Measuring Net Benefits Resulting from University-Industry Collaboration: An Example from the New Mexico Chile Task Force

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Introduction

As universities face increasingly tight operating budgets, their need to justify expenditures on both basic and applied research is increasing (Oehmke, van Ee, and Ledebuhr 2000; Boyle 1997). At the same time, businesses face increasingly competitive business environments. For many, innovation is the key to productivity and survival. Universities and industries are joining forces to meet their respective needs, forming formal and informal collaborations (Scott et al. 2002).

Analysts and policy-makers are becoming more interested in examining and understanding the relationships between academic research and economic activity. One area of growing interest is the measurement of net benefits generated through these relationships. To accurately measure the return to industry-university collaboration, researchers must consider all associated returns and costs (both direct and indirect). Benefits that may accrue from collaborative efforts include: (1) new scientific information, (2) increased educational opportunities for students, (3) new networks and stimulating interactions, (4) expanded problem-solving capacity, (5) new methodologies and technologies, (6) new firms and (7) expanded social knowledge (Scott et al. 2002).

Valuing all direct and indirect benefits and costs associated with collaborative efforts is difficult, if not impossible. This paper outlines a methodology that can be used to measure one source of economic benefits -- the development of a new technology. The paper uses as an example a mechanical vegetable thinner developed through the collaborative efforts of the Southwestern chile pepper industry and New Mexico State University (NMSU).

Background

Acknowledging that industry leaders and participants possess a unique understanding of their industry, NMSU's College of Agriculture and Home Economics adopted a task-force approach to working with the state's industries. The task forces[2] are teams composed of industry and university professionals who work on industry-identified problems and challenges. The teams' interdisciplinary nature has led to a holistic research and development approach. The work conducted by the task forces has, in general, had wide support from stakeholders. Teams working within the task-force framework are working with a strong sense of purpose (Schickedanz 2005).

The New Mexico Chile Task Force was created in 1998 in response to economic difficulties facing the chile pepper industry. Members come from industry and academia and have varied backgrounds in agricultural science and production, business management, communications, and engineering. Task force members identify and implement procedures and technologies that will help the chile pepper industry remain viable in the face of increasing pressure from foreign-produced chile. One of the technologies developed by the task force is a mechanical vegetable thinner that may help chile growers reduce their production costs.

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[2] There are four College of Agriculture and Home Economics task forces: The Range Improvement Task Force, Water Task Force, Chile Task Force, and Wine Task Force.

The mechanical thinner was developed by engineers at NMSU's Manufacturing Technology and Engineering Center (M-TEC), under the leadership of the Chile Task Force. It selectively thins vegetable crops using computer-controlled, hydraulically operated knives that swing across rows in a back-and-forth motion to eliminate unwanted plants. Using NMSU Cooperative Extension cost and return estimates, Lillywhite et al. (2005) estimate that net returns attributable to cost savings generated from mechanical thinning adoption could be as high as $49 per acre.

Analysis

To estimate the net returns associated with mechanical vegetable thinner development, benefits and costs from three areas were examined (figure 1). These areas are benefits to chile growers (consumer surplus), benefits to the mechanical thinner manufacturer (producer surplus) and associated indirect costs and benefits to other chile industry stakeholders. As indicated above, a number of indirect costs and benefits may be associated with a particular project. Relative to indirect costs and benefits, we followed the work of Schmitz and Seckler (1970). We accounted for indirect costs associated with hand labor displacement as a result of mechanical thinner adoption by assuming those costs are equal to lost earnings.[3] While we recognize other benefits and costs (e.g., networking), we do not explicitly account for these benefits or costs in this analysis.

Consumer Surplus Estimation

Based on previous research by Lillywhite et al. (2005), we used present value estimations of per-acre cost savings to estimate a representative grower's willingness-to-pay for a mechanical thinner. Willingness-to-pay was estimated by calculating the mechanical thinner price that would just drive the present value of annual savings attributable to the thinner to zero. This price or willingness-to-pay point was assumed to represent a point on the grower's demand curve for the mechanical thinner. Differences in savings have a direct relationship with a grower's willingness to purchase a thinner. A primary determinant of annual savings, and thus the estimated willingness-to-pay level, is the number of acres over which the thinner is operated. A grower with 500 acres of chile (with an approximate per-acre savings of $49) would be willing to pay $119,425 per four-row thinner. The same grower with 400 acres (per-acre cost savings of approximately $48) would be willing to pay only $107,628 per four-row thinner. By arranging growers by descending chile acreage (and thus arranging growers by descending willingness-to-pay estimations), we can approximate the market demand curve for a mechanical thinner. Each of these willingness-to-pay points represents a point on a particular grower's demand curve. The market demand for the mechanical thinner can be estimated by repeating the willingness to pay procedure for each chile producer (i.e., horizontally summing individual grower demand curves). Figure 2 depicts New Mexico chile farmers' estimated demand curve for the mechanical thinner.

Figure 1. Steps in Net Benefit Estimation

1. Estimation of Consumer Surplus
    - Estimate present value of cost savings using Extension cost and return estimates.
    - Estimate thinner price resulting in zero present value of cost savings.
    - Repeat for acreage categories.
2. Estimation of Producer Surplus
    - Estimate producer surplus as a percentage of sales.
3. Estimation of Indirect Social Costs (Lost Labor)
    - Estimate labor cost using custom labor rates.
    - Diminish annual labor costs as displaced labor is absorbed into economy.

[3] Schmitz and Seckler (1970) approximated consumer surplus by examining cost savings related to adoption of the mechanical tomato harvester. In this analysis, we directly estimate consumer surplus by estimating a representative grower's willingness to pay for the thinner. Additionally, we provide estimates of producer surplus that may accrue to the thinner manufacturer.

The methodology described above was used to estimate the New Mexico chile industry's market demand for the mechanical thinner. Using NMSU cost and return estimates (Hawkes et al. 2004)[4], cost savings and corresponding willingness-to-pay estimates were generated for a representative grower. These cost savings and willingness-to-pay estimates were projected to all growers within New Mexico using a 1997 USDA National Agricultural Statistics Service (USDA-NASS 2000) acreage categorization of New Mexico chile pepper farms.[5] The USDA-NASS data categorized 447 New Mexico chile farms within 21 different acreage levels (1 to 25 acres, 26 to 50 acres, . . .). Midpoints were used to estimate the average acreage within each category. These averages were then used in developing annual cost savings. Table 1 provides annual cost savings estimates and the present value of the savings (using a 15-year life and a discount rate of 6.5%).

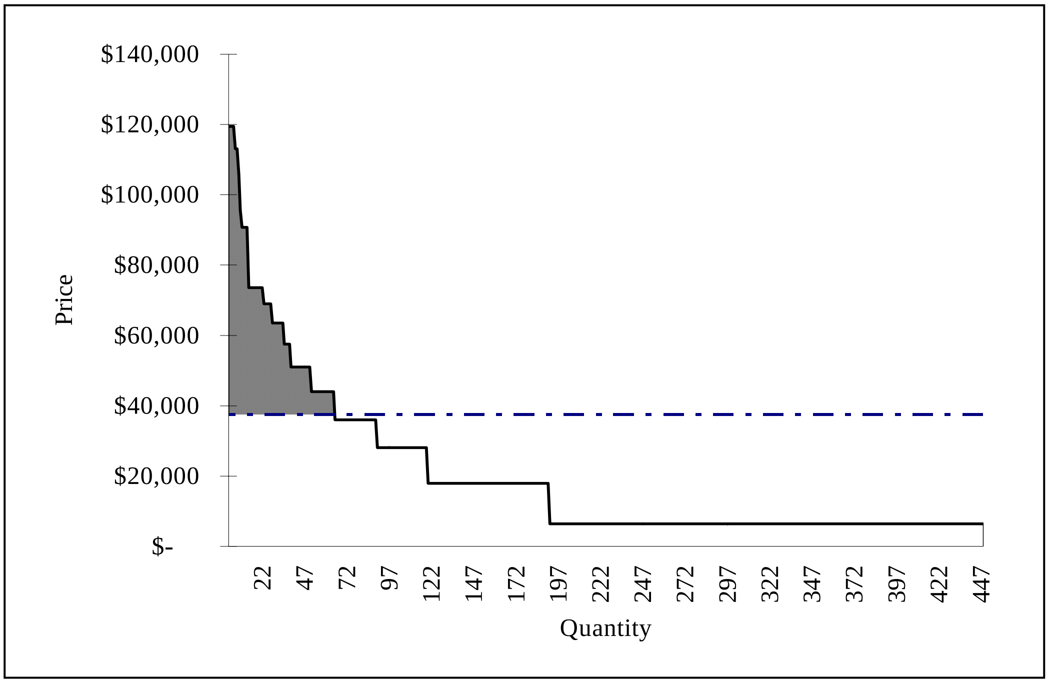

Figure 2. Consumer surplus for four-row mechanical chile thinner (price equals $37,525).

The NMSU thinner was available commercially for the first time in Spring 2005. The initially agreed upon retail price for a four-row thinner was $37,525.[6] Using this estimated price and the demand curve derived above, potential consumer surplus generated by the development of the NMSU mechanical chile thinner is estimated at $1,822,013.

Producer Surplus Estimation

Without knowing specific manufacturer cost information, it is not possible to accurately determine producer surplus associated with the mechanical thinner. A simple producer-surplus estimate can be made by assuming constant marginal costs of production (an assumption that is reasonable given the likelihood that a limited number of thinners will be produced (63 thinners estimated above, based on

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4 Readily available cost and return estimates and the underlying framework associated with those estimates provided by NMSU Extension were of great help in developing the net benefit estimates presented here.

5 A breakdown of farms by chile acreage for the 2002 Census of Agriculture was not available.

6 The price at which initial commercial machines would be sold was a factor in NMSU's selection of a qualified manufacturer.

NMSU cost and return estimates) and that the thinner product line will be a supplement to the manufacturer's other equipment production.[7]

We used an estimated 5% return on net sales as a measure of producer surplus[8]. If all chile producers deemed "willing-to-pay" actually purchased the thinner, the producer surplus would be $118,204.

Indirect Social Costs

To estimate the net benefits to society from mechanical thinner development, an accounting of costs associated with displaced labor must be made. For purposes of this analysis, costs of displaced labor are limited to hand laborers' lost income.

The NMSU cost and return budgets used to calculate individual grower willingness-to-pay estimate that a representative grower spends $70 per acre for contracted hand thinning. Using only farms and acreages where previous calculations showed that growers would be willing to purchase the thinner at the suggested retail price, the thinner would be adopted on approximately 13,342 acres. Multiplying this acreage level by $70, we estimated the total annual value of lost hand-thinning wages to be $933,940.

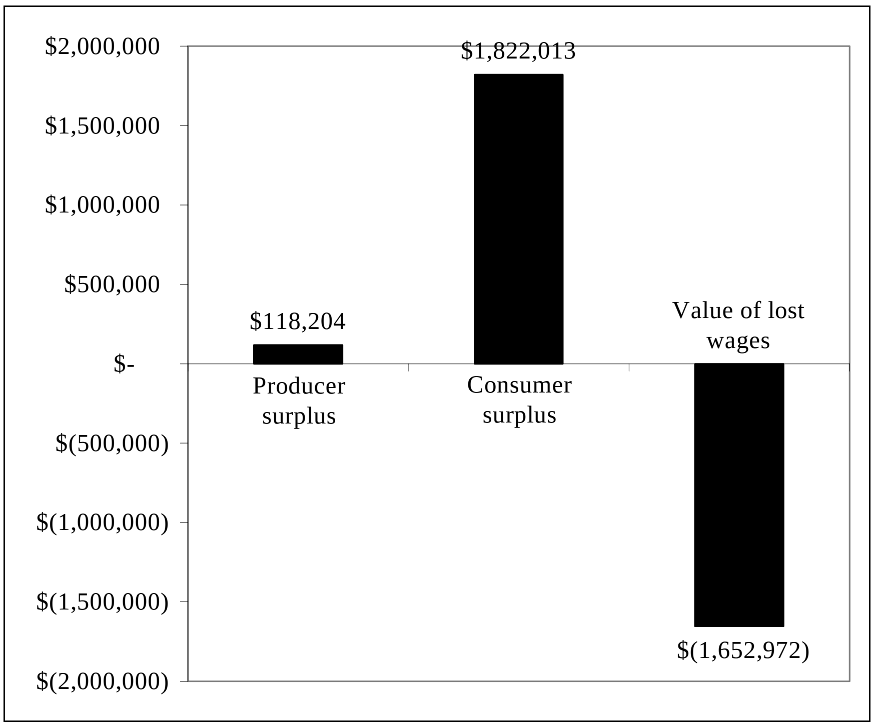

Figure 3. Components of estimated net benefits

The annual cost of lost labor is expected to decrease over time as displaced workers find other employment opportunities.[9] For this analysis, the decrease is estimated at 50% per year for the study's

7 The particular manufacturer chosen to build the mechanical thinner also produces specialized rock crushing equipment and has excess unused floor capacity in a facility recently purchased by the firm. It also is likely that the firm has some degree of excess labor capacity.

8 As a point of reference, John Deere has averaged a 5.5% return on net sales over the last 10 years (John Deere 2004). We recognize that adoption of the thinner will occur over time, suggesting the need to discount surplus measures. Additional work related to estimating adoption rates and timing are underway.

9 The assumption of decreasing labor costs appears reasonable as there are currently unfilled positions in many of the state's chile processing facilities. While some positions may require skills not possessed now by field workers, the workers eventually could acquire the skills needed.

15-year horizon. That is, over the 15-year horizon, we decreased the total value of lost hand-thinning wages by 50% annually. The present value of lost hand-thinning wages is estimated at $1,652,972.[10]

Net Benefits

Using estimates of consumer surplus, producer surplus and the present value of lost hand-thinning labor wages, we estimated the net social benefit to the development of the mechanical thinner to be $287,245 (producer surplus = $118,204, consumer surplus = $1,822,013, and value of lost wages = $1,652,972). Net social benefits are approximately equal to initial research and development costs, estimated to be between $250,000 and $300,000.[11] It should be noted that this analysis estimated benefits and costs for chile produced only in New Mexico. Impacts resulting from adoption by Texas and Arizona producers, who are part of the regional chile industry, were not included.

Conclusions

Analysts and policy-makers are increasingly interested in measuring net benefits generated through industry-university relationships. A comprehensive measure of net benefits requires examination of a variety of benefits and costs associated with the collaborative relationship (e.g., value of increased educational opportunities for students). Quantifying many of these benefits (or costs) in economic terms is difficult. This paper demonstrated an approach to measuring a specific benefit resulting from industry-university collaboration, that of new technology development.

The example used in the paper is that of the collaborative effort of the Southwestern chile pepper industry and NMSU to develop a mechanical vegetable thinner. Using the concepts of consumer surplus, producer surplus, and externalities (e.g., lost labor), we estimated the net benefit attributable to mechanical thinner development to be $287,245, approximately equal to the initial research and development investment costs. Additional work needs to be done to account for adoption and diffusion rates associated with the thinner and incorporate present value calculations based on adoption.

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[10] Schmitz and Seckler (1970) assume an infinite life for displaced labor. Oehmke, van Ee, and Ledebuhr (2000) restrict lost earnings for displaced labor to one year.
[11] Herbon, R. 2005(March 1). Personal communication.

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Table 1. Cost savings for representative New Mexico chile pepper farms.

Category	Average Acreage	Number of Farms	Annual Savings	Present Value of Savings	Willingness to Pay
1 – 25	13.0	257	$ (1,545.98)	$ (15,481.23)	$ 6,636.47
26 – 50	38.0	72	(234.27)	(2,345.91)	18,110.63
51 – 75	63.0	30	1,095.30	10,968.12	28,279.10
76 – 100	88.0	25	2,278.39	22,815.44	36,204.61
101 – 125	113.0	14	3,597.97	36,029.51	44,162.65
126 – 150	138.0	12	4,892.76	48,995.34	51,122.22
151 – 175	163.0	4	6,231.75	62,403.79	57,650.43
176 – 200	188.0	7	7,581.94	75,924.38	63,619.25
201 – 225	213.0	5	8,942.22	89,545.98	69,099.11
226 – 250	238.0	9	10,233.66	102,478.27	73,739.52
276 – 300	288.0	4	13,350.50	133,689.81	90,816.16
301 – 325	313.0	1	14,766.53	147,869.70	95,640.12
376 – 400	388.0	1	18,468.08	184,936.42	105,773.02
426 – 450	438.0	2	21,314.86	213,443.64	113,196.67
501 +	501.0	4	24,714.45	247,486.62	119,546.50

Table 2. Return on manufacturer sales (Assuming 5.5%).

Category	Average Acreage	Number of Farms	Manufacturer Return on Sales
101 – 125	113.0	14	$ 26,267
126 – 150	138.0	12	22515
151 – 175	163.0	4	7,505
176 – 200	188.0	7	13,133
201 – 225	213.0	5	9,381
226 – 250	238.0	9	16,886
276 – 300	288.0	4	7,505
301 – 325	313.0	1	$1,876
376 – 400	388.0	1	$1,876
426 – 450	438.0	2	$3,752
501 +	501.0	4	$ 7,505