed, graduate business schools teach executives ways to pursue *sustainable* competitive advantage (Porter 1985).

Below we compare the evaluation findings of this study to a 2001 study of the Baldrige Program and to other studies of infrastructure R&D investments.

Comparison to the 2001 Study of the Baldrige Program

The benefit-to-cost ratios presented in Table 6 are consistent, given the differences in the types of firms and organizations applying for the Award and the differences in the categories of benefits measured, with an earlier evaluation of the Baldrige Program. In 2001, Link and Scott completed an evaluation of the Baldrige National Quality Program and concluded, based on survey information from members of the American Society for Quality (ASQ) that the ratio of ASQ benefits (i.e., benefits to the population of ASQ members) to the total social costs associated with the Program was 18.2-to-1.[18] Projecting the benefits to the economy as a whole, the benefit-to-cost ratio was estimated to be 207-to-1.[19]

For purposes of comparing the results in the 2001 study to the findings of this new study, it is important to observe that only the first of the three categories of benefits in Table 6 (i.e., the counterfactual saving of implementation costs) was measured in that study. Moreover, the 2001 study utilized a much smaller sample of respondents; in order to estimate benefits an econometric model was employed for the projection of benefits. In contrast, the present study not only considers the Award applicants that have a demonstrated interest in benefiting from the Baldrige Program and not only evaluates three categories of benefits rather just the one, but also the response rate from the pool of sampled applicants was excellent and allowed using the benefit information reported by the respondents directly rather than relying on an econometric model to project implementation cost savings benefits.

[18] ASQ is a global community of experts and the leading authority on quality in all fields, organizations, and industries. As a professional association, ASQ advances the professional development, credentials, knowledge and information services, membership community, and advocacy on behalf of its more than 85,000 members worldwide. ASQ members are driven by a sense of responsibility to enrich their lives, to improve their workplaces and communities, and to make the world a better place by applying quality tools, techniques, and systems. Long-known as the American Society for Quality and established in 1946, ASQ has been the sole administrator of the Malcolm Baldrige National Quality Program Award since 1991. See, <http://asq.org/about-asq/who-we-are/index.html>.

[19] The analysis in Link and Scott (2001) was peer reviewed for academic publication. See Link and Scott (2006).

The results of the current study can be compared to those of the earlier study by observing that the 3.0-to-1 benefit-to-cost ratio for the survey population of applicants for the Award for the years 2007 through 2010 uses only the counterfactual implementation cost savings, as was the case for the earlier study. The earlier study's estimate of 18.2-to-1 was for population of 875 member organizations of ASQ, while in this present study the 3.0-to-1 ratio is for the survey population of 273 applicants for the Award since 2006. Moreover, the earlier study's 18.2-to-1 ratio compared the benefits net of any application costs for the firms to the total cost of the program. The narrowest category of benefit net of any application costs for 875 firms was compared to all of the Program costs in the former study, and here the same narrowest category of benefit, but not net of the applicant's application costs for 45 firms, is compared to all of the Program costs plus the application costs for the firms. Thus, for a rough comparison of the estimated benefits relative to the costs in the two studies, controlling for the different sample sizes and different treatment of application costs (i.e., 875 members compared to 273 applicants), we have the estimate of 18.2-to-1 in the first study and the extrapolated estimate of 15.5 for the second study.[20] Projecting to economy-wide benefits from these similar findings for the two populations for the sampled beneficiaries would yield similar findings for the economy-wide benefit-to-cost ratio. Given that in contrast to the earlier study which surveyed mostly industrial corporations, the present study reflects the composition of applicants for the Award and includes firms and organizations from the education, health care, and nonprofit sectors, the findings of the two studies are remarkably consistent.

To compare in more detail the 2001 study with the current study, we considered five different dimensions. First, the 2001 study used for benefits only the counterfactual implementation cost savings, while in contrast the present study also estimates the benefits from avoided shortfalls in consumer and producer surplus. However, as shown above, when the present study is made comparable to the 2001 study by using only the benefits of the counterfactual implementation cost savings and by adjusting for the different sample sizes, the benefit-to-cost ratios for the two studies are quite similar. Second, the 2001 study projected the counterfactual implementation

[20] To have the comparable benefit-to-cost ratio, in the present study compare the benefits net of application costs to the total Program costs, and for the 273 applicants, the estimate is then the benefits of (749,586.23 – 120,124.63) × (3.563) divided by the total Program costs of 464,795.28 to have a benefit-to-cost ratio of 4.83. Then, to compare that ratio for the 273 applicants to the comparable ratio for the 875 members of ASQ in the earlier study, multiply 4.83 by 875/273 to get the comparable benefit-to-cost ratio of 15.5.

cost savings to the entire economy, while the present study estimates all of the benefits—avoided implementation costs and avoided shortfalls in consumer and producer surplus—for just applicants for the Baldrige National Quality Award. Third, the 2001 study was able to work with a non-blinded master data set including all of the surveyed organizations, and that enabled an econometric model to be designed to use the very small amount of available benefit data from the small number of responses to the survey to extrapolate to the economy as a whole. In contrast, the present study does not use an econometric model to project the results to the entire economy, but instead estimates the benefits directly from a larger number of responses from the applicants for the Baldrige Award.[21] Fourth, the 2001 study compared the estimated benefits (again, just the implementation costs avoided rather than those benefits plus the benefits to consumer and producer surplus) for the entire economy to the costs of the Baldrige Program, while the present study uses the cluster approach and compares the estimated benefits for only the applicants to the Baldrige Program to all of the Program's social costs. Fifth, subsequent to the sample period examined in the 2001 study, the Baldrige Performance Excellence Program expanded its coverage of the sectors of the economy, and the present study uses the sample of applicants for the Award since 2006 and therefore, unlike the previous study, reflects the increased importance of participation in the Program by educational institutions, health care institutions, and nonprofit organizations.

Taking these five comparative dimensions into consideration, the 2001 estimate of a benefit-to-cost ratio for the economy as a whole of 207-to-1 is not inconsistent with our estimate of a benefit-to-cost ratio of 820-to-1 for the survey population of Award applicants. The results are consistent because, as explained above, if only the single category of benefits used in the 2001 study is used and then projected to the economy, a similar benefit-to-cost ratio would be expected with the present study's findings for that single benefit category. That is, the ratio of 18.2-to-1 for the population of ASQ members projected to the economy as a whole using only

[21] Using the non-blinded master data set including all of the surveyed organizations, the earlier study could estimate a formal econometric model of response to the survey and use it in developing the model of benefits that was then used to project the benefits to the economy. The present study had to work with blinded data, and the data about the nonrespondents was insufficiently complete to support such an econometric model. However, because of the much better response to the survey in the present study, such a model was not necessary (as it was in the earlier study) as a way to make the most from a small sample. Therefore, the present report works solely with the applicants for the Baldrige National Quality Award and works directly with a much larger number of organizations that provided benefit data.

implementation cost savings as benefits yielded an economy-wide benefit-to-cost ratio of 207-to-1. Adjusting for the different sample sizes, the present study finds the benefit-to-cost ratio of 15.5-to-1, which is observationally close to 18.2-to-1, for the survey population of Award applicants using only implementation cost savings. Because the two studies yield similar benefit-to-cost ratios for comparable sample sizes when measuring the same subset of benefits, those ratios should extrapolate similarly to the economy as a whole if information were available in the present study for such an extrapolation.

The 820-to-1 ratio reflects the additional two categories of benefits estimated in this present study that were not estimated in the earlier study. We do not project those two additional categories of benefits to the economy-wide level because the experience of the applicants for the Award with regard to those two categories of benefits cannot reasonably be considered representative of the experience of other organizations throughout the economy. While the single category of benefits—the counterfactual implementation costs avoided—used in the 2001 study would reasonably be representative of those same costs for other organizations, certainly the quality and operational resource savings benefits observed for the applicants for the Award would not be representative, and so those benefits have not been projected to the level of the entire economy.

Comparison to Other Evaluation Studies

As observed above, the Baldrige Performance Excellence Program is, in a broad sense, a measurement-and-standards infrastructure R&D investment program, with the associated investments in operations and maintenance. Publicly funded and publicly performed infrastructure R&D, and related operations and maintenance investments, occur within the Program in the sense that therein the Baldrige Criteria were originally developed and therein, through the Baldrige Award process, appropriate applications of the criteria for performance excellence are evaluated.

In this broad sense, the Baldrige Performance Excellence Program is similar to a National Institute of Standards and Technology (NIST) laboratory that performs infrastructure technology R&D investments and sets performance standards (i.e., the Baldrige Criteria) and then

continually calibrates bench standards used in private-sector laboratories to achieve a predetermined level of performance (i.e., the Baldrige Award process). As an infrastructure R&D investment program, it is therefore reasonable to ask how the benefit-to-cost ratio of 820-to-1 compares with the ratios estimated in several evaluations of economic impact of infrastructure technology investments in the laboratories at NIST.

Link and Scott (2011b) have reviewed the previous evaluations of economic impact at NIST, and discussed six evaluations that have found benefit-to-cost ratios of 100-to-1 or greater. In all six cases, as with the present study, the evaluations were able to quantify the benefits from avoiding shortfalls in consumer and producer surplus. Apart from measuring the benefit of avoiding the costs of developing an alternative to NIST's program, typically the studies were able to measure portions of the reductions in costs for R&D, or for production, or for sales efforts that were made possible by having the NIST infrastructure technology project rather than the counterfactual alternative. Those reductions in costs were then not just a measure of greater producer surplus, but instead a mixture of consumer and producer surplus because the lower costs are in part passed on as a benefit to consumers in the form of lower prices. The evaluations of economic impact with benefit-to-cost ratios of roughly 100-to-1 or greater included evaluations of NIST programs in radiopharmaceutical research, standard reference materials for sulfur in fossil fuels, data encryption standards, role-based access control, wavelength references for optical fiber communications, and injectable composite bone grafts.

The present analysis provides a workable way to estimate the combination of consumer and producer surplus gains from the Baldrige Performance Excellence Program, and it also provides an estimate of the two types of surpluses separately.

The evaluation of the NIST project for injectable composite bone grafts, for example, was able to document a large portion of the combined gains in consumer and producer surplus and moreover used the traditional approach that considers the counterfactual alternative to the NIST program to be the status quo in the absence of NIST's program (rather than an alternative replacement program performed by industry in place of NIST's program). Thus, using that traditional approach, the evaluation of the work with bone grafts used the entire stream of consumer and

producer surplus gains from NIST's program rather than just the shortfalls from those gains given a counterfactual alternative program. It would be expected then, other things being the same, that the benefit-to-cost ratio estimated for the injectable composite bone graft program would be especially high. It was in fact the highest among the economic impact studies reviewed by Link and Scott (2011b), with the benefit-to-cost ratio for the bone graft program estimated to be 5400-to-1.

Concluding Statement

To conclude, the benefit-to-cost ratio of 820-to-1 that is reported in Table 6 was developed from the responses to the survey of individual organizations, all of which have shown great interest in management for performance excellence given that they all have applied for the Malcolm Baldrige National Quality Award, and *those individual responses are all sensible, believable, and entirely credible*. Examining those observations and thinking about the expected benefits for an organization intent on pursuing performance excellence with the implementation of the Baldrige Criteria, the benefit-to-cost ratio of 820-to-1—using only the benefits for the group of surveyed applicants for the National Quality Award since 2006 but using all of the social costs of the Baldrige Program—is not surprising. If the social costs were compared to the benefits for the economy as a whole, the benefit-to-cost ratio would be considerably higher. The estimated benefit-to-cost ratio of 820-to-1 certainly supports the belief that the Baldrige Program creates great value for the U.S. economy. The Baldrige Performance Excellence Program is a public-private partnership that—with the imprimatur of national leadership and a prominent national award presented by the President—creates great value that could not be replicated by private sector actions alone.

Table 1
Number of Award Applicants, by Year and by Sector

Year	Manufacturing	Service	Small Business	Education	Health Care	Nonprofit	TOTAL
1988	45	9	12	n/a	n/a	n/a	66
1989	23	6	11	n/a	n/a	n/a	40
1990	45	18	34	n/a	n/a	n/a	97
1991	38	21	47	n/a	n/a	n/a	106
1992	31	15	44	n/a	n/a	n/a	90
1993	32	13	31	n/a	n/a	n/a	76
1994	23	18	30	n/a	n/a	n/a	71
1995	18	10	19	n/a	n/a	n/a	47
1996	13	6	10	n/a	n/a	n/a	29
1997	9	7	10	n/a	n/a	n/a	26
1998	15	5	16	n/a	n/a	n/a	36
1999	4	11	12	16	9	n/a	52
2000	14	5	11	11	8	n/a	49
2001	7	4	8	10	8	n/a	37
2002	8	3	11	10	17	n/a	49
2003	10	8	12	19	19	n/a	68
2004	8	5	8	17	22	n/a	60
2005	1	6	8	16	33	n/a	64
2006	3	4	8	16	45	10	86
2007	2	4	7	16	42	13	84
2008	3	5	7	11	43	16	85
2009	2	4	5	9	42	8	70
2010	3	2	7	10	54	7	83
TOTAL	**357**	**189**	**368**	**161**	**342**	**54**	**1,471**

Source: <http://www.nist.gov/baldrige/about/faqs_recipients.cfm>.

Figure 1
Consumer Surplus and Producer Surplus

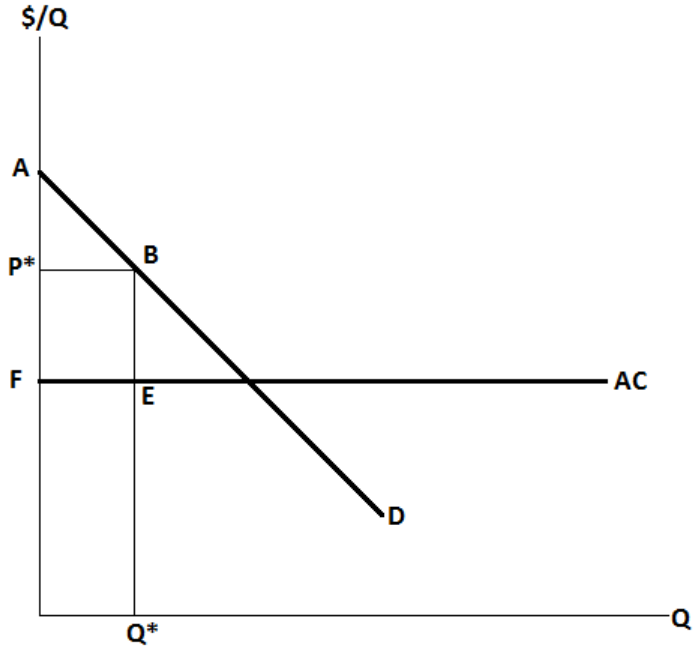

Figure 2
Consumer Surplus and Producer Surplus from Implementing the Baldrige Criteria

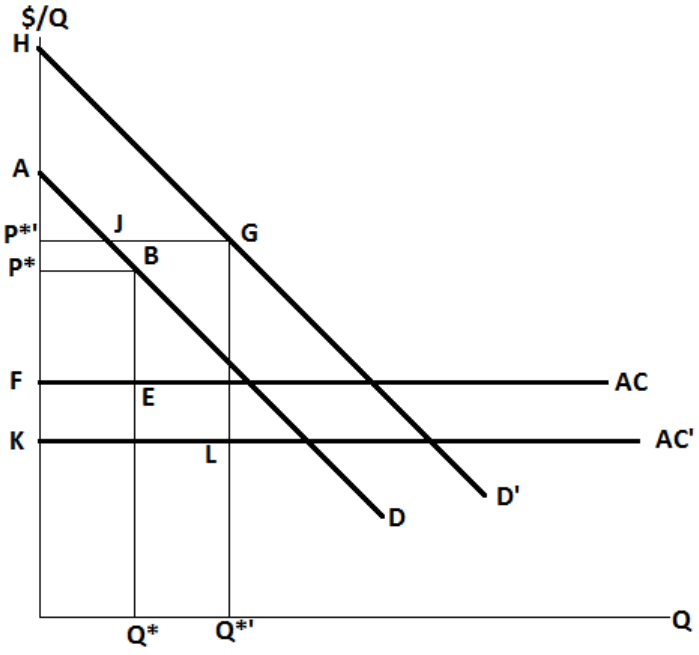

Table 2
Baldrige Performance Excellence Program Operating Costs ($2010 thousands)[a]

(1) Fiscal Year	(2) NIST Allocations	(3) Foundation Allocations[b]	(4) Firm Reimbursed Examiner Expenses[b]	(5) Examiner Time (hours)[b]	(6) Total Operating Costs[c]
1988	$249.67	*$749.01*	*$237.19*	*37,995*	$4,218.47
1989	$509.33	*$749.01*	*$237.19*	*37,995*	$4,478.13
1990	$609.19	*$749.01*	*$237.19*	37,995	$4,577.99
1991	$1,270.82	*$749.01*	*$237.19*	46,510	$5,908.04
1992	$1,850.05	*$749.01*	*$237.19*	49,763	$6,742.64
1993	$1,903.73	*$749.01*	*$237.19*	46,223	$6,518.43
1994	$3,570.27	$910.01	$237.75	45,944	$8,324.64
1995	$4,507.78	$867.19	$234.86	51,259	$9,633.66
1996	$3,576.51	$813.94	$200.02	44,143	$8,055.70
1997	$3,962.25	$971.96	$214.47	44,090	$8,609.75
1998	$3,757.52	$1,009.55	$197.09	43,662	$8,391.63
1999	$4,839.84	$1,447.25	$232.26	51,735	$10,580.55
2000	$6,658.68	$1,482.46	$200.19	51,349	$12,372.23
2001	$7,080.60	$1,807.14	$117.70	50,760	$12,990.10
2002	$6,786.43	$1,397.59	$94.54	48,720	$12,103.08
2003	$7,098.57	$1,134.57	$99.46	49,560	$12,223.05
2004	$6,691.37	$1,110.56	$104.34	52,800	$12,051.07
2005	$6,028.64	$841.24	$104.93	54,600	$11,260.91
2006	$7,863.71	$1,681.21	$253.48	63,840	$14,809.84
2007	$8,371.55	$1,133.21	$276.94	63,480	$14,764.89
2008	$8,636.94	$1,360.76	$318.63	66,600	$15,544.43
2009	$9,529.57	$993.49	$268.33	70,200	$16,302.10
2010	$9,907.60	$387.62	$291.52	68,880	$15,993.82

Notes:
[a] Cost data were provided by the Program Office in current dollars. These values were converted to $2010 using the chain-type price index for Gross Domestic Product (GDP). See: <http://www.gpoaccess.gov/eop/tables11.html>, Table B-7.
[b] Values in italics were estimated by the Program Office. In addition to the public funding through NIST, there are private sources of funds. The Program was initially endowed by private industry with $10 million. The Foundation for Malcolm Baldrige National Quality Award was established to manage these funds and to allocate the interest earned to the Program for award ceremonies, publication costs, and partial training and travel costs for examiners.
[c] The value of examiner time is included. The value of a fully-burdened 2000 hour examiner year in $2010 is $157,000, as suggested by the Program Office.

Table 3
Present Value of Baldrige Performance Excellence Program Operating Costs and Application Costs

(1) Fiscal Year	(2) Total Operating Costs ($2010 K)	(3) Present Value of Total Operating Costs ($K)	(4) Present Value of Application Costs ($K)
1988	$4,218.47	$18,689.52[a]	$4,651.92
1989	$4,478.13	$18,541.96	$4,347.59
1990	$4,577.99	$17,715.39	$4,063.17
1991	$5,908.04	$21,366.61	$3,797.35
1992	$6,742.64	$22,789.66	$3,548.93
1993	$6,518.43	$20,590.50	$3,316.76
1994	$8,324.64	$24,575.69	$3,099.77
1995	$9,633.66	$26,579.56	$2,896.98
1996	$8,055.70	$20,771.90	$2,707.46
1997	$8,609.75	$20,748.16	$3,072.55
1998	$8,391.63	$18,899.56	$5,433.41
1999	$10,580.55	$22,270.48	$8,393.10
2000	$12,372.23	$24,338.04	$7,844.02
2001	$12,990.10	$23,881.76	$7,537.68
2002	$12,103.08	$20,795.35	$7,072.05
2003	$12,223.05	$19,627.55	$7,151.35
2004	$12,051.07	$18,085.40	$6,615.97
2005	$11,260.91	$15,794.01	$4,906.83
2006	$14,809.84	$19,412.68	$6,398.00
2007	$14,764.89	$18,087.62	$6,420.45
2008	$15,544.43	$17,796.82	$6,421.17
2009	$16,302.10	$17,443.24	$5,795.12
2010	$15,993.82	$15,993.82	$4,633.00
TOTAL	**$236,455.13**	**$464,795.28**	**$120,124.63**

Note:
[a] $\$4{,}218.47 \times (1.07)^{22} = \$18{,}689.52$

Table 4
Present Value of Counterfactual Cost Savings

(1) Fiscal Year	(2) Counterfactual Cost Savings ($2010 K)	(3) Present Value of Counterfactual Cost Savings ($K)
1988	$5,500.00	$24,367.21[a]
1989	$5,500.00	$22,773.09
1990	$5,500.00	$21,283.26
1991	$13,000.00	$47,014.86
1992	$13,000.00	$43,939.12
1993	$13,000.00	$41,064.60
1994	$13,000.00	$38,378.13
1995	$14,000.00	$38,626.44
1996	$14,125.00	$36,421.79
1997	$14,917.50	$35,948.86
1998	$15,957.50	$35,939.35
1999	$16,032.50	$33,746.04
2000	$16,050.00	$31,572.78
2001	$20,775.50	$38,194.91
2002	$20,815.50	$35,764.90
2003	$20,748.00	$33,316.75
2004	$20,550.50	$30,840.76
2005	$18,350.50	$25,737.53
2006	$22,038.00	$28,887.32
2007	$23,088.00	$28,283.79
2008	$24,438.00	$27,979.07
2009	$23,988.00	$25,667.16
2010	$23,838.50	$23,838.50
TOTAL	**$378,213.00**	**$749,586.23**

Note:
[a] $\$5{,}500.00 \times (1.07)^{22} = \$24{,}367.21$

Table 5
Present Value of Shortfalls Avoided in Consumer Surplus and Producer Surplus

(1) Fiscal Year	(2) Consumer Surplus ($2010 K)	(3) Present Value of Consumer Surplus ($K)	(4) Producer Surplus ($2010 K)	(5) Present Value of Producer Surplus ($K)
1988	$97,500.00	$431,964.17	$97,500.00	$431,964.17
1989	$97,500.00	$403,704.83	$78,000.00	$322,963.87
1990	$97,500.00	$377,294.24	$58,500.00	$226,376.54
1991	$97,500.00	$352,611.43	$17,289,000.00	$62,526,144.55
1992	$97,500.00	$329,543.40	$13,819,500.00	$46,708,974.08
1993	$97,500.00	$307,984.48	$10,350,000.00	$32,693,737.43
1994	$97,500.00	$287,835.97	$6,900,000.00	$20,369,929.87
1995	$97,500.00	$269,005.58	$3,450,000.00	$9,518,658.82
1996	$109,875.00	$283,316.44	$6,187.50	$15,954.68
1997	$145,475.00	$350,572.20	$31,750.00	$76,512.58
1998	$320,475.00	$721,771.10	$130,152.50	$293,128.37
1999	$320,475.00	$674,552.43	$102,555.00	$215,863.09
2000	$980,475.00	$1,928,742.73	$494,957.50	$973,656.32
2001	$1,141,725.00	$2,099,014.84	$565,610.00	$1,039,850.92
2002	$1,222,481.25	$2,100,450.39	$497,718.75	$855,173.48
2003	$1,222,481.25	$1,963,037.75	$340,485.00	$546,744.51
2004	$1,389,112.50	$2,084,683.29	$370,882.50	$556,594.62
2005	$1,407,487.50	$1,974,074.03	$201,322.50	$282,365.22
2006	$1,505,425.00	$1,973,305.08	$189,325.00	$248,166.45
2007	$1,537,587.50	$1,883,610.80	$144,915.00	$177,527.11
2008	$1,666,962.50	$1,908,505.37	$222,368.75	$254,589.98
2009	$1,666,962.50	$1,783,649.88	$144,572.50	$154,692.58
2010	$1,666,962.50	$1,666,962.50	$100,102.50	$100,102.50
TOTAL	**$17,083,962.50**	**$26,156,192.92**	**$55,585,405.00**	**$178,589,671.72**

Table 6
Disaggregated Analysis of the Components of the Ratio of Social Benefits to Social Costs

Categories of Benefits	**$B/C_{n=45}$**	**$B/C_{\text{Baldrige Award Applicants}}$**
Counterfactual Implementation Cost Savings	1.3-to-1	3.0-to-1[a]
Counterfactual Implementation Cost Savings + Avoided Shortfalls in Consumer Surplus	46-to-1	107-to-1[b]
Counterfactual Implementation Cost Savings + Avoided Shortfalls in Consumer Surplus + Avoided Shortfalls in Producer Surplus	351-to-1	820-to-1[c]

Notes:
[a] ($749,586.23 × 3.563) / ($464,795.28 + ($120,124.63 × 3.563))
[b] (($749,586.23 + $26,156,192.92) × 3.563) / ($464,795.28 + ($120,124.63 × 3.563))
[c] (($749,586.23 + $26,156,192.92 + $178,589,671.27) × 3.563) / ($464,795.28 + ($120,124.63 × 3.563))

REFERENCES

Griliches, Zvi (1958). "Research Costs and Social Returns: Hybrid Corn and Related Innovations," *Journal of Political Economy*, 66: 419-431.

Link, Albert N. and John T. Scott (1998). *Public Accountability: Evaluating Technology-Based Institutions*, Norwell, Mass.: Kluwer Academic Publishers, 1998.

Link, Albert N. and John T. Scott (2001). "Economic Evaluation of the Baldrige National Quality Program," NIST Planning Report 01-03, Gaithersburg, MD: National Institute of Standards and Technology.

Link, Albert N. and John T. Scott (2006). "An Economic Evaluation of the Baldrige National Quality Program," *Economics of Innovation and New Technology*, 15: 83-100

Link, Albert N. and John T. Scott (2011a). *Public Goods, Public Gains: Calculating the Social Benefits of Public R&D*, New York: Oxford University Press.

Link, Albert N. and John T. Scott (2011b). "The Theory and Practice of Public Sector R&D Economic Impact Analysis," NIST Planning Report 11-01, Gaithersburg, MD: National Institute of Standards and Technology.

Link, Albert N. and Donald S. Siegel (2007). *Innovation, Entrepreneurship, and Technological Change*, Oxford, Oxford University Press, 2007.

Mansfield, Edwin, John Rapoport, Anthony Romeo, Samuel Wagner, and George Beardsley (1977). "Social and Private Rates of Return from Industrial Innovations," *Quarterly Journal of Economics*, 91: 221-240.

Mueller, Dennis C. (1977). "The Persistence of Profits above the Norm,"*Economica*, 44: 369-380.

Mueller, Dennis C. (1986). *Profits in the Long Run*, Cambridge: Cambridge University Press.

Office of Management and Budget (2002). *OMB Circular A-94: Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, Washington, DC: Government Printing Office.

Porter, Michael E. (1985). *Competitive Advantage: Creating and Sustaining Superior Performance*, New York: The Free Press, Macmillan.

Ruegg, Rosalie and Gretchen Jordan (2011). "Guide for Conducting EERE Retrospective Benefit-Cost Studies," Draft Report to EERE, Washington, DC: U.S. Department of Energy.