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Economic Implications of Cleaning Soybeans in the United States

William Lin

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Economic Implications of Cleaning Soybeans in the United States. By William Lin. Commercial Agriculture Division, Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No. 737.

Abstract

Overall, the costs of delivering cleaner soybeans on a universal basis exceed domestic benefits. The cost of cleaning export soybeans beyond current levels at the least net-cost locations (both river elevators and inland subterminals), at minimum, exceeds domestic benefits by $26 million per year. However, a small percentage of producers could lower soybean foreign material (FM) with no or little additional cost by changing harvesting and handling practices. Most FM originates from the farm. Although soybean cleaning is not common, producers can alter production and harvesting practices to reduce FM, which mainly consists of plant parts, broken beans, weed seed, and dirt. One strategy to address the soybean cleanliness issue is to create incentives for producers to alter production and harvesting practices, such as better weed control and combine adjustment.

Keywords: Soybeans, foreign material (FM), grain quality, cleaning, costs, benefits, premiums, discounts

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Summary

The costs of increased soybean cleaning exceed the benefits. Even at the most cost-effective points of cleaning (river elevators and inland subterminals), additional cleaning of U.S. export soybeans would add a net cost in domestic markets in the range of $26-$76 million annually. Thus, benefits from international markets would need, at minimum, to exceed $26 million to justify additional cleaning of all U.S. export soybeans, and they would not.

Soybean cleanliness refers to the level of foreign material, which consists of all extraneous material, such as pieces of soybeans, weed seeds, plant parts, other grains, leaves, dirt, stone, and stalks, that passes through an 8/64-inch, round-hole sieve and all nonsoybean material that remains in the sample after sieving. The composition of soybean foreign material for the 1991 crop, according to an annual 29-State survey conducted by the American Soybean Association, was 37.5 percent plant parts, 24.2 percent broken beans, 23.5 percent weed seeds, 9.6 percent dirt, 2.4 percent whole beans, 2.3 percent pods, 0.6 percent insects, and 0.1 percent corn.

The costs associated with cleaning soybeans are weight loss, the cost of cleaner operation, and increased transportation and storage costs. Weight loss accounts for the bulk of cleaning costs, ranging from two-thirds at the farm to about three-fourths at interior elevators, and over 90 percent at export elevators. The benefits include reduced penalties for foreign material, increased storability, the sale of screenings, and decreased transportation costs. Producers and commercial elevators cited avoiding weight deduction and/or price discounts as the most important reasons for cleaning soybeans.

Cleaning at both river elevators and inland subterminals has the least net cost because (1) these elevators limit cleaning to export volume, which is smaller than volume marketed by farms or handled by country elevators, and (2) the per-bushel cost of cleaning is lower than that at export elevators due to a smaller value of weight loss. Net costs of cleaning averaged at least 6.2 cents per bushel at both river elevators and inland subterminals. Producers and handlers in the South would bear a disproportionate share of the net costs because the average foreign material level is the highest in this region (3.0 percent), and the South exported 48 percent of its soybean production, compared with 26 percent for the Corn Belt.

To convey the value of cleanliness to their suppliers, soybean buyers use weight deductions, price discounts, and contract specifications. Weight deduction refers to the common practice of buyers deducting the weight of foreign material from the gross weight of the soybeans they agree to purchase when the foreign material level exceeds 1 percent. According to an on-farm survey of producers who delivered soybeans with foreign material of greater than 1 percent, 73 percent were charged weight deductions. However, domestic buyers seldom offer premiums for cleaner soybeans. Thus, any incentives for additional cleaning, in terms of premiums for cleaner soybeans, would need to come from foreign buyers. All export elevators clean soybeans primarily to meet contract specifications.

Although most soybean foreign material originates from the farm, the foreign material level in U.S. soybeans increases as soybeans move toward export. The proportion of broken beans increases during handling and the proportion of nonsoybean materials decreases because of cleaning and the fact that foreign material,

once removed, is prohibited from being re-added to soybeans. The average level of foreign material increases from 1.3 percent at harvest to 1.5 percent when delivered to country and subterminal elevators, and 1.8 percent upon arrival at export elevators.

One strategy to address the soybean cleanliness issue is to create incentives for producers to alter production and harvesting practices. For instance, better weed control and combine adjustment offer potential to lower foreign material in soybeans.

Economic Implications of Cleaning Soybeans in the United States

William Lin

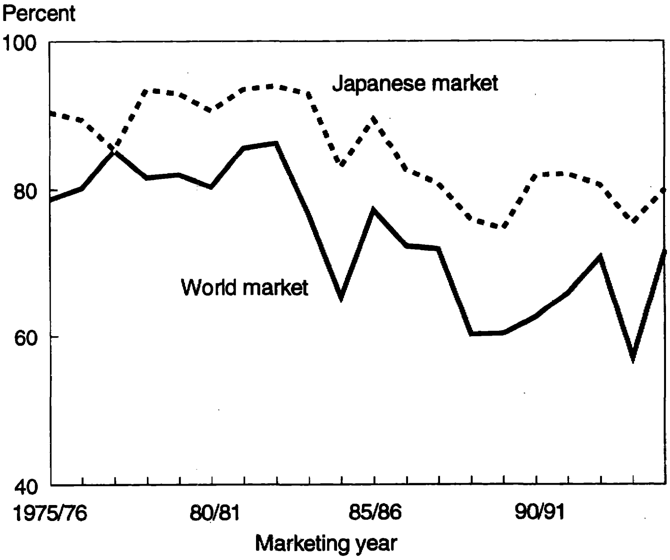
Introduction

Foreign buyers often perceive soybeans exported from the United States as containing more *foreign material* (FM) (italicized words are defined in the glossary) than soybeans exported from competitors, such as Brazil, Argentina, and China. This perception coincides with a report from several studies that foreign buyers often received U.S. exported soybeans with higher FM levels than soybeans exported by competitors. During 1992-94, the FM level for U.S. soybeans reported on export certificates at loading averaged 1.7 percent, down from 1.9 percent during 1982-89. In contrast, the FM in Argentine soybeans averaged only 0.48 percent during 1982-89, and the FM in Brazilian beans exported to Japan averaged 0.6 percent in 1989 (Bender, Hill, and Valdes; Japanese Oilseed Processors Association).[1] In addition, some foreign buyers (especially in Europe) have complained about receiving U.S. soybeans with levels of FM that exceed the 2-percent limit for U.S. No. 2 even though annual averages for FM in U.S. exported soybeans at loading are below contract specification.[2] Brazilian beans, in addition to having 1-percentage-point lower FM levels, have been reported to have higher protein and oil contents. During 1986-89, Brazilian beans showed an average of 0.4 percent higher protein and 1.2 percent higher oil than U.S. beans (Mounts and others).

Congress and U.S. soybean producers are concerned about whether U.S. competitiveness in the world market may have been hampered by higher levels of FM in exported soybeans. Between 1975/76 and 1982/83, U.S. market share of world soybean trade trended upward, reaching its peak of 86 percent in 1982/83 (fig. 1). However, since then U.S. share has been trending down. A similar pattern in U.S. market share has emerged in the Japanese soybean market—an important export market for U.S. soybeans where the decline in U.S. share in recent years received much publicity in congressional hearings. The reason for the decline has not been determined. Many questions remain unanswered: was the decline in U.S. market shares linked to quality differences between U.S. soybeans and beans exported by competitors? Even if it was, would benefits from additional cleaning justify the cost?

To better understand costs and benefits associated with grain cleaning, Congress included a Grain Quality Title

Figure 1
U.S. market share of soybean trade



Estimates are on local marketing year basis.

Source: Calculated by ERS from data compiled by USDA's Foreign Agricultural Service.

[1] Argentine soybeans, however, contained 11.4-percent splits, which was higher than the 8.8 percent recorded for U.S. soybeans (Bender, Hill, and Valdes). "Export quality" soybeans from Brazil are tested for oil content before shipment and only permitted to have 1-percent FM. No FM data in more recent years are available for soybeans exported from Argentina and Brazil. Names in parentheses refer to References at the end of this report.

[2] U.S. No. 2 accounted for 92 percent of U.S. trade during 1992-94 (USDA/FGIS, 1995). These foreign buyers received U.S. export soybeans with levels of FM typically one-half percentage point higher than contract specification.

(XX) in the Food, Agriculture, Conservation, and Trade Act of 1990 (P.L. 101-624). Section 2005 of the Grain Quality Title requires the Federal Grain Inspection Service (FGIS), U.S. Department of Agriculture (USDA), to establish or amend the grain *grades and standards* to include "economically and commercially practical levels of cleanliness" for *grain* meeting the requirements of grade U.S. No. 3 or better. Prior to implementing changes, USDA is required to conduct a comprehensive commodity-by-commodity study of technical constraints and economic costs and benefits associated with additional cleaning. Studies were mandated for wheat, corn, soybeans, sorghum, and barley.

Changing the grade limit itself may not necessarily result in additional cleaning, because foreign buyers can switch the grade of soybeans purchased. At present, the FM limit is 2 percent for U.S. No. 2 and 3 percent for U.S. No. 3 exported soybeans. If the limit is reduced to 1 percent for U.S. No. 2 and 2 percent for U.S. No. 3, foreign buyers not willing to pay a higher price for cleaner soybeans can always switch from the current base grade of U.S. No. 2 (the grade most commonly traded) to U.S. No. 3. Under this circumstance, the change in FM limit will not result in additional cleaning. Thus, contract specification would ultimately determine whether additional cleaning follows a reduction in the grade limit for FM.

This report has been prepared in response to the congressional mandate. The Economic Research Service (ERS) of the USDA, in cooperation with researchers at land-grant universities and the U.S. grain industry, was charged with conducting these studies along with FGIS. This report, the third in a series which began with wheat, focuses on the costs and domestic benefits of removing additional FM from export soybeans beyond current levels. It does not analyze the effects of selling cleaner U.S. soybeans in the international market. The international benefits from selling cleaner soybeans are covered in a companion report (Mercier and Gohlke).

The Structure of the Study

The terms "cleanliness" and "quality" have different implications and are sometimes confused. FM in soybeans, to some extent, is correlated with other quality characteristics, such as *damaged kernels* and *splits* (Hurburgh and Buresh). The second section examines the definition of cleanliness and its role within a much broader context of soybean quality.

Section 3 discusses the economics of cleaning soybeans by examining the motivation of final buyers and suppliers of cleaner soybeans. The value of and demand for cleaner soybeans are derived from the importance of cleanliness to buyers; that is, the contribution of cleaner soybeans to the value and production of a final product. The supply of cleaner soybeans depends largely upon both the costs of delivering cleaner soybeans to the next stage in the marketing system and the price that buyers are willing to pay for these soybeans.

The fourth section focuses on current practices for delivering cleaner soybeans at each market location and alternatives to these practices. Options include changes in production, harvesting and drying practices on farms, as well as mechanical cleaning and blending at the farm, processor, and elevator. The advantages and disadvantages of each option are discussed.

Section 5 describes the procedures used in deriving the costs and benefits of cleaning soybeans. Costs and benefits of additional soybean cleaning at each stage of the marketing system are estimated under three scenarios where the FM limit is lowered: (1) from the current 1.0 percent to 0.5 percent for U.S. No. 1 beans at farms, (2) from the current 1.5-percent FM level to 1.0 percent at interior elevators, and (3) from the current limit of 2.0 percent for U.S. No. 2 beans at export elevators to 1.0 percent. The last scenario would reduce the allowable FM limit in U.S. No. 2 export soybeans by one-half to 1.0 percent, making the grade limit of FM for U.S. export soybeans comparable with Brazilian soybeans. [3]

The sixth section examines the determinants of costs and benefits of cleaning soybeans and the rationale behind each determinant. Then, the costs and benefits of cleaning soybeans to the lower FM level are examined for each market point.

Finally, section 7 presents the costs and benefits of cleaning soybeans for producers, country elevators, subterminal elevators, and export elevators. Appendices present more detailed information about the data and study results.

[3] Whether lowering grade limits would make the FM level of U.S. export soybeans comparable with Brazilian soybeans depends on foreign buyers' decisions to maintain a U.S. No. 2 contract or not.

The Role of Cleanliness in Soybean Quality

Cleanliness is only one of many quality characteristics that determine overall soybean value. In this report, soybean cleanliness refers to the level of foreign material (FM). FM consists of all material, such as pieces of soybeans, weed seeds, plant parts, other grains, leaves, dirt, stone, and stalks, that passes through an 8/64-inch, round-hole sieve and all nonsoybean material that remains in the sample after sieving (Hurburgh, Lang, and Buresh). Cleaning soybeans would remove some proportion of the FM and, to a lesser extent, split soybeans.

Foreign material is measured in terms of broken corn and foreign material (BCFM) for corn, and FM for soybeans. The composition of soybean FM differs from that of BCFM for corn. Unlike corn, where kernels and pieces of kernels account for nearly 90 percent of BCFM, soybean FM primarily consists of plant parts, weed seeds, dirt, and broken beans. According to an annual survey conducted by the American Soybean Association in 29 States (with a size of 1,677 samples of freshly harvested soybeans and an average weight of 450 grams each), the composition of soybean FM for the 1991 crop at harvest was: plant parts, 37.5 percent; broken beans, 24.2 percent; weed seeds, 23.5 percent; dirt, 9.6 percent; whole beans, 2.4 percent; pods, 2.3 percent; insects, 0.6 percent; and corn, 0.1 percent (Hurburgh, Lang, and Buresh).

Soybean Quality

The ultimate measure of soybean quality is its performance in producing the final product by end-use processors (see box for soybean quality dimensions). It is difficult to improve soybean quality across the board because end-users may place different values on the same quality factor.[4] The following discussion examines the different soybean quality characteristics and how they affect end-use processors.

Physical Characteristics

Physical characteristics, for purposes of this study, refer broadly to the external visible appearance or measurements of the kernel, including kernel size, shape, color, moisture, damage, density, the cleanliness of the grain, and freedom from defects.

The cleanliness of soybeans is measured by the level of FM. High-FM soybeans reduce milling yield, and pose a risk to bean crushers in meeting the protein and fiber requirements for soymeal.[5] Under normal circumstances, crushers must meet certain protein specifications at 12-percent moisture for low- and high-protein meals, respectively. In addition, high-FM

[4] In the United States, 99 percent of soybeans are crushed for oil and meal, compared with three-quarters in Japan.

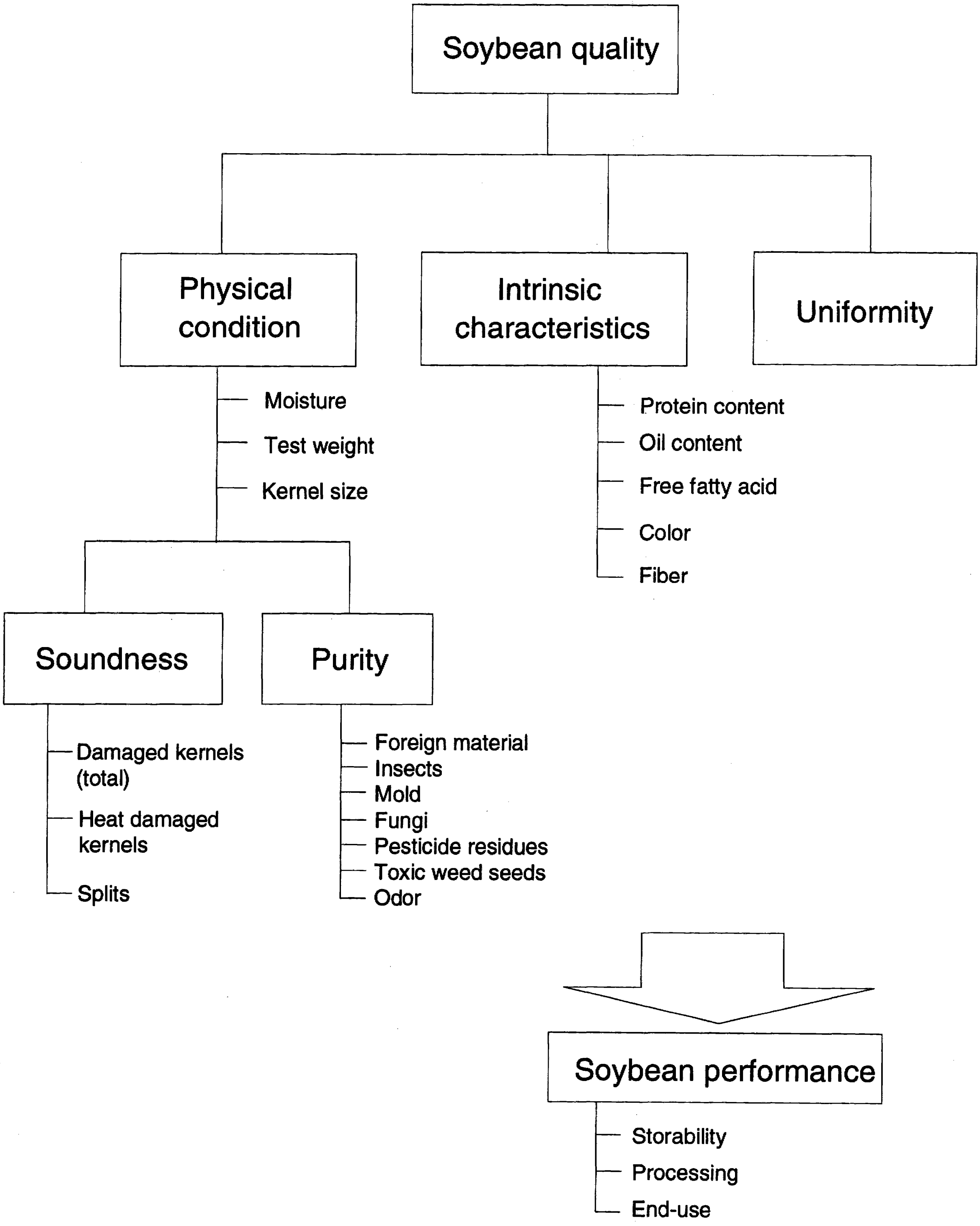
[5] Milling yield loss can be mitigated to the extent that processors reblend FM removed from soybeans with the meal. However, most processors remove coarse FM of large particle sizes prior to crushing, which would lead to a reduction in milling yield.

Soybean Quality Dimensions

Soybean quality has three dimensions: physical condition, intrinsic characteristics, and uniformity (fig. 2). Physical condition has two categories, soundness and purity. Soundness includes physical defects and damage, such as total damaged kernels, *heat-damaged kernels*, and splits. FGIS defines total damaged kernels to include soybeans and pieces of soybeans which are heat-damaged, sprouted, frosted, badly ground-damaged, badly weather-damaged, moldy, diseased, stinkbug-stung, or otherwise materially damaged. Immature soybeans are considered damaged when a cross-section of the bean shows an intense green color—a characteristic disliked by domestic and foreign buyers. Purity includes measures of the quantity of nonsoybean material, as well as sanitary and quarantine factors, such as FM, mold, fungi, pesticide residues, toxic weed seeds, insects (live or dead), and odor. Intrinsic characteristics are the structural and biological attributes inherent in soybeans. Uniformity is the degree of variation in the physical and intrinsic characteristics within and between shipments.

Figure 2

Soybean quality dimensions that affect end-use performance



Source: Adapted from the ERS domestic corn cleaning study.

soybeans are associated with higher *free fatty acid* (FFA) levels, and can cause mold growth during shipment and storage. Soybean processors usually distinguish between nonbean FM and broken beans. The presence of nonbean FM can have undesirable effects on flavor and color of the oil (Hutchins).

Damaged and split soybeans tend to have a higher *FFA* content. A higher FFA level lowers the quality of soybean oil and adversely affects the taste, flavor, and other food quality characteristics of soybeans, reducing their usefulness for tofu production and other food products (Mounts).[6] Crude soybean oil normally has 0.3-0.7 percent FFA (Mounts). In addition, high-FFA soybeans result in higher refining costs to processors. The National Oilseed Processors Association in its trading rules limits the FFA in crude soybean oil to a maximum of 0.75 percent. Excess FFA contributes to increased *neutral oil loss* during processing. Seventy-nine percent of foreign processors measured FFA in their bean purchases in the late 1980's because of their concerns about the effect of FFA on soybean oil quality (Hill, Shonkwiler, Bender).

Splits, pieces of soybeans that are not damaged but expose the interior of the seed, are an important physical quality factor for foreign buyers, especially food processors. Splits, just like cracked seeds and any damage to the soybean hull, result in higher risk of deterioration in storage and in transport, stemming from increased mold counts and higher respiration. Splits will not produce sprouts, and in the case of tofu production, it is claimed that splits are often washed out in the process of soaking the beans in water (Lee).

Other physical characteristics include *moisture* content, kernel size, and *test weight.* Although moisture and kernel size are not included in purity or soundness, they are physical characteristics that are important to soybean users. Moisture, although not a grade-determining factor, is a very important quality factor for soybeans. Excess moisture reduces the quantity of dry matter per ton of soybeans and therefore the final yield of oil and meal. In addition, soybeans with moisture above 13 percent are more susceptible to mold and bacteria growth during storage, and are thus subject to price discounts. High-moisture soybeans, when combined with long-term storage, increase FFA and deteriorate the quality of oil. However, soybean moisture at harvest is substantially lower than corn moisture levels, typically below 12 percent. Thus, drying after harvest is seldom needed to lower the moisture content to a safe storage level, lessening concerns over breakage susceptibility.

Test weight is not as important as moisture content to either domestic or foreign buyers. Soybeans with lower test weights have a different volume-weight relationship than beans with higher test weights, and require more space to store the same weight of soybeans. However, it is unclear how test weight affects oil and protein contents (Hill, Shonkwiler, and Bender).

Food processors are especially concerned about bean size. Processors making bean sprouts prefer a small bean because it will generate more sprouts per pound of beans than large-seeded varieties. Tofu manufacturers prefer large-seeded varieties because they are perceived by some processors to be associated with high protein and desirable flavor characteristics in the finished product (Hill, Shonkwiler, Bender).

Intrinsic Characteristics

Intrinsic characteristics are the structural and biological attributes inherent in soybeans. Important intrinsic characteristics include protein content, oil content, and FFA in soybeans. The quantity and quality of soybean protein and oil are important quality factors to processors since the main products of crushing are high-protein meals and oil.[7] Tofu producers prefer soybeans of high protein content and with clear or light *hilum.* In addition, characteristics for soybean end-products, such as oil color, are also important quality attributes concerning some foreign buyers and end-users. The National Oilseed Processors Association also set a 7-percent maximum limit for fiber in low-protein soymeal.

Many factors, including variety, climate, and geographic location, influence the protein and oil contents. Soybean meal, the most widely used oilseed meal in the United States, is a high-protein supplement feed which balances the amino acid deficiencies and

[6] Foreign buyers often specified quality needs for food soybeans even tighter than U.S. No. 1. For example, buyers of soybeans for sprout use in South Korea specified a maximum of 2-percent unsound kernels in 1990, compared with a maximum of 10-percent splits allowed in U.S. No. 1 soybeans (Lee). Similarly, they specified a maximum of 1-percent damaged beans, compared with the 2-percent maximum limit for U.S. No. 1 beans.

[7] Surveys of soybean quality at destinations have indicated that soybeans purchased from Brazil receive premiums because of their higher oil content (Nicholas and Whitten; Nicholas; Mounts and others; and Hurburgh, 1989).

low amounts of protein in cereal feed grains and their byproducts.[8] Protein is inversely related to the FM level since cleaning increases the protein content of soybean meal (Hurburgh, 1994). Foreign processors ranked protein, oil, FFA, and moisture as the most important soybean characteristics, followed closely by foreign material and damage (U.S. Congress; Hill, Shonkwiler, Bender). Information about oil and protein contents is included on FGIS inspection certificates if requested by foreign buyers. Unlike domestic processors who can control the oil and protein content to some degree by selecting geographical regions for purchases, foreign processors (other than food processors) seldom specify the geographic origins within the United States in their contracts due to either the cost of segregating and transporting the shipment through the marketing channels or a lack of information which would allow them to distinguish high-oil from low-oil soybean producing areas. As a result, they have a strong interest in specifying minimum acceptable oil and protein contents in their contracts.

Uniformity

Uniformity is the degree of variation in the physical and intrinsic characteristics within and between shipments. Uniform quality allows processors to avoid frequent adjustment in operations. Tofu producers, for example, desire a uniform size of kernels. However, a multitude of soybean varieties, necessary to grow soybeans in widely different climates, will inevitably result in less uniformity. Because several foreign buyers frequently share shipload lots, uniformity is even more important in export markets.

Wrap-Up

The importance of each soybean quality characteristic differs depending on the end-use of soybeans. Bean crushers, accounting for the use of nearly 70 percent of soybeans sold by producers, are concerned with the protein, oil, and FM contents of soybeans because these characteristics affect the quality of soybean oil and high-protein soybean meal the most. Tofu processors are also concerned with protein content, FM, and splits, and may require tighter standards for FM, splits, and damaged kernels. Food processors are concerned about taste and consumer acceptance.

[8] Mechanically extracted soybean meal contains 41-44 percent crude protein at 12-percent moisture, compared with 44-50 percent crude protein for solvent-extracted soybean meal.

Foreign processors ranked splits even higher than domestic processors because the splits, combined with high moisture and long-term shipment associated with trade, can increase damage levels and FFA (Hill, Shonkwiler, and Bender).

Many important quality characteristics, such as protein and oil contents, are not included in the official U.S. grades and standards for soybeans as grade-determining factors.[9] These are two very important quality characteristics that affect the quality or quantity of final products. In contrast, some grade-determining factors, such as test weight, although included in the soybean grades and standards, exert no effect on the quality or quantity of the final products. Other quality factors, such as FM, can affect processing costs. However, since FM can be removed, it does not necessarily alter end-use products' quality.

Role of Cleanliness in U.S. Grain Grades and Standards

Numerical *grades* provide a composite description for a set of physical characteristics of interest to traders. The soybean grades and standards help buyers and end-users determine product yield, cleanliness, and other quality factors of soybeans; provide information to aid in determining soybean storability; and facilitate trade by defining uniform and accepted terms to describe soybean quality. Physical characteristics included in the grades and standards are test weight, heat-damaged kernels, total damaged kernels, FM, splits, and soybeans of other colors. In addition, foreign buyers may and often do request that some intrinsic characteristics, such as oil and protein, be recorded on inspection certificates. There are four numerical grades, U.S. No. 1 to U.S. No. 4, as well as a sample grade. While U.S. No. 1 is the base grade for the domestic market, the most common grade traded in the international market is U.S. No. 2 (USDA/FGIS, 1995).[10]

U.S. grain grades and standards reflect cleanliness for soybeans through the inclusion of a maximum limit for FM for each numeric grade (table 1). The maximum FM permitted in U.S. No. 1 is 1 percent and in U.S.

[9] U.S. grades and standards focus on physical quality characteristics.

[10] Price discounts are established for many quality factors in domestic sales and applied whenever a sample of soybeans fails to meet the quality of the U.S. No. 1 base grade. Many elevators, however, ignore test weight because they always meet the minimum requirement through blending and in good years, they sometimes ignore FM for the same reason. Soybean sales for export must meet the grade limit.

No. 2 is 2 percent. The Grain Quality Improvement Act of 1986 prohibited addition or recombination of FM to grain (including soybeans), once removed, although blending of soybeans with different FM levels is still permitted. As a part of its regular review activity, FGIS is in the process of reviewing the soybean FM standards to determine if any changes are warranted.

Not all buyers and producers rely on the soybean grades and standards to specify needs. Food-use soybeans, although accounting for only a minute share of U.S. production, are often grown under *identity preservation (IP)* contracts that specify strict quality characteristics.

Cleanliness in U.S. Soybeans

Most soybean FM originates from the farm. Despite breakage of kernels during handling, the amount of FM removed during cleaning largely offsets the amount of breakage. This pattern applies also to soybean

Table 1--Grade and grade requirements for soybeans

Soybeans

§ 810.1604 - Grades and Grade Requirements

Grading factors	U.S. grade numbers 1	2	3	4
	Minimum limits of:			
Test weight lbs/bu	56.0	54.0	52.0	49.0
	Maximum percent limits of:			
Damaged kernels				
Heat (part of total)	0.2	0.5	1.0	3.0
Total	2.0	3.0	5.0	8.0
Foreign material	1.0	2.0	3.0	5.0
Splits	10.0	20.0	30.0	40.0
Soybeans of other colors[1]	1.0	2.0	5.0	10.0
	Maximum count limits of:			
Other material				
Animal filth	9	9	9	9
Castor beans	1	1	1	1
Crotalaria seeds	2	2	2	2
Glass	0	0	0	0
Stones [2]	3	3	3	3
Unknown foreign substance	3	3	3	3
Total [3]	10	10	10	10

U.S. sample grade
Soybeans that:
(a) Do not meet the requirements for U.S. Nos. 1, 2, 3, or 4; or
(b) Have a musty, sour, or commercially objectionable foreign odor (except garlic odor); or
(c) Are heating or otherwise of distinctly low quality.

1 Disregard for Mixed soybeans.
2 In addition to the maximum count limit, stones must not exceed 0.1 percent of the sample weight.
3 Includes any combination of animal filth, castor beans, crotalaria seeds, glass, stones, and unknown foreign substances. The weight of stones is not applicable for total other material.

Source: Grain Inspection, Packers and Stockyards Administration (formerly known as the Federal Grain Inspection Service)/USDA.

cleaning at interior elevators and export ports. However, as soybeans move through the marketing system, the proportion of broken soybeans in FM increases due to breakage during handling and the proportion of nonsoybean materials decreases. The changes in the composition of FM are due in large part to the removal of nonsoybean materials through cleaning and the restrictions against re-adding FM into soybeans, once removed.

The FM level in U.S. soybeans increases as soybeans move toward export ports. The level of FM at harvest averages 1.3 percent, according to an on-farm survey conducted by grain grower associations in 1991.[11] This level exceeds the 1-percent FM limit for the base grade U.S. No. 1 in domestic markets.[12] As soybeans move beyond the farm gate, however, the FM level increases to 1.5 percent when delivered to country elevators. For a typical channel for export nationwide, soybeans would move from country elevators to subterminals and export elevators. The FM level averages 1.5 percent when it arrives at subterminal elevators, and 1.8 percent by the time soybeans arrive at export elevators (NGFA).

Breakage of kernels occurs during handling and cleaning and slightly exceeds the amount of FM removed at earlier market points of the marketing channel. For example, while an average of about 0.15 percentage point of FM is removed at country elevators, breakage of 0.21 percentage point occurs during handling.[13]

Economics of Cleaning Soybeans

End-users employ various methods to convey the value of quality characteristics to their suppliers. For FM in soybeans, these methods include weight deductions, price discounts, contract specifications, and premia. Bean crushers reflect increased quantity and better quality of the oil and meal crushed from cleaner soybeans in the value of cleaner soybeans. If the marketing system is efficient, this value would be communicated through the marketing channels through grades and prices.

Weight deductions are often used to deduct the FM content over a base level from the gross weight of soybeans before payment is made. Under this practice, soybeans are priced on a modified net weight basis. In general, buyers accept a certain base level of FM as nondeductible before the weight deduction begins. The most common nondeductible FM level used for domestic sales is 1 percent, the grade limit for U.S. No. 1.

In addition to weight deductions, some buyers assess price discounts to soybeans with a FM level greater than the nondeductible level to discourage high-FM beans (appendix A). Price discounts increase as FM levels rise. Foreign buyers rely on contract specification as a means of ensuring minimum quality requirements. For example, the maximum FM limit is 2 percent for U.S. No. 2; if the shipment fails to meet this specification, exporters will have to negotiate a new, lower price than for U.S. No. 2.

Buyers seldom offer premiums for cleaner soybeans in the domestic markets. As a result, producers and handlers have little financial incentive to deliver soybeans with less than 1-percent FM.

Farms

The market offers little incentive for farmers to produce or deliver cleaner soybeans. According to a 1991 on-farm survey conducted by the University of Illinois, 128 of the 403 respondents answering the question about FM indicated that they were already delivering soybeans with less than 0.5-percent FM. An additional 28 were delivering soybeans with more than 0.5-percent FM, but could deliver clean soybeans with less than 0.5-percent FM at no or low additional cost (Hill, 1991b). Thus, with additional incentives, some soybean producers could meet the 0.5-percent FM limit proposed by FGIS in 1991 with no or low additional costs.

Producers cited avoiding weight deductions or price discounts as the most important reason for cleaning soybeans, according to the on-farm survey. Weight deduction is the most common penalty charged to producers who deliver high-FM soybeans. According to the on-farm survey, of the producers delivering soybeans with a FM level of greater than 1 percent, 73 percent received weight deduction against FM in soybeans. On average, the deduction begins when FM

[11] This on-farm survey was conducted by wheat, corn, sorghum, and barley grower associations, compared with a direct survey of commercial elevators that handle soybeans conducted by the National Grain and Feed Association (NGFA). Also, the response rate of the on-farm survey is low, although not unexpectedly so.

[12] According to the on-farm survey, 64 percent of soybean producers indicated that the FM level in soybeans at harvest averages less than 1 percent (Hill, Bender, and Beachy).

[13] Breakage is inferred from the FM levels in two successive market points and the amount of FM removed.

exceeds 1 percent. Elevators forgave only 8 percent of the respondents. The remaining 19 percent were charged price discounts, in lieu of weight deductions, with the discounts to begin at over 2-percent FM. Soybean prices received by producers, on average, were discounted 1.0 cent per bushel if the level of FM was between 2 and 3 percent, and 1.3 cents per bushel if the FM level was between 3 and 4 percent. Over 85 percent of soybean producers avoided weight deductions.

Producers regarded improved storability of soybeans as the second most important reason for cleaning. Cleaning soybeans reduces the accumulation of *fines* during storage and transportation. These fines can promote mold growth and hot spots. In addition, cleaning can reduce *aeration* costs and *shrink* during storage. In the South, improving storability remains an important concern to soybean producers because higher FM levels, consisting mainly of green materials such as plant parts and weed seeds, must be removed from soybeans to enhance storability. However, soybeans require less artificial drying and, since soybeans are not eligible for the farmer-owned reserve (FOR), they are typically marketed within the year, mitigating concerns over long-term storability.

Despite the general lack of price premiums, some producers receive premiums by entering into direct contracts with buyers of food-grade soybeans in Japan. Contract specifications often call for deliveries of identity preserved soybeans of specific soybean varieties with less than 0.5-percent FM, and very low limits for seed damage and splits (Guinn). These buyers require large-seeded varieties with clear or light hilum. In addition, growers are frequently subject to restrictions placed by buyers on field operations and production/harvesting practices. Under such contracts, buyers may have agents in the field telling producers when to harvest the soybeans to achieve the desired characteristics. Agents may also recommend or require certain varieties, and harvesting and drying techniques. In return, the producers are awarded with price premiums, typically in the range of $1.50-$2.00 per bushel. Food soybeans are often shipped in containers. Container shipments are about 150,000 tons a year, nearly 15 percent of total food-grade soybeans imported by Japan under identity preserved contracts. Over the last decade, however, most tofu processors in Asian countries (such as South Korea and Japan) purchased U.S. beans on a numeric grade basis. Also, more direct contracts occurred with middlemen, not producers.

Some soybeans grown in the general area of the Midwest (including Indiana, Ohio, and Michigan and adjacent areas) are also sold as food-grade soybeans in Japan with a distinct brand name "IOM," and command price premiums in the Japanese soybean market. "IOM" beans, in general, refer to beans with 36-percent protein or more, 2,200 seeds per pound or less, and clear or light hilum. Japanese buyers screen bulk soybeans with a 20/64-inch screen from any origin to obtain beans that are sold as IOM. Producers do not enter into direct contracts with the buyers in Japan, and are thus subject to no restrictions on their field operations or production and harvesting practices. Handlers, however, can sort soybeans received to meet the Japanese buyers' quality preferences, such as clear or light hilum, large seed, low FM, little splits, and seed damage. These Japanese buyers typically specify U.S. No. 1 in their buying tenders. While handlers and exporters may receive premiums for the high-quality soybeans, producers may not receive any premiums for a lack of explicit contracts (Guinn).

Country Elevators

Country elevators receive most of their soybeans from producers and ship them to processors, river elevators, inland subterminals, and export elevators. Premiums are not generally offered to country elevators for cleaner soybeans except under special circumstances.[14] For this reason, country elevators rarely offer premiums to producers. However, weight deductions and price discounts are often used to discourage high-FM soybeans.

Country elevators can supply cleaner soybeans through mechanical cleaning, and bring high-FM lots down to average with blending. The delivery of cleaner soybeans and the method used to obtain them depend on market incentives, costs of cleaning, markets for screenings, and transportation costs. In addition, elevators can sort soybeans received to meet specific quality preferences of buyers. Even without premiums for clean soybeans, elevators that sort soybeans to meet food soybean buyers' quality preferences could command premiums. In contrast, soybean crushers seldom offer premiums for cleaner soybeans.

[14] Higher bid prices for cleaner soybeans are sometimes offered by exporters or processors when FM levels are unusually high.

According to the survey of elevators conducted by the National Grain and Feed Association, 22 percent of the responding country elevators cleaned soybeans. Country elevators owning cleaners seldom clean all soybeans received. Instead, a portion of high-FM soybeans is cleaned to a level well below the desired one. These soybeans are then blended with others to meet the grade limit. According to the NGFA elevator survey, country elevators cleaning soybeans cleaned an average of 53 percent of beans handled, removing an average of 1.3 percent of the volume as FM (Hyberg, Ash, and Just).

Soybean cleaning at commercial elevators is more common in the South due to higher FM in soybeans harvested than in the Midwest. The NGFA survey showed that 77 percent of all commercial elevators in the South cleaned some portion of soybeans received, compared with 32 percent in the Midwest. While the FM level in new-crop soybeans averaged 1.8 percent and 1.3 percent, respectively, for the western Corn Belt and eastern Corn Belt during 1987-90, the FM level averaged 3.1 percent and 3.0 percent for the Midsouth and Southeast (table 2).

Processors or terminal elevators typically charge weight deductions on soybeans supplied by country elevators when the FM level exceeds 1 percent. In addition to weight deductions, country elevators are routinely charged price discounts, ranging from 0.2 cent per bushel for 1-2 percent FM to 1.4 cents per bushel for over 5-percent FM (appendix A). This discount schedule, together with weight deductions, amounts to a greater penalty than the weight deduction applied to soybean producers by country elevators. Price discounts are lowest in the South where the soybeans average a higher FM content, and highest in the Plains States (North Dakota, South Dakota, Kansas, Nebraska, Oklahoma, and Texas) where FM is lower.

Table 2--FM in new-crop soybeans by region

Region	FM (1987-90)	Proportion of U.S. soybean production (1993-95)
	Percent	
Western Corn Belt	1.8	37.0
Eastern Corn Belt	1.3	39.3
Midsouth	3.1	12.0
Southeast	3.0	2.9

Source: Hurburgh, 1994; USDA, 1996.

Subterminal Elevators

Subterminal elevators (river elevators and inland subterminals) serve as intermediaries for export market points and, to a smaller extent, for final domestic locations. The demands for cleaner soybeans by river elevators and inland terminals are communicated to country elevators and producers primarily through weight deductions and price discounts. The market seldom offers premiums for soybeans cleaner than 1-percent FM, although bid prices to selected sellers are sometimes increased to obtain a supply of clean soybeans. River elevators and inland terminals also have the capability to blend or to do additional cleaning as needed.

Export Elevators

Exporters respond to foreign demand for cleanliness by making certain that the level of FM is within the grade limit specified in the purchasing contract. Pricing schedules of the export elevators reflect the demand for clean soybeans by foreign buyers. All U.S. export soybeans sold by numeric grade must be inspected to determine the levels of all grade-determining factors. The oil and protein contents are also measured if requested by foreign buyers.

Export elevators purchase on the basis of U.S. No. 1, but sell predominantly on a No. 2 basis. FM in soybeans received by export elevators may exceed the 1-percent grade limit for U.S. No. 1; however, some lots of soybeans arriving at export elevators must be cleaned to meet the U.S. No. 2 (the base grade traded for export markets) standards for FM prior to loading. The high-speed, large-volume operations of export elevators often require more cleaning capacity to meet the grade limit than exists at country and subterminal elevators. (The penalties for not meeting contract provisions and/or delaying a ship are high.) International traders deal on the "certificate final" basis; that is, the minimum assured quality is determined by official inspection at the time of loading. Under such contracts, exporters are not responsible for any changes in quality after loading.

Processors

Processors do not generally store soybeans for a long period of time. Each lot of soybeans is tested for moisture and FM upon its arrival at the processing plant.[15] The soybeans are then segregated by moisture so that soybeans of similar moisture content are stored and dried, if necessary, together. To prevent loss, soybeans with the highest moisture content (over 14 percent) are usually dried to 11-12 percent for processing.

Processors clean or scalp most soybeans before the crushing process (see box below). Soybeans are first cleaned to remove dust, weed seeds, plant parts, dirt, and other kinds of foreign material. To the extent possible, screenings, along with the hulls, are reblended by crushers into soybean meal (Hurburgh, 1994). The remainder are sold as millfeed. Soybean crushers have a low tolerance for FM and have adopted an extremely risk-averse strategy for dealing with nonbean material. Since processors clean or scalp most soybeans before crushing regardless of the FM level in soybeans received, they are unlikely to offer premiums for low-FM soybeans.

Options for Cleaning Soybeans Within the Production-Marketing System

This section discusses options for delivering clean soybeans available to producers, interior elevators, processors, and export elevators. While mechanical cleaning is an option throughout the production-marketing system, changes in production and harvesting practices are also options available to producers.

On-Farm

Although soybean cleaning is not common on farms, there are technologies that would allow producers to deliver cleaner soybeans. Production, harvest, storage and handling practices can be altered to reduce FM, in addition to more mechanical cleaning (see box on soybean cleaning needs).

Production Practices

Most soybean FM originates from the farm, but producers can alter production practices to reduce FM. Practices which reduce FM include additional tillage, crop rotations (especially under reduced tillage), and the prudent application of herbicides and other chemicals.

To be effective in lowering FM, production practices must reduce weed seed. More cultivation and tillage of soil can reduce weed problems and reduce herbicide input required for weed control. However, these changes involve additional expenses and contribute to other problems, such as soil erosion. Bad weather can also thwart the effectiveness of weed control. Concerns over sustainability of agriculture have led to an increasing adoption of reduced tillage practices

[15] The moisture content of the soybeans being processed works best between 11 and 12 percent.

Soybean Crushing Process

After cleaning, soybeans are cracked, conditioned with heat, and put through the flaking rolls. Cracking rolls gradually reduce particle size and also remove the hulls, which are then suctioned off. Hulls are sometimes added back to the meal after processing. The heat-conditioned soybean flakes enter the extraction column and are mixed with solvent which separates the oil and carries it off. After the solvent is removed, the oil is stored in tanks. The solvent is also removed from the remaining meal, and the meal is toasted and cooled. It is then screened, ground, and stored (Schaub and others; U.S. Congress).

After processing soybeans into oil and meal, processors sell the oil to refiners, exporters, and manufacturers of consumer or industrial products. Soybean oil is primarily used in edible products, such as salad and cooking oils, margarine, shortening, and salad dressings. Some soybean oil is used in industrial products such as paints, plasticizers, and fatty acids. Processors may sell the meal to feed manufacturers or to exporters, use it in own-farm livestock feeding, or export it themselves. Feed manufacturers use the soybean meal as a high-protein ingredient in their prepared livestock feeds. They also sell soybean meal to farmers for use in feeding livestock.

(including no-till and various forms of conservation tillage). Because weed seed is such a significant component of soybean FM, the FM level can be reduced through increased herbicide applications. Chemicals are already applied to virtually 100 percent of all soybeans in the United States; however, reduced cultivation could require additional herbicide use. Although increasing herbicide applications may lower FM levels and raise yields, it also raises per-acre production costs. The viability of increasing chemical applications to reduce FM in soybeans is and will continue to be controversial because of public concerns over water pollution and chemical residues on food.

Crop rotations can be used to interrupt the life cycle for some pests and reduce the incidence of weed, insect pests, and diseases. Rotating crops effectively reduces chemical costs and raises crop yields. The most common rotation is a corn-soybean rotation because of its high profitability. The nitrogen contribution of soybeans reduces fertilizer requirements for the following crop and by rotating the crops, weeds, insect pests, and diseases associated with specific crops are reduced (Sundquist, Menz, and Neumeyer). Because this practice is already in widespread use, additional adoption to control weed seeds and other problems is limited.

Producers indicated that altering production practices to reduce FM offers potential to enhance soybean cleanliness. According to an on-farm survey, 69 percent of the respondents indicated that they can reduce the level of FM in soybeans by changing production practices (Hill, 1991b). Drilled planting and herbicide use appear to be the two most effective production practices of reducing FM in soybeans. Drilled planting offers an alternative to increased tillage or herbicides. With drilled planting, soybeans shade the soil much more quickly in narrower rows than when planted in regular rows, thus becoming more effective in controlling weed growth. Drilled soybean planting can also be used in conjunction with reduced tillage.

In addition to plant parts and weed seeds, broken beans are an important fine FM component. Some soybean breakage occurs during handling. Hurburgh reported that 24.2 percent of soybean cleanings removed from freshly harvested soybeans are broken soybeans, although more weed seeds are expected in the South.

Harvesting Practices

Producers can alter harvesting and handling practices to lower FM and to reduce breakage. Since soybean breakage susceptibility is more a function of moisture than of variety, producers can better reduce broken beans through changes in harvesting practices than changes in production practices.

Combine adjustment is the most common method to alter harvesting practices to lower the FM level. A modern, properly adjusted combine will remove nearly all of the stem and pod pieces at harvest.[16] However, there are costs associated with such adjustments. Modifications to improve grain separation may delay harvest schedule and result in higher seedcoat damage or loss of grain.[17]

The moisture content at harvest affects the amount of kernel damage produced through combining. Harvesting soybeans at a moisture content around

[16] The cylinder/rotor speed is adjustable from the cab and the required peripheral cylinder/rotor speed varies by type of crop, crop varieties, and by moisture content of the crop. In general, as crop moisture decreases, threshing speed should also be decreased.

[17] Combine adjustment was reported to cause a 0.6-percent field loss of soybeans (Hurburgh, 1994). The latest generation of grain harvesters can automatically monitor and adjust the concave opening to cylinder speed for maximum cleanliness and minimal damage (U.S. Congress).

Soybean Cleaning Needs

There are several important aspects of production and marketing practices that differentiate the need to clean soybeans. First, unlike corn, which requires artificial drying because of its high moisture content (typically about 20-25 percent), soybeans are naturally dry, and lose moisture quickly. Thus, less aeration is needed to maintain soybean condition. Second, unlike wheat, the amount of broken seeds increases each time soybeans are handled; however, the degree of breakage of soybeans during handling is not as severe as corn. Finally, value of cleanliness for soybeans differs depending on its end-use. Cleanliness in soybeans for food processing is even more critical than for crushing.

13-15 percent generally results in less breakage than harvesting at higher moisture because the *pericarp* is not as easily damaged. As soybeans dry down for the first time, it is generally recommended that soybeans not be harvested until moisture content reaches 13.5 percent (Paulsen). Harvesting can be accomplished at a higher moisture but 13.5 percent provides a little more time for green beans in upper pods to mature. Increased field losses occur when soybeans are harvested at moisture levels below 12 percent (Paulsen).

Farm Cleaning

Most analysts believe soybean cleaning on farms does not exceed 20 percent. Because soybean screenings cannot be used on-farm as feed for nonruminants, but must be processed, there are few benefits to on-farm cleaning. Thus, nearly 70 percent of the producers who responded to the on-farm survey indicated that they had to dispose of soybean screenings as trash.[18]

Producers owning cleaners cleaned an average of 37 percent of their soybean crop. FM contents removed by these producers from soybeans during cleaning averaged 1.8 percentage points (Hill, 1991b).[19] The most common type of cleaner is the rotary screen cleaner, which separates foreign material from soybeans by particle size. Of the soybean producers with cleaners, about 80 percent owned rotary cleaners.

Country Elevators

Country elevators handle approximately 80 percent of the soybeans sold by producers. Most of these elevators measure the FM content of incoming soybeans. The soybeans are usually cleaned or blended to meet the FM limit of 1 percent for U.S. No. 1.

Nationwide, 22 percent of country elevators handling soybeans cleaned soybeans as part of normal operations. This percentage varied across regions. Over 50 percent of the responding elevators in the Southeast and Delta States cleaned soybeans. These elevators cleaned an average of 53 percent of beans handled and removed 1.3 percent of the volume as FM.

Cleaning capacity of the responding country elevators averaged 5,900 bushels per hour. Total soybean cleaning capacity at commercial elevators is estimated at 7.1 million bushels per hour, based on elevators currently cleaning soybeans (see box on soybean cleaning capacity). This estimate does not include the potential cleaning capacity for other elevators that handle soybeans and have appropriate cleaners, but that for economic reasons do not clean soybeans. Thus, total cleaning capacity would be higher if these elevators were included in the estimation.

Subterminal Elevators

Most inland subterminal elevators clean a portion of soybeans handled. The average cost of operating cleaners is lower at inland terminal elevators than at country elevators because the former handle larger volumes. However, the lower cleaning cost is offset by other factors, including a requirement for a high-capacity system to match load-out capacity; smaller revenues from sales of screenings; higher transportation costs for screenings; and possible limits in storage capacity for screenings (especially river elevators) and in cleaner capacity. As a result, per-bushel cleaning cost at subterminal elevators could be higher than at country elevators.

Because of their high throughput and limited facility space, many river elevators are not equipped to accommodate cleaners. Soybeans are transferred directly from trucks to barges at many river elevators and cleaning is not a practical alternative at these locations. In the short run, most river subterminals would not be able to clean the soybeans they receive because of a lack of cleaners. Additional facilities would have to be built to house the cleaning equipment.

Export Elevators

All export elevators clean soybeans primarily to meet contract specifications. If the shipment fails to meet specifications, export elevators will have to negotiate a new, lower price. According to the NGFA elevator survey, 43 percent of export elevators cleaned some soybeans and removed an average of 1.2 percentage points of FM. Unlike producers and country elevators, improvements in storability would not be expected to enter export elevator cleaning decisions because they do not have long-term storage facilities. The exception is export elevators on the Great Lakes, which operate

[18] In contrast, 71 percent of producers responding to a similar survey indicated that they either fed corn screenings to their own livestock or sold them to feed manufacturers.

[19] This percentage excludes two outliers that reported a removal of FM from soybeans of greater than 5 or 10 percentage points. Including these two outliers would yield an average of 2.5 percentage points, which would bias the survey results.

Soybean Cleaning Capacity

An examination of the Agricultural Stabilization and Conservation Service (ASCS) records from 1989 indicates that U.S. commercial grain elevators have over 8.3 billion bushels of storage capacity. The National Grain and Feed Association surveyed commercial elevators in 1991. The 895 elevators with nearly 1.5 billion bushels of storage capacity provided usable responses. Of these elevators, 617 with a storage capacity of 860 million bushels handled soybeans. This implies a total storage capacity of 4.9 billion bushels at elevators handling soybeans. However, not all of this storage capacity is available for soybeans because these elevators also handle other commodities during the soybean harvest season.

Total soybean cleaning capacity at commercial elevators is estimated to be 7.1 million bushels per hour (BPH). This estimate was obtained using the ratio of estimated total storage capacity to storage capacity at elevators handling soybeans times the soybean cleaning capacity from the survey. The commercial elevator survey included 166 elevators with grain cleaners that were used to clean soybeans. This is 27 percent of the elevators handling soybeans. The total cleaning capacity available to clean soybeans at elevators participating in the survey was 1.3 million BPH, and average cleaning capacity for these elevators was nearly 8,000 BPH.

Storage and cleaning capacities for soybeans were not distributed alike. The storage capacity available to soybeans was primarily located in the Corn Belt (75 percent), with much of the remainder in the Plains States (16 percent). The distribution of cleaning capacity is different, with regions having higher levels of FM having a disproportionate amount of cleaning capacity. The South, which has the highest FM content but only 2 percent of the storage capacity, has 10 percent of the cleaners. The Corn Belt has the lowest FM level and three-fourths of the storage capacity, but accounts for only 45 percent of the cleaners. The Plains States have 16 percent of the storage capacity, and account for 23 percent of the cleaners.

like inland terminals when lake shipping is closed during winter months.

Processors

Cleaning is an integral part of soybean processing. Most soybean crushers clean all their soybeans to reduce FM to a minimal level before crushing. By cleaning all soybeans, processors gain more control over protein content of the soymeal and quality of soybean oil. Thus, cleaning would continue at the crushing facilities regardless of the level of FM present in soybeans received, limiting incentives to purchase cleaner soybeans.

Domestic processors crush about 60-65 percent of U.S. soybean production. Soybeans delivered to these facilities do not require an official inspection, but are purchased based on processors' needs. Soybean crushers depend on producing soybean oil that satisfies not only health standards, but also consumer quality preferences. Contaminants in soybeans can give the oil an off-flavor and, in some cases, cause discoloration and render the oil unfit for human consumption.

Methodology

The analysis of this study quantifies the costs and benefits of additional soybean cleaning under two scenarios: (1) lower bound cost, and (2) upper bound cost. The lower bound cost scenario uses FM frequency distribution data at each market point of the production-marketing system to estimate the quantity of soybeans to be cleaned, while the upper bound cost scenario is based on the average FM in soybeans at each market point and assumes that each bushel of soybeans produced or handled requires additional cleaning.

Lower Bound Cost Scenario

The lower bound cost scenario estimates the costs and domestic benefits of additional cleaning by examining FM frequency distribution data at each market point to determine the portions of soybeans produced or handled that require additional cleaning to meet the target FM limits, which are 0.5 percent at the farm and 1.0 percent at interior and export elevators. The lower limit for on-farm cleaning, given the increase in FM as soybeans move through the production-marketing system, would make the grade limit of FM for U.S. export soybeans comparable with Brazilian soybeans. The FM frequency distribution data at the farm level are based on the on-farm survey (Hill, 1991b), while those at interior and export elevators are obtained from GIMS database for both domestic and export shipments during FY1989 through FY1991 collected by the Grain Inspection, Packers and Stockyards Administration (GIPSA) (formerly the Federal Grain Inspection Service).

The net costs of additional cleaning estimated under this scenario are regarded as the lower bound for the following reasons:

(1) Producers and elevators are assumed to do additional cleaning on a selective basis in order to meet the new target FM levels;

(2) Frequency distribution data may be biased by showing a larger percentage of soybeans produced or handled that contain low FM levels, which understates the needs for additional cleaning and the associated cleaning costs. This potential problem could be especially serious for data obtained from the on-farm survey, according to reactions from analysts familiar with the soybean industry; and

(3) The estimates of weight loss could potentially be understated to the extent that weight deductions (for FM that exceeds 1 percent) charged by buyers could be recaptured later in the marketing channel, from the industry standpoint, through blending.

The most important factor that sets apart the cost estimates between the lower bound and upper bound scenarios is the estimated value of weight loss. Weight loss refers to the loss of revenues resulting from not being able to sell screenings (including FM and non-FM components) at soybean price. Under the lower bound cost scenario, value of weight loss is computed in three steps. First, the portion of FM that is removed to meet the target level, which would receive the same price as soybeans under current standards, is determined. FM greater than 1 percent that would commonly be deducted by buyers in the absence of additional cleaning is not considered as weight loss from cleaning. Second, additional, non-FM portion of screenings removed is then determined by using the following percentages of volume cleaned to compute total screenings (including FM and non-FM components) obtained from Hurburgh's soybean cleaning study:

On-farm	2.8%
Country elevator	1.8%
River and inland subterminals	2.2%
Export elevator	3.1%

Thus, screenings removed, which is considered as weight loss, include both FM removed and additional, imperfect removal including sound kernels, damaged kernels, and splits. Finally, the sum of the FM removed and considered as legitimate weight loss and additional, non-FM screenings is multiplied by the price of soybeans to obtain the value of weight loss.

Per-bushel cost of cleaning within the FM range of the Hurburgh study, from the current 1.5-percent FM level to 1.0 percent at interior elevators, for example, is the weighted average cost of operating cleaners. Twenty percent of producers and 22 percent of handlers are assumed to clean soybeans, and the remaining producers or elevators would require capital investment in cleaners. If cleaners now used only for corn were considered also, the lower bound estimate would be reduced. Both fixed and variable costs of operating cleaners apply to producers or handlers who do not own cleaners while only variable operating costs apply to those who already own cleaners.[20] In contrast, per-bushel cost of cleaning outside the FM range of the Hurburgh study is based on the on-farm and NGFA commercial elevator surveys. According to the on-farm survey, the per-bushel cost of operating cleaners is estimated to be 4.4 cents for soybeans with FM levels of greater than 1 percent. Similarly, according to the NGFA elevator survey, the per-bushel cost of operating cleaners is estimated to be 3.0 cents at country elevators, 2.5 cents at river elevators and inland terminals, and 2.6 cents at export elevators.

Value of screening sales, which partially offset weight loss, is computed by multiplying the price of screenings by total screenings removed from cleaning, which are determined by the percentages obtained from

[20] Producers or handlers who already own cleaners are likely to base their cleaning decisions on variable costs of operating cleaners. Depreciation, which occurs regardless of additional cleaning of soybeans or not, is not likely to influence cleaning decisions of the producers or handlers.

the Hurburgh study (table 7-6): 2.8 percent on the farm, 1.8 percent at country elevators, 2.2 percent at river elevators and inland subterminals, and 3.1 percent at export elevators. Price of screenings is adjusted downward from $100/ton assumed in the Hurburgh study to $50/ton (based on the NGFA elevator survey). In addition, according to the on-farm survey, producers dispose about 70 percent of screenings as waste and screening sales at the farm level are thus limited to 30 percent of screenings generated from additional cleaning.

Improved storability, a benefit from cleaning at the farm and country elevators, is limited to reported volume of on-farm and off-farm stocks on March 1, 1991, by allowing for a 6-month storage of soybeans after harvest as assumed in Hurburgh's economic-engineering model (USDA, 1992). Thus, improved storability calculated this way is smaller than that based on total production or volume handled by country elevators reported in the Hurburgh study.

Upper Bound Cost Scenario

This upper bound scenario estimates the costs and benefits of additional cleaning based on the average FM in soybeans at each market point and thus assumes that each bushel of soybeans produced or handled requires additional cleaning. Contrary to the lower bound cost scenario, this scenario makes no use of the FM frequency distribution data utilized under the lower bound cost scenario.

The net costs of additional cleaning estimated under this scenario are regarded as the upper bound because of the following arguments:

(1) Commercial elevators are assumed unable to do additional cleaning on a selective basis in order to meet the new FM target, particularly for high-volume operations in river and export elevators. However, analysts of grain trade generally dispute this argument. They believe selective cleaning is a common practice at country elevators and is not that uncommon at river and export elevators either.

(2) This scenario ignores the fact that there is a certain percentage of soybean lots that contain FM of not greater than the new target level and thus require no additional cleaning.

The value of weight loss is computed by multiplying total screenings removed by the price of soybeans. Total screenings are calculated from the same screening percentages indicated in the lower bound section, although weight loss is treated to be identical to total screenings removed from cleaning under this upper bound scenario. Per bushel cost of cleaning includes both fixed and variable costs, and is all based on Hurburgh's economic-engineering model. Price and sales of screenings have the same basic assumptions as under the lower bound scenario, although the volume of screenings is higher here due to the requirement of cleaning all soybeans produced or handled. Estimates of improved storability from additional cleaning at the farm and country elevators are identical to those under the lower bound scenario.

Data

This analysis incorporates data from four broad sources: (1) economic-engineering studies, (2) surveys, (3) economic analyses, and (4) other soybean-related studies, such as those conducted by oil chemists and other analysts.

An economic-engineering study by the Department of Agricultural and Biosystems Engineering at Iowa State University was used to quantify part of the costs and benefits of cleaning soybeans (Hurburgh, 1994). Economic-engineering studies allow the assessment of cost-output relationships for a production process by separating the production activities into stages and estimating the input-output relationships at each stage of the production operation. A corn cleaning model developed by Hurburgh (1994) was modified to accommodate soybean cleaning. The model incorporates physical relationships, such as airflow resistance of soybeans with fines, into the estimation of cleaning costs.

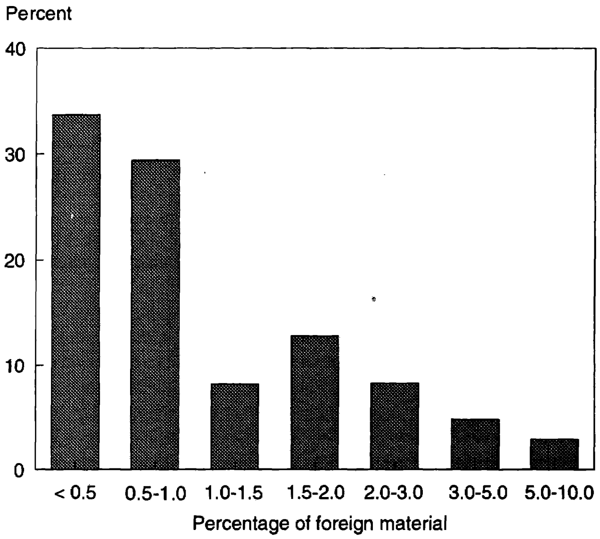
The costs and domestic benefits of cleaning were calculated for farms, country elevators, river elevators and inland subterminals, and export elevators. The economic-engineering calculations, which underlie the upper bound cost scenario, assume the initial and targeted FM levels at various market points as shown in table 3. In contrast, the lower bound cost scenario is based on the FM frequency distribution data obtained from the GIMS database collected by the GIPSA (formerly FGIS), as shown in figures 3-5.

Table 3--Initial and targeted FM levels at various market points

Market point	Initial FM	Targeted FM
	Percent	
Farm	1.0	0.5
Interior elevator	1.5	1.0
Export elevator	2.0	1.0

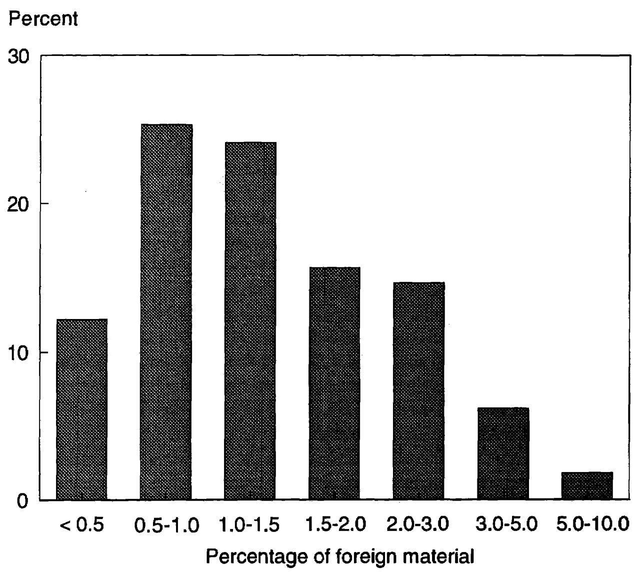
Source: Economic Research Service/USDA.

Figure 3
U.S. soybean FM distribution at harvest, 1990



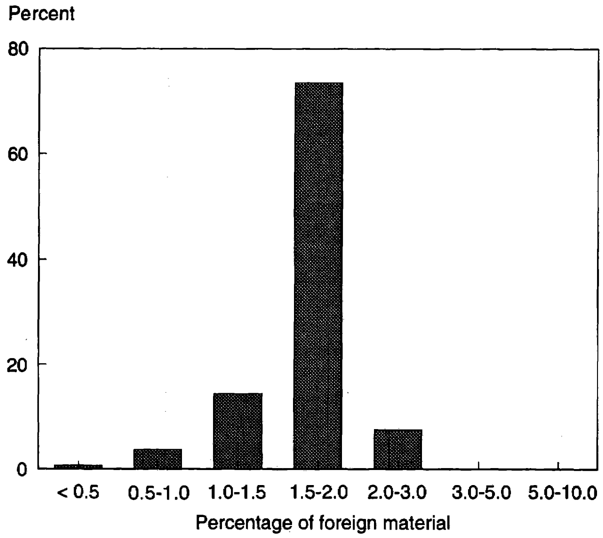
Source: Economic Research Service/USDA.

Figure 4
FM distribution at interior elevators, 1989-91



Source: GIMS database, GIPSA/USDA.

Figure 5
FM distribution at export elevators, 1989-91



Source: GIMS database, GIPSA/USDA.

The costs and benefits of cleaning soybeans are associated with additional cleaning beyond the current level. The targeted FM level would make the FM limit of U.S. export soybeans comparable with beans exported by competitors. Costs and benefits were not calculated for domestic bean crushers because more stringent FM requirements would not alter their operational practice of cleaning all soybeans to a minimal level prior to processing.

The survey of producers was conducted by various grain grower associations in conjunction with the University of Illinois (see "On-Farm Survey" box and appendix B). The surveys of elevators were conducted by the National Grain and Feed Association (NGFA) (see "Commercial Elevator Survey" box and appendix C).

Determinants of Costs and Benefits of Cleaning

Decisions of producers, handlers, exporters, and crushers to clean soybeans are based on the benefits of lowering the FM level versus associated costs. Factors affecting costs of cleaning include the cost of operating cleaners, cleaning capacity and efficiency of cleaners, weight loss, costs for storing and transporting screenings, and the beginning and ending FM level. Potential benefits (excluding trade effects) include smaller discounts for FM; improved storability in terms of savings in shrinkage, insect control, and aeration costs; revenues generated from screening sales which partially offset the weight loss; transportation

On-Farm Survey

Two types of questionnaires were sent in 1991—a short postcard and a long-form survey. The postcard survey was sent to 67,000 members of the National Association of Wheat Growers, 25,000 members of the National Corn Growers Association, 2,500 members of the National Grain Sorghum Producers Association, and 2,000 members of the National Barley Growers Association. Many growers of wheat, corn, sorghum, and barley also grow soybeans. Of the 479 postcards returned from members of the grain associations who also grow soybeans, about 42 percent of the respondents owned cleaners (higher than most analysts believe). Although the response rate of the postcard survey is small, it is not unusually low for this type of survey. The long form was sent by the University of Illinois to 200 soybean producers owning cleaners, including growers who are members of the grain grower organizations, to obtain more indepth information about cleaning. Responses from 79 producers were received.

The short form covered information about (1) grains produced, (2) the level of FM in soybeans at harvest and cleanliness levels for other grains, (3) the viability of delivering cleaner grains (at no or little additional cost) by changing harvesting and handling practices, and (4) ownership of cleaners.

The long form asked questions dealing with: (1) the purpose of cleaning, (2) the extent of cleaning, (3) types of cleaners used, (4) alternative strategies to reduce FM, (5) premiums and discounts for FM, and (6) storage and sales of screenings.

Commercial Elevator Survey

Survey questionnaires were sent by NGFA in April 1991 to 6,237 elevators registered by the Agricultural Stabilization and Conservation Service, USDA. Respondents to the NGFA survey included 635 elevators that handled soybeans. Of the responding elevators, 20 percent cleaned soybeans. All elevators were asked general questions about the type of operation, volume handled, and source of grain. The survey was also divided into commodity-specific sections. Questions were asked concerning winter wheat, spring wheat, corn, soybeans, sorghum, and barley. This report uses the soybean section of the survey.

The soybean section included questions about: (1) the source of soybeans, (2) FM levels received and removed, (3) cost of cleaning, (4) premiums and discounts for FM, (5) soybean storage practices, (6) storage and sales of screenings, and (7) rationale for cleaning and not cleaning.

savings on a reduced volume of soybeans; and greater uniformity. The existence of weight deduction and/or price discounts and the lack of premiums are both important in determining the current level of cleaning.

Determinants of the Costs of Cleaning

Although the determinants of costs are separated into distinct categories, they are interrelated and these relationships affect the overall costs of cleaning.

Cost of Operating Cleaners

The costs of operating a grain cleaner include fixed and variable costs (appendix D). Fixed costs are the costs of ownership and remain the same regardless of use. These costs include depreciation, interest expense, taxes, and insurance, and usually account for two-thirds or more of the cost of operating a cleaner, depending on the market point and the volume being cleaned. Fixed costs per bushel are reduced as volume cleaned increases and when the cleaner can also be used to clean other grains. Soybean producers and handlers often use the same cleaner to clean corn and soybeans. The variable costs of operating a cleaner are incurred only when the cleaner is in operation. These costs include labor, energy, and repairs.

Capacity and Efficiency of Cleaners

The capacity and efficiency of a grain cleaner are important determinants of cleaning costs. Cleaning efficiency, the percentage of FM removed relative to the percentage of FM to be removed, depends on the type of cleaner used and the volume cleaned. Processors and handlers with efficient grain cleaning equipment are able to clean soybeans at a lower cost.

Grain is cleaned by *screening* (particle-size separation) and *aspiration* (density-terminal velocity separation). Since much of the nonbean material is of low density (such as pods, stems, and other plant parts) and not well-defined by size, aspiration could represent an efficient method for cleaning soybeans (Hurburgh, 1989). Aspiration followed by recleaning of screenings could be used to meet lowered foreign material factor limits and would remove more nongrain material than screen cleaning (Hurburgh, 1994).

The most common cleaners owned by soybean producers and handlers are rotary and screen-in-auger cleaners, both of which clean based on size. The rotary cleaner has the following advantages over the screen cleaner: a simple drive, dynamic balance, and easy cleaning of openings (Hill, 1991a). Because of their low unit capacity, rotary cleaners are best suited for farms or elevators with low cleaning volume.

Based on data collected in the on-farm survey, operating capacities of all types of cleaners owned by producers were estimated to average 1,203 bushels per hour.[21] Of the farmers owning cleaners, 71 percent owned rotary cleaners. Additional cleaning of soybeans would require an increase in cleaning capacity at country and export elevators which, together with the variable expense, would result in an increase in the cost of operating the cleaner. Country elevators generally clean more intensively than terminal elevators.

Weight Loss

Mechanical cleaning results in some weight loss for soybeans. Screenings are generated from the removal of FM and damage or loss of broken or whole-kernel soybeans during the cleaning process. Total screenings removed as a result of reducing the FM level by 1 percentage point through cleaning amounts to 5.6 percent of soybeans cleaned at the farm, 3.6 percent at country elevators, and 4.4 percent at river elevators and inland subterminals (Hurburgh, 1994). The proportion of FM in weight loss relative to non-FM screenings differs by market point.

Weight loss accounts for the bulk of cleaning costs, ranging from two-thirds at the farm to about three-fourths at interior elevators and over 90 percent at export elevators. The amount of soybeans included under the working definition of weight loss accounts for only a proportion of screenings removed because screenings removed from soybean lots with FM of greater than 1 percent yield no weight loss. For example, weight loss, in physical quantity, amounts to 54 percent of total screenings removed at country elevators under the lower bound scenario. Revenues remain unchanged as a result of removing these screenings because in the absence of additional cleaning, buyers typically deduct FM of greater than 1 percent from the gross weight before payment is made to producers or elevators.

The loss occurs because these screenings are sold at a lower price than soybeans; screenings, if sold as millfeed (an energy feed that competes with corn, other feed grains, and processed byproducts) instead of being reblended with low-protein (44-percent protein) soymeal as in soybean crushing plants, will bring about 60-70 percent of the price of corn, on a weight basis (Erickson and others; Brumm and Hurburgh). Additional cleaning is estimated to lower the price of screenings to about $50/ton by increasing the supply of screenings available.

Increased Transportation and Disposal Costs of Screenings

Since soybean screenings are not useable as a feedstuff for nonruminants until being toasted or reblended with the meal, most screenings generated outside crushing facilities have to be disposed of as waste. Nearly 70 percent of soybean screenings at the farm were disposed of as waste, 13 percent fed to own livestock, and 11 percent sold to feeders or feed manufacturers (Hill, 1991b). As transportation distance and quantity of screenings increase, transportation cost also increases. Because most feeders and feed manufacturers are located near livestock production areas, additional transportation costs for shipping

[21] Rotary cleaners often used on farms were reported to have a rated capacity of 1,500-4,000 bushels per hour, compared with 5,000-10,000 bushels per hour capacity for screen cleaners at elevators (Hurburgh and Meinders).

screenings to these facilities are the lowest at the farm level. In contrast, export elevators tend to incur the highest cost per unit because of the greater transportation distances.

The changing composition of screenings counteracts the increase in transportation cost as soybeans are moved through the marketing system. A smaller proportion of soybean screenings at interior and export elevators requires disposal than at the farm. The value of screenings would increase as soybeans are moved through the marketing system because the composition of screenings would contain more broken beans and less nongrain material due to cleaning and breakage during handling. At elevator and processor market points, screenings are often sold as byproduct feeds and, to the extent possible, are typically reblended into low-protein soymeal at crushing plants.

Cost of Storing Screenings

With additional cleaning, the volume and thus the cost of storing screenings would increase. Most producers, however, do not store soybean screenings and thus incur no storage cost because they have to dispose of screenings as waste.[22] Other producers who feed screenings to their own ruminant livestock soon after cleaning do not need to store screenings either. Because elevators receive grain continuously and handle larger volumes, it is not practical to transport screenings after each cleaning. Instead, these elevators store the screenings. Cost of storing screenings was estimated to be 0.1 cent per bushel or less at country elevators (Hurburgh, 1994).

Terminal elevators have larger storage capacity than country elevators. Port elevators, however, have less ability to store screenings than country elevators due to the large volume of soybeans handled, rapid turnover, and the lack of storage facilities.

Beginning and Ending FM Levels

Beginning and ending FM levels are important factors in determining costs of cleaning. In general, larger differences between beginning and ending FM levels mean longer cleaning times and a higher cost of cleaning.

[22] This analysis assumes that the cost of discarding screenings by producers is negligible.

The level of FM in soybeans at harvest depends on weather and region. The costs of cleaning soybeans vary by crop year in part because weather during the growing and harvesting seasons influences the amount of FM in each crop. Rain during harvest means longer drying time and more broken beans. Levels of FM in the 1990 soybean crop at harvest averaged 1.3 percent nationwide, according to both the 1990 on-farm survey and the FGIS new crop quality report (Hill, 1991b; Hurburgh, 1994).[23]

Soybean cleaning appears to be related to the FM level in soybeans delivered to the elevator. In general, as the level of FM in deliveries increases, the percentage of soybeans cleaned and FM removed increases. The costs and benefits of additional cleaning (under the lower bound scenario) estimated from soybean FM frequency distribution takes into account the percentage of soybeans that requires no additional cleaning, as well as the percentage of soybeans that requires additional cleaning and their beginning and ending FM levels.

Determinants of the Benefits of Cleaning

Avoiding weight deduction/price discounts and improved storability are two main reasons for cleaning soybeans. Premiums are generally not offered for clean soybeans. Revenue from screening sales, although it partially offsets the value of weight loss, is not the main reason for cleaning.

Avoiding Weight Deductions and/or Price Discounts

The 79 producers surveyed for cleaning soybeans on the farm cited avoiding weight deductions or price discounts applied to FM as the most important reason for cleaning (Hill, 1991b). FM in soybeans in excess of the 1-percent limit is often deducted from gross weight. The marketplace sometimes assesses price discounts to producers in lieu of weight deduction.

Commercial elevators also cited avoiding weight deductions and price discounts as the most important reason for cleaning soybeans (NGFA). Domestic

[23] The 1.33-percent FM level based on this data source is identical to the 1.3-percent FM level obtained from the 1990 FGIS new crop quality report (Hurburgh, 1994). However, FGIS data from the new crop quality report are inspected during the first 4 weeks of harvest, and may reflect soybean crop quality at any interior market point during that period, not necessarily the FM of new soybean crop at the farm.

soybean processors and terminal elevators typically deduct FM content from gross weight beginning at 1-percent FM for soybean purchases from country elevators.[24]

Improved Storability

Producers and commercial elevator operators cited enhanced storability as the second most important reason for cleaning soybeans. The longer the expected storage, the greater the benefit. Cleaning reduces soybean losses during storage by reducing the potential for developing storage molds. The storability of soybeans depends on the level of FM, management practices, grain moisture, temperature, energy requirements, and length of storage. The removal of FM extends the safe storage life of soybeans by improving airflow and reducing power requirements, shrinkage, mold growth, and insect damage. Cleaning also allows soybeans to be stored at a higher moisture level, which reduces shrinkage and drying costs. Soybeans are stored within the marketing year primarily based on market conditions. As a result, soybean cleaning brings about a benefit from improved storability of nearly 1 cent per bushel cleaned at elevators (Hurburgh, 1994). Export elevators and processors benefit little from enhanced storability because soybeans are only temporarily stored at these facilities.

Screening Sales

Revenue from screening sales to feeders and feed manufacturers partially offsets the value of weight loss that occurs during the cleaning process. However, screenings are typically priced between 60 and 70 percent of the price of corn. This is the case because the price of screenings is determined not only by corn price but also by the supply and demand of grain screenings. According to the NGFA commercial elevator survey in 1991, the price of soybean screenings was the highest (around $80 per ton) during May-July, but dropped sharply to the range between $40 and $60 per ton just after harvest of the corn crop (Hyberg, Ash, and Just). The net value of screenings (less handling and transportation costs) declines rapidly as the distance to buyers increases.

[24] According to Hurburgh (1994), a common discount rate charged by domestic bean processors was 1 percent of soybean price per point over 1.0-percent FM. Thus, if soybeans are priced at $6.00 per bushel, the price could be discounted by 6 cents per bushel, which is equivalent to weight deduction once FM exceeds 1 percent.

If additional cleaning is applied to all exported soybeans, the supply of soybean screenings would increase by 0.26 million tons, a 32-percent increase over the base level of 0.80-million tons (Ash, Lin, and Johnson). Based on estimated nutritional value and transport costs, the price of screenings would not fall below 60 percent of the price of corn under the additional cleaning scenario. Using this assumption, soybean screening prices might decline from $56/ton to $50/ton at country elevators as a result of additional cleaning. Revenues from sales of screenings, which averaged 3 cents per bushel of soybeans cleaned at country elevators offset about one-half of the value of weight loss.

Transportation Savings

Cleaning soybeans is most advantageous when transportation rates are high or account for a substantial portion of the total price. Although country elevators may face the highest transportation costs, other factors such as destination and mode of transportation may offset this incentive to clean. Soybeans moving toward export points offer greater cost savings than those used domestically. However, most soybeans are exported from the Gulf ports. These soybeans reach the Gulf by barge, a less costly mode of transportation than rail or truck, which lowers the incentives to remove excess FM.

Premiums

In the current system, the U.S. soybean industry rarely offers premiums for clean soybeans. The NGFA survey of commercial elevators revealed only a handful of elevators offer premiums for low-FM soybeans. Most soybean processors, given their risk-averse attitude toward FM, remove FM from soybeans prior to crushing regardless of the FM level and thus seldom offer premiums for low-FM soybeans to country elevators. Under the current system, with the cost of weight loss and no premiums, farmers have little incentive to deliver soybeans with less than 1-percent FM.

Costs and Benefits of Cleaning Soybeans

Overall, the costs of universally delivering cleaner soybeans exceed domestic benefits. The river and inland subterminals are the most cost-effective points for cleaning export soybeans beyond the current level.

Potential benefits from delivering cleaner soybeans in the international market are not discussed here, but are reported in a companion report (Mercier and Gohlke). A universal reduction in the FM level could benefit the soybean industry only if cleaner U.S. soybeans induce benefits in the international market, in terms of additional trade or premiums, that exceed the domestic net costs. However, the companion report concludes that benefits from international markets do not exceed domestic net costs.

This section presents the estimated costs and domestic benefits of delivering cleaner soybeans at each point in the U.S. production-marketing system under the two scenarios: (1) lower bound cost, and (2) upper bound cost. These estimates address the crucial question: would the benefits from delivering cleaner soybeans in domestic markets be sufficient to offset the costs of additional cleaning beyond the current level? In addition, the distribution of the costs and benefits may be different for market participants in different regions.

On-Farm

Mechanical cleaning of all soybeans marketed and altering production and harvesting practices on a wholesale basis would not yield net benefits for producers. Additional on-farm cleaning applies to all soybeans marketed by producers because they cannot differentiate soybeans sold for domestic markets from those destined for export markets. Weight loss is estimated to account for 1.1 percent of the volume cleaned under the lower bound scenario, but 2.8 percent under the upper bound scenario. The value of screening sales offsets 19 percent of the weight loss. Producers can also deliver cleaner soybeans by changing production practices. Twenty-eight of 263 respondents who reported FM levels greater than 0.5 percent to a voluntary survey could deliver clean soybeans with less than 0.5-percent FM at little or no additional cost by changing harvesting and handling practices. Because weed seeds account for the largest share of the FM in soybeans, changing production practices to lower FM in soybeans offers a practical alternative to cleaning.

Additional cleaning of all soybean production at FM above 0.5 percent at the farm would incur a net cost of $107 million under the lower bound scenario and $345 million under the upper bound scenario (tables 4 and 5). Weight loss is the major cost of additional cleaning, accounting for two-thirds of all cleaning costs. Details of the cost of operating a grain cleaner on-farm and at country elevators are presented in appendix D.

To induce producers to undertake additional cleaning, the market would have to offer incentives, such as premiums, more severe discounts, or an increase in U.S. soybean sales to compensate for the net domestic cost. The costs of segregating cleaner soybeans could reduce operational efficiency and would further increase net cost. In addition, cleaning soybeans beyond the farm gate would still be needed to meet lower limits for cleaner soybean exports. There appears to be no market motive for increased incentives.

Country Elevators

Additional cleaning of soybeans at country elevators is analyzed under two cases: (1) cleaning the entire volume handled, and (2) cleaning only the volume exported. Cleaning a volume of soybeans equivalent to all exports (684 million bushels in 1991/92) at the country elevator would incur a net cost of $25 million per year under the lower bound cost scenario, but rises to $63 million under the upper bound scenario. However, the latter is an optimistic, but unlikely scenario in which country elevators are assumed to have perfect knowledge about the destination of soybean shipments from this market point. As a result, additional cleaning can apply only to outbound shipments for export, not the entire volume handled (tables 4 and 5). In reality, country elevators are not certain of the destination of their soybean shipments, although contract specifications may vary by destination. Thus, cleaning of soybeans to 1-percent FM for export might require cleaning of the entire volume handled by country elevators. Net costs of cleaning would then increase to $71 million under the lower bound cost scenario, and $185 million under the upper bound scenario.

Weight loss is the predominant cost of soybean cleaning at country elevators, accounting for 70 percent of the total cost of cleaning under the lower bound cost scenario. The costs of operating a cleaner and transporting screenings account for the remainder. Additional cleaning of soybeans to the 1.0-percent FM level is estimated to cost 8.3 cents per bushel. Additional unestimated segregation costs for cleaner soybeans must be added to arrive at total costs of cleaning.

Table 4--Annual costs and domestic benefits of additional soybean cleaning: lower bound cost scenario[1]

Point of cleaning	Volume cleaned	Costs	Benefits	Net costs
	Million bushels		*Aggregate (million dollars)*	
Farms:				
Mechanical	1,353	135.1	28.2	106.9
Combine	2,041	73.5	10.2	63.3
Country elevators:				
Volume handled	1,276	105.6	35.0	70.6
Volume exported	428	35.2	10.7	24.5
River elevators and inland subterminals	428	39.9	13.5	26.4
Export elevators	654	130.9	33.2	97.7
			Cents per bushel cleaned	
Farms				
Mechanical		10.0	2.1	7.9
Combine		3.6	0.5	3.1
Country elevators:				
Volume handled		8.3	2.7	5.5
Volume exported		8.2	2.5	5.7
River elevators and inland subterminals		9.3	3.2	6.2
Export elevators		20.0	5.1	14.9

[1] Additional cleaning involves the removal of FM from an initial level of 1.0 percent to a 0.5-percent target at the farm, from 1.5 percent to a 1.0-percent target at country and river/inland subterminal elevators, and from 2.0 percent to a 1.0-percent target at export elevators.
Source: Adapted from Hurburgh (1994).

The value of screening sales can offset about 43 percent of the weight loss from additional soybean cleaning under the lower bound scenario. On a per-bushel basis, additional cleaning of soybeans would generate 2.5 cents of screening sales value, which partially offsets a weight loss of 5.8 cents stemming from cleaning. Other benefits of soybean cleaning include *shrink* savings and transportation savings. Aggregate benefits, under the lower bound scenario, are estimated to total $35 million if all soybeans handled are cleaned, but decline to $11 million if cleaning is limited to exports.

Subterminal Elevators

Based on this analysis, river elevators and inland subterminals have been determined to be the least net-cost point of cleaning U.S. export soybeans. Net costs of additional cleaning of the export volume in 1991/92 are estimated to be $26 million under the lower bound cost scenario, which is smaller than the net costs of additional cleaning at farms, export elevators, and country elevators if cleaning applies to the entire volume handled.[25] The main reasons for river elevators and inland subterminals being the least net-cost location are: (1) additional cleaning can be limited to the export volume (684 million bushels), which is much smaller than the 2,041-million-bushel volume marketed by producers and handled by most country elevators, and (2) per-bushel cost of cleaning is lower than that at export elevators due to a smaller value of weight loss (tables 4 and 5).

The net cost of additional cleaning, under the lower bound cost scenario, is estimated to be 6.2 cents per bushel cleaned. Additional cleaning applies to all volume received at river elevators and inland

[25] During 1988-89, 42.9 percent of river elevators and 69.2 percent of subterminals reported using cleaners, compared with 50.4 percent for country elevators (Hill, Bender, Christy, Haas, and Anderson). The cost of additional cleaning allows for investment in cleaners needed to achieve the reduction in FM levels due to cleaning capacity constraints.

Table 5--Annual costs and domestic benefits of additional soybean cleaning: upper bound cost scenario[1]

Point of cleaning	Volume cleaned	Costs	Benefits	Net costs
	Million bushels		*Aggregate (million dollars)*	
Farms:				
Mechanical	2,041	381.7	36.8	344.9
Combine	2,041	73.5	10.2	63.3
Country elevators:				
Volume handled	2,041	242.8	58.3	184.5
Volume exported	684	81.3	18.5	62.8
River elevators and inland subterminals	684	99.2	23.0	76.2
Export elevators	684	143.7	34.7	109.0
			Cents per bushel cleaned	
Farms:				
Mechanical		18.7	1.8	16.9
Combine		3.6	0.5	3.1
Country elevators:				
Volume handled		11.9	2.9	9.0
Volume exported		11.9	2.7	9.2
River elevators and inland subterminals		14.5	3.4	11.1
Export elevators		21.0	5.1	15.9

[1] Additional cleaning involves the removal of FM from an initial level of 1.0 percent to a 0.5-percent target at the farm, from 1.5 percent to a 1.0-percent target at country and river/inland subterminal elevators, and from 2.0 percent to a 1.0-percent target at export elevators.
Source: Adapted from Hurburgh (1994).

subterminals, most of which is destined for export markets. River elevators are the major supplier of soybeans to export elevators, accounting for over 70 percent of total flow.

Export Elevators

Additional cleaning at export elevators, at minimum, would incur a total net cost of $98 million. The per-bushel cost of cleaning at this point, 14.9 cents per bushel, is the highest of all market points. This higher cost is due to the higher price of soybeans and resultant higher value of weight loss, higher costs of transporting screenings, and increased fixed cost associated with increased cleaning capacity required.

Revenue from sales of screenings is the only domestic benefit from additional cleaning at export elevators. Export elevators mostly sell screenings to processors for reblending into low-protein meal. Revenue from screening sales partially offsets the weight loss. Very few export elevators have to dispose of screenings as waste. No benefits from improved storability of cleaner soybeans is expected because soybeans are stored for only short periods at port facilities.

Distributional and Regional Impacts

Lowering the grade limits of FM in soybeans would likely have different effects on market participants, if changing the limits did not change the grade of soybeans purchased. However, if foreign buyers simply switch their imports from U.S. No. 2 to U.S. No. 3 and the FM limit for the latter were 2-percent maximum, then there would be virtually no change in the soybean FM level in either domestic or export markets.

The distributional effects of a change in markets, if any, would vary among producers and handlers. Some producers and elevators that produce or handle soybeans with a diverse FM distribution among the lots can meet a grade limit through blending without additional cleaning. However, meeting the grade limit through blending would become more difficult if the limit is set at a lower FM level, such as 0.5 percent for producers, and in some cases may be downright impossible. Also, blending may not produce net benefits to many producers or handlers. Overall, blending without cleaning will not alter the average FM level in U.S. export soybeans and will not be a viable option to meet reduced FM limits set in this study (Hurburgh, 1994). If FM limits in soybeans marketed are to be reduced, producers and interior elevators would have to supply cleaner soybeans to meet the lower limits or face the possibility of weight deduction and/or price discounts. Export elevators, on the other hand, would have to supply cleaner soybeans or accept prices for a lower quality grade.[26] Cleaner soybeans, because of their higher value in producing better-quality soymeal, would be priced higher than before if the marketplace adjusts its base price. However, soybeans that meet the present cleanliness standards but not the tighter standards, as defined in this study, would be subject to weight deduction and/or price discounts.

It is not known with certainty how the additional costs of cleaning would be distributed among market participants. The FM level in soybeans delivered by producers most likely would be lower because of the incentive for delivering cleaner soybeans and their interest in avoiding weight deduction which could begin at a FM level of above 0.5 percent. In contrast, the FM level in soybeans delivered by interior elevators would not change appreciably because the FM limit remains at 1 percent. Meeting the target cleanliness standards, however, would have more apparent, direct effects on export elevators vis-a-vis interior elevators and producers because of the lower FM limit of 1 percent. Exporters would have to remove nearly an additional 1-percentage point FM from the soybeans received from river elevators and inland subterminals if foreign buyers retain U.S. No. 2 as their base grade. This will generate about 8-9 million bushels of screenings at export ports, and would have a net cost, at minimum, of 14.9 cents per bushel cleaned (table 4). The additional cleaning cost would eventually be passed back to interior elevators and producers, or added to tender offers. If the former turned out to be the case, more impact would be felt in regions, such as the South, where there is less crusher competition for beans and FM is higher. On contrary, the effect of meeting the tighter FM standards on export elevators would be less apparent, or even negligible, if foreign buyers compensate for the cost of additional cleaning or simply switch their purchases from U.S. No. 2 to a lower grade soybean, such as U.S. No. 3.

Marketing cleaner soybeans would affect relative prices received by different producers if the marketplace adjusts its base price. Currently, producers selling soybeans with less than 1-percent FM are not being compensated for lower FM content. However, if the FM limit for U.S. No. 1 soybeans were lowered from the current 1 percent to 0.5 percent, these producers might be compensated partially with higher prices than they currently receive. This group of producers include 128 respondents who currently deliver soybeans with less than 0.5-percent FM, accounting for nearly a third of all 403 respondents who answered the question about FM. In addition, it also includes the additional 28 respondents, about 11 percent of the respondents who currently deliver soybeans with more than 0.5 percent FM, but could deliver clean soybeans with less than 0.5 percent FM at little additional cost. Thus, 156 (128 + 28) of the total 403 respondents to the voluntary on-farm survey, who are not currently compensated by the marketplace for selling clean soybeans, would be paid higher prices for selling cleaner soybeans under the tighter cleanliness standards, if purchasers maintained the current grades of their purchases.[27]

In contrast, producers delivering soybeans with FM levels of more than 0.5 percent would likely continue to be penalized through weight deduction except that the penalty (weight deduction) under the new cleanliness standard would be more stiff due to a higher base price. Thus, marketing cleaner soybeans might result in a greater price penalty for high-FM soybeans to farmers.

Producers in various regions would also be affected differently. In general, soybean producers in the Corn Belt region would be less affected by lower FM limits because this region exhibits the lowest average FM

[26] However, this assumes foreign buyers will not shift their purchases from the current U.S. No. 2 base grade to U.S. No. 3 once the FM limit is lowered from the current 2 percent to 1 percent for U.S. No. 2. Due to price considerations, it is possible that foreign buyers might continue to purchase U.S. No. 2 soybeans with the exception that the FM limit is specified at 2 percent, the new limit for U.S. No. 3, in their contracts.

[27] The increase in base price could be tempered somewhat if the marketplace adjusts its base price and other producers respond to this new-found incentive by supplying low-FM soybeans.

level (1.3 percent) at harvest. Producers who currently deliver soybeans with FM levels between 0.5 and 1.0 percent are not penalized by weight deduction, but could under the tighter cleanliness standards if the marketplace adjusts its base price. These producers are likely those in the Corn Belt, because not many producers in the South (including Delta States, Appalachian, Southeast, and Southern Plains) harvest soybeans with FM levels less than 1 percent. In contrast, producers in the South would be most adversely affected because the average FM level is the highest in this region.

While the South accounts for about nearly 20 percent of U.S. soybean production, this region would likely bear a larger share of the net cost of cleaning if additional cleaning occurs at the farm level simply because of the high FM level in this region. The South would bear a disproportionate share of the net cost of cleaning even more because this region altogether accounted for about 35 percent of U.S. soybean exports (based on 1985 grain flow survey, the latest year data are available) (Larson, Smith, and Baldwin) despite its 15-percent average share of U.S. production during 1993-95. In 1985/86, the South exported 48 percent of its soybean production, compared with 26 percent for the Corn Belt. Thus, additional cleaning could impose an additional burden on producers in the South who, in general, already have higher costs of soybean production than producers in the Corn Belt. In addition, producers in the South would be penalized by higher price discounts.

Although all regions would feel a change in foreign buyers' FM levels, the impact of cleaner soybeans on port elevators would critically depend on the responses of foreign buyers. If foreign buyers retain U.S. No. 2 as their base grade, export elevators that supply countries with contract specifications for cleaner soybeans would incur higher cleaning costs than elevators exporting to countries with less demand for cleaner soybeans. Otherwise, there would be virtually no effect.

Conclusions

There is no basis for mandatory additional cleaning of soybeans in the United States unless benefits from selling cleaner soybeans in the international market, at minimum, exceed the $26-million annual net cost of cleaning at the least net-cost locations, river elevators and inland subterminals. However, a companion report concludes that international market benefits would not exceed the domestic net cost. Cleaning is more economical at river elevators and inland subterminals because elevators there can identify export soybeans and thus have a smaller cleaning volume than farms or country elevators, and have a much smaller value of weight loss than export elevators.

The costs and benefits of additional soybean cleaning may be quite different for individual commercial elevators because of differences in elevators' size, location, and the FM level in soybeans handled. Depending on the practices of the elevator, the costs and the benefits for a specific elevator may be greater or less than the ones indicated in this report.

Lowering the grade limits for FM in soybeans would likely have different effects on market participants. If the marketplace adjusts its base price, marketing cleaner soybeans might result in a greater price differential for low-FM soybeans to farmers. Soybean producers in the Corn Belt region, in general, would be less affected by lower FM limits. In contrast, producers in the South would be most adversely affected because the average FM level is the highest in this region.

Changing the grade limit itself may not necessarily result in additional cleaning, depending on whether foreign buyers switch the grade of soybeans purchased or not. Contract specifications would ultimately determine whether additional cleaning follows a reduction in the grade limit for FM. If foreign buyers retain U.S. No. 2 as their base grade, export elevators may have to supply cleaner soybeans or receive prices of a lower quality grade. However, if foreign buyers simply switch their imports from U.S. No. 2 to U.S. No. 3, then there would be virtually no change in the extent of soybean cleaning and in the soybean FM level in either domestic or export markets.

Because plant parts, broken beans, and weed seeds are the main components of soybean FM, changing production and harvesting practices offers more potential than mechanical cleaning to lower FM in soybeans harvested. One strategy to address the soybean cleanliness issue is to create incentives for producers to alter production and harvesting practices. However, there would be costs and benefits from this alternative also, which have yet to be fully evaluated.

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Glossary

Aeration—The passage of air through the grain mass to control the adverse effects of excessive moisture, temperature, and humidity. This is usually done by forcing air through the grain mass with fans.

Aspirator—A device that draws a column of high-velocity air across a flowing grain stream to separate low-density materials from the grain kernels. The air pressure is based on the weight of the grain. An aspirator can operate at a higher throughput capacity than screen cleaners but may result in a higher soybean loss. Aspirators are generally used to remove low density materials such as stems, weed seeds, chaff, and dead insects.

Blending—The systematic combining of two or more lots of grains with different characteristics to obtain a uniform mixture of a desired specification.

Breakage susceptibility—The probability that a given soybean kernel will crack during handling. It has been scientifically established that breakage susceptibility is lower for kernels of soybeans than for corn kernels.

Cleanliness—The level of foreign material in soybeans.

Crop rotation—A system of growing different kinds of crops in recurrent succession on the same land. Farmers plant crops in rotations as farm management practice to reduce costs and increase production. Different crop sequences can alter the soil fertility, the susceptibility of the crop to insects and disease, and likelihood of soil erosion.

Damaged kernels—Soybeans and pieces of soybeans which are badly ground-damaged, badly weather-damaged, diseased, frost-damaged, heat-damaged, insect-bored, mold-damaged, stinkbug-stung, or otherwise materially damaged.

Discount—Reductions from the base price offered for grain. Generally calculated for factors that lower the value of the grain. May be expressed as a percentage of the price or as a fixed amount per bushel. Discounts serve as disincentive for selling grain below the quality of the base grade.

Fines—The materials obtained from passing soybeans over a sieve of a size smaller than the kernels; the small particles passing through the sieve, either in an inspection procedure or in a commercial cleaning operation.

Foreign material (FM)—All matter, including soybeans and pieces of soybeans, that pass readily through an 8/64-inch, round-hole sieve and all matter other than soybeans (including splits) that remain on top of the sieve.

Free fatty acids (FFA)—The uncombined fatty acids (not in a triglyceride) present in a fat or oil which are indicative of damage to a soybean seed. Excess free fatty acids lower the quality of the crude and refined oil and reduce the product yield.

Grade—A number designation assigned to grain based on a pre-established set of criteria.

Grain grades and standards—Specific standards established for each grain that describe the physical characteristics of different lots. The grades and standards facilitate trade by permitting the purchase of grain without the need for visual inspection and testing by the buyer.

Heat-damaged kernels—Soybeans and pieces of soybeans which are materially discolored and damaged by heat.

Hilum—The eye of a soybean seed, located at the central point of the bean.

Identity preservation—Segregation of a commodity from one point to the next in the marketing system. The initially identified commodity is delivered to the next point in the marketing system without being mixed with other units of the same commodity during handling and shipment.

Intrinsic value—Characteristics critical to the end-use of grains and soybeans. These are nonvisual and can only be determined by analytical tests. For example, the intrinsic quality of soybeans is determined by characteristics such as protein, oil, and free fatty acid.

Moisture—The water content of grain as determined by an approved electronic moisture meter. The percentage of moisture in a sample does not affect the numerical grade.

Neutral oil loss—Loss occurs after removing the unsaponifiable material (oil soluble material that cannot be saponified by the usual caustic treatment, including higher aliphatic alcohols, sterols, pigments, and hydrocarbons) and free fatty acids from natural fats and oils consisting essentially of triglycerides and unsaponifiable material.

Nongrade-determining factors—Factors that influence the quality of grain, and must be reported as information whenever an official inspection is made. However, they are not used in determining the numerical grade. Moisture, protein, and oil content are examples.

Pericarp—The covering of a seed that is derived from the ovary wall.

Premium—Increases from the base price offered for grain of higher quality characteristics than specified for the base grade. Generally calculated for factors that increase the value of the grain.

Screen cleaner—A series of angled perforated plates or wire screens that separate the grain from particles that are larger or smaller than the grain kernel. The screens may be stationary, shaken, or rotated. The screen cleaner removes FM in soybeans on the basis of particle size. The screens may differ, but screen cleaners are generally used to remove large particles.

Screenings—The material removed from soybeans by means of mechanical devices. Generally include splits, broken beans as well as nongrain material removed on the basis of density or particle size.

Shrink—The loss of volume or weight that occurs during drying or as a result of fermentation and bacterial action.

Soybeans of other colors—Soybeans which have green, black, brown, or bicolored seed coats. Before September 9, 1985, this factor was called "brown, black, and/or bicolored soybeans in yellow or green soybeans."

Splits—Soybeans with more than one-fourth of the bean removed and which are not damaged.

Subterminal elevator—A grain elevator that receives much of its grain from other elevators. Subterminal elevators act as intermediaries between country elevators, export elevators, and/or domestic processors. Subterminal elevators tend to handle a larger volume of grain than country elevators, but this is not always the case.

Test weight—Pounds of grain per Winchester bushel. A measure of grain density determined by weighing the quantity of grain required to fill a 1-quart container and converting this to a bushel equivalent.

Weight loss—The loss of revenue from the removal of splits, FM, and sound soybeans from the soybeans during the cleaning process.

Appendix A: Premiums and Discounts

Grain buyers use premiums and discounts to convey their demands for quality. Surveys indicate that premiums are seldom used in the marketplace to encourage the delivery of soybeans with FM contents below the base level—1 percent for U.S. No. 1 in domestic markets and 2 percent for U.S. No. 2 for export markets. In contrast, buyers often apply discounts against soybean sales with FM levels exceeding the base levels. The most common form of discounts against FM in soybeans is weight deduction where the weight of FM content is deducted from the gross weight before the payment is made to the seller. In general, buyers do not begin the weight deduction until FM in soybeans exceeds 1 percent in domestic markets. Other discounts include price discounts (in combination with or in lieu of weight deduction) charged to producers and price discounts over and above the weight deduction charged to commercial elevators.

Weight deduction is the predominant form of discounts received by producers. Of the producers responding to the 1991 on-farm survey conducted by the University of Illinois and delivering soybeans with a FM level of greater than 1 percent, 73 percent of them received weight deductions against FM in soybeans, with the deduction to begin at 1.1 percent. An additional 19 percent reported that buyers discounted soybean prices in lieu of weight deduction. The remaining 8 percent of producers were forgiven because elevators did not apply either weight deductions or price discounts.

Producers charged with price discounts by buyers were penalized less than those receiving weight deductions for selling high-FM soybeans. The former were forgiven for selling soybeans with FM levels between 1.1 and 2.0 percent (appendix table 1), while the latter were subject to weight deductions. If soybeans were priced at $6.00 per bushel, a producer who delivered soybeans with 2.1-percent FM would receive 6.6 cents discount per bushel under the weight deduction, but would be charged a 1.0-cent per bushel discount under the price discount.

Producers received lower price discounts from their buyers than did commercial elevators (appendix table 2). Country elevators, which purchase about 80 percent of the soybeans sold by producers, most often deduct FM content from the gross weight. They sometimes charge lower discounts to producers for high FM soybeans through price discounts (in lieu of weight deduction) and, in some cases, even forgive producers for selling high-FM soybeans to maintain their business volume. This is because of the competitive market structure at the country elevator level. Blending soybeans with different FM contents at

Appendix table 1--Average price discounts received by producers (in lieu of weight deduction)

FM level	Discount
Percent	*Cents/bushel*
1.1-2.0	0
2.1-3.0	1.0
3.1-4.0	1.3
Above 4.0	1.4

Source: Economic Research Service/USDA.

this market point makes this discounting practice possible.

In contrast, country elevators often receive not only weight deductions if FM content in soybeans exceeds 1 percent, but also price discounts over and above the weight deduction. According to the NGFA commercial elevator survey, the average discount for FM increases as the FM content increases and decreases as the beans move through the marketing system. A graduated discount schedule reflects the reduced value of soybeans containing greater levels of nonsoybean material (Hyberg, Ash, and Just). Since soybeans are traded mostly on a U.S. No. 2 basis for export markets, which have a 2-percent FM limit instead of the 1-percent limit for domestic sales, export elevators incur lower costs of meeting this standard than country elevators, permitting them to charge lower price discounts to river elevators and inland subterminals.

Appendix table 2--Average price discounts received by elevators (above weight deduction)

FM level	Discount
Percent	*Cents/bushel*
1.1-2.0	0.15
2.1-3.0	0.23
3.1-4.0	0.39
4.1-5.0	0.56
Above 5.0	1.41

Source: Economic Research Service/USDA.

Discounts differ by region. The discounts at commercial elevators are highest in the Plains States, ranging from 0.6 cent per bushel at 1-2 percent FM, up to 3.4 cents per bushel at FM levels above 5 percent.[28] Elevators in the South where the FM is highest have an average discount below 0.15 cent per bushel. Elevators in the Corn Belt reported price discounts ranging from 0.1 cent to 1.5 cents per bushel.

[28]The Plains States include North Dakota, South Dakota, Kansas, Nebraska, Oklahoma, and Texas.

Appendix B: On-Farm Survey

Dear Wheat Grower:

The 1990 Farm Bill calls for a comprehensive study of the cost and benefit of additional cleaning of various grains. Your prompt response is vital for achieving a timely, precise, and representative profile of conditions that affect on-farm grain cleaning. We ask that you complete the survey no later than **May 15, 1991.** Please type or print legibly all responses in the spaces provided. If precise information is not available, your best estimate is preferable to no response. Return the postcard to: c/o Lowell Hill, 306 Mumford Hall, 1301 W. Gregory Drive, Urbana, IL 61801.

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1. What was your 1990 **production** for each of the following grains (*in bushels*)?

Wheat					Corn	Soybeans	Sorghum	Barley
HRW	SRW	HRS	Durum	White				

2. Estimate the average **factor levels** for the following grain(s) that you harvest:

Wheat__________% dockage __________%FM
Corn__________% broken kernels & foreign material (BCFM)
Soybeans __________%FM
Sorghum__________% broken kernels & foreign material(BNFM)
Feed barley__________% dockage __________%FM
Malting barley__________% dockage __________% thins __________%FM

3. Could you deliver cleaner grain (at no or little additional cost) **by changing your harvesting and handling practices?** Yes __ No __
If yes, then what **factor levels** for the following grains could you deliver?

Wheat: dockage_____% and foreign material____%
Corn: broken corn and foreign material ____%
Soybeans: foreign material _____%
Sorghum: broken kernels and foreign material_____%
Malting barley: dockage _____% and foreign material ____%
Feed barley: dockage ______% and foreign material _____%

4. Does your farm have **cleaners** (excluding combine attachments)? Yes __ No __
If yes, do you currently clean grain (excluding for seed)? Yes ___ No __

5. **Your name:** ____________________
Address: ____________________
____

On-Farm Cleaning Survey (Long-Form)

1. Please indicate the importance of the following reasons for cleaning soybeans given each reason a score of: 1= Great importance, 2= Some importance, or 3= Little importance.

Reasons	Score 1, 2, or 3
To improve grade or avoid discounts	
To increase storability	
To reduce insect problems	
To increase dryer or aeration efficiency	
To obtain screenings as a feed or sell	
Other (specify)	

2. On average, over the past few years, what percent of your total soybean crop did you clean? ____%.

3. List number of cleaners by type and the age and cleaning capacity for each unit:

Type of cleaner	Number	Age	Estimated capacity
Rotary		years	bu/hr
Screen in auger		years	bu/hr
Other (specify)		years	bu/hr

4. How much foreign material do you usually clean from soybeans? ____% points.

5. Can you reduce the level of FM in your soybeans by changing (check all that apply):
_____ (a) production practices such as better weed control.
_____ (b) harvesting and handling practices such as combine setting.
_____ (c) additional cleaning.

6. (a) Estimate the cost (in cents/bu) to reduce FM by the following percentage points by changing production practices:

0.1-0.5%	0.6-1.0%	1.1-1.5%	1.6-2.0%	Over 2%
¢/bu	¢/bu	¢/bu	¢/bu	¢/bu

(b) Estimate the cost (in cents/bu) to reduce FM by the following percentage points by altering harvesting and handling practices:

0.1-0.5%	0.6-1.0%	1.1-1.5%	1.6-2.0%	Over 2%
¢/bu	¢/bu	¢/bu	¢/bu	¢/bu

7. (a) Estimate the operating cost required to clean a bushel of soybeans with your cleaner. _____ cents/bu.

(b) With average (normal) crop quality, what percentage of the total weight is removed by one pass through your cleaner? ____%.

8. Estimate the quantity of screenings removed from soybeans in 1990? _____ tons.

How were the screenings used?	Percent	Estimated value or disposal cost: $/ton
Fed to your livestock	%	$
Sold to other feeders	%	$
Sold to commercial firms	%	$
Disposed as waste	%	$
Other (specify)	%	$

9. (a) What percent of your soybean sales in 1990 were discounted for FM? _____%.
(b) What is the usual method of adjusting for excess FM in your area?
_____ (1) Buyer did not deduct for FM.
_____ (2) FM in my soybeans was always below the base level.
_____ (3) Buyer subtracted weight for FM above ___%.
_____ (4) Discount the price.
(c) List any discounts from the base grade (in ¢/bu) that are routinely used by buyers of your soybeans for the following levels of FM:

0.1-1.0%	1.1-2.0%	2.1-3.0%	3.1-4.0%	Above 4.0%
¢/bu	¢/bu	¢/bu	¢/bu	¢/bu

(d) Will any buyers in this area pay premiums for grain with FM below the base level? Yes ___ No ___ If yes, ____ cents/bu below ____%.

10. It has been suggested that cleaner soybeans might increase exports. Which of the following methods would you like to see implemented? How effective do you think each method will be in reducing FM? Rating: 1= Very effective, 2= Limited effect or 3= No improvement.

Methods	Yes or No	Score 1, 2, or 3
Better weed and insect control in the field		
Better harvesting practices, combine adjustments		
More cleaning on the farm		
More cleaning by elevators		
Larger discounts for foreign material		
Offer more premiums for cleaner grain		
Other (specify)		

Please respond to the questionnaires for corn, wheat, sorghum, and barley if any crop accounts for over 10% of your farm's total grains and oilseeds production.

Appendix C: Survey of Commercial Elevator Grain Cleaning Facilities

PART I: General Questions

1. Name of firm, address and telephone:

Name of firm:
Address:
Telephone: ( )

2. Check the term that best describes your business operation:

Elevator* (*see below*)			
Country	Inland terminal	River	Export

3. What is the average annual volume of grain moved through this elevator? (Bu.)

All wheat	Corn	Soybeans	Sorghum	Barley

4. What is this elevator's loadout capacity? (*bushels/hour*)

Truck	Rail	Barge	Ocean vessel

5. Does this elevator have cleaners? (*check one*) . . . . . Yes ___ No ___

If yes, what type of cleaner(s) do you have? (*list all units below*)

Manufacturer	Model	Year installed	Actual throughput capacity (bu/hr)	Type of grain(s) cleaned

6. (a) Can you install or retrofit additional cleaning capacity within the present available space? (*check one*) Yes ___ No ___

(b) If yes, how much additional capacity can be installed or added? _____ bu/hr.

(c) Estimate how much the additional capacity would cost you (*check one*)

Less than $100,000	$100,000 to $500,000	Over $500,000

Please complete the following commodity-specific questionnaires for winter wheat, spring wheat, corn, soybeans, sorghum, and barley for each commodity that accounts for at least 10 percent of your entire operation

*Country elevator is defined as one which receives over 50 percent of its grain from farmers, while inland terminal receives over 50 percent of its grain from other elevators.

PART II: Soybean-Specific --1

1. Percent of soybeans received annually from:

Farmers %	Other elevators %

2. Estimate the average foreign material of inbound soybeans: ____%

3. Do buyers of your soybeans deduct FM over 1 percent from gross weight (Processor's Discount Schedule No. 1)? (*Check one*)
Yes ______ No _____

4. Besides the FM weight deduction, what discounts (*in cents/bushel*) do buyers of the base grade of soybeans routinely charge for the following levels of foreign material?

1-2%	2-3%	3-4%	4-5%	Over 5%

5. What premiums (*in cents/bushel*) do buyers of the base grade of soybeans routinely offer for the following levels of foreign material?

0.0-0.5%	0.5-1.0%	1.0-1.5%	1.5-2.0%

6. What percent of stored grain is treated with these protectants:
Malathion ____% or Reldan ____% or other (*specify*) ______________%

7. (a) How often are stored beans fumigated? __________ times/year
(b) If applicable, estimate the cost per fumigation: ______ cents/bushel

8. Do you have aeration equipment in storage bins? (*check one*) Yes ___ No ___
How often are stored beans turned for conditioning? _____ times/year

9. Do you clean soybeans that you handle? Yes ____ No ____
(*If yes, skip to #11*)

10. If No for #9, what are the major reasons for not cleaning?	Rank (*1= Great importance, 2= Some, 3= Little*)
Insufficient market for screenings	
Insufficient premium for cleaned beans	
Equipment investment too costly	
Difficulty in handling screenings	
Inadequate storage for screenings	
Time constraints	
Other (*specify*)	

Answer the remaining questions only if you clean soybeans in most recent years.

PART II: Soybean-Specific --2

11. What reasons do you clean your soybeans?	Rank (*1= Great importance, 2= Some, 3= Little*)
Grade improvement or avoid discount	
Increase storability	
Reduce moisture problems	
Reduce insect problems	
Increase dryer or aeration efficiency	
Maintain or increase export share	
Meet contract specification	
Other (*specify*)	

12. What is the average percentage of soybeans cleaned annually? ________ %

13. How much FM is usually removed from soybeans? __________ percentage points

14. (a) Estimate the normal cost to clean out the FM in #14 (***includes energy, wages, and interest on working capital but excludes lost beans***): ________ ¢/bu.
    (b) Estimate what it would cost (*in cents/bu.*) to reduce FM by the following levels:

0.0-0.5%	0.5-1.0%	1.0-1.5%	1.5-2.0%	Over 2%
¢/bu.	¢/bu.	¢/bu.	¢/bu.	¢/bu.

15. When are soybeans usually cleaned? (Percent)

at receiving %	during storage or turning %	at loadout %

16. How much soybean screenings were produced in 1990? _________ tons (*2,000 lbs.*)

17. How were your 1990 soybean screenings used?	Percent	Estimated sales value or disposal cost ($/ton)
Sold to feed market	%	$
Used in your own feed mill	%	$
Disposed as waste	%	$
Other (*specify*)	%	$

18. Estimate the average distance screenings sold were hauled: _____ miles

PART II: Soybean-Specific --3

19. What is the average capacity available for screenings? ______tons

20. Describe any regulatory or legal restrictions on disposing screenings: ____

____

21. (a) Is there equipment to pellet screenings at this elevator? Yes ___ No ___
 (b) If Yes, what percent of screenings were pelleted? ____%

22. When are screenings sold?

Please fill in the following monthly price and sales information for 1990. If you know the price (even if no screenings were sold that month) please report it.

Month	Price ($/ton)	Percent of 1990 sales
January	$	%
February	$	%
March	$	%
April	$	%
May	$	%
June	$	%
July	$	%
August	$	%
September	$	%
October	$	%
November	$	%
December	$	%
1990		100%

Thank you for your conscientious effort in completing this confidential survey.

Appendix D: Unit-Cost of Operating a Grain Cleaner

Operating a grain cleaner incurs both fixed and variable costs. Fixed costs include depreciation, interest expense, taxes, and insurance. The variable costs are those that are incurred only when the cleaner is in operation. These costs include labor, power, and maintenance.

The per-bushel cost of operating a cleaner tends to increase as the volume of soybeans cleaned decreases. Like corn cleaning, fixed costs account for the bulk of the cost of operating a grain elevator. Depreciation is the largest component cost.

On-Farm

As shown in appendix table 3, the cost of operating a grain cleaner was estimated based on a rotary cleaner with a rated capacity of 2,500 bushels per hour, which costs $5,280 to install (which includes acquisition costs). The volume of soybeans cleaned is assumed to be 50,000 bushels per year.[29] The depreciation estimates were based on a 10-percent interest rate, assuming a 10-year useful lifetime for the cleaner.

[29] Estimates of fixed costs recognize that the same cleaner may be used for corn cleaning.

Appendix table 3--Cost per bushel of operating a grain cleaner on-farm and at country elevators[1]

Cost	On-farm	Country elevator
	Cents per bushel	
Fixed costs:		
Depreciation and interest	1.3	0.4
Insurance and others	0.4	0.1
Average fixed costs	1.7	0.5
Variable costs:		
Labor	0.2	0.2
Energy	0.03	0.01
Repairs	0.2	0.1
Average variable costs	0.4	0.3
Average operating costs	2.1	0.8

[1]Costs are indicated for cleaning to the 0.5-percent FM level on farm and to the 1.0- percent FM level at country elevators.
Source: Adapted from Hurburgh (1994).

Interest on investment was 10 percent times the average remaining balance over the projected cleaner's lifetime. Insurance and miscellaneous expenses were assumed to be 4 percent of the capital investment or $210. Variable costs include labor, energy, repairs and maintenance. It is estimated that an operator's supervision is required for 50 percent of the time the cleaner is in operation. The labor rate was assumed to be $7.50 per hour. Energy costs were based on a rate of 7 cents per kilowatt-hour, which translate into 0.03 cent per bushel cleaned. Repairs and maintenance were assumed to cost 5 percent of the initial purchase price.

The cost of operating a grain cleaner is estimated to be 2.1 cents per bushel, of which about 80 percent are fixed costs, mainly depreciation. The largest components of variable costs were labor and repairs. The energy requirement was the smallest cost component of variable costs, at 0.03 cent per bushel.

Country Elevator

The cost of operating a grain cleaner at country elevators was estimated based on a cleaner with a rated capacity of 10,000 bushels per hour, which costs $40,000 to install (which includes acquisition cost). The volume of soybeans cleaned is assumed to be 1 million bushels per year.

The fixed cost of cleaning soybeans at country elevators accounted for nearly two-thirds of the 0.8-cent total cost. As on the farm, the largest cost component of the fixed costs was depreciation expense, accounting for 80 percent of the average fixed cost. Unlike the farm, no operator's supervision is required to run the cleaner. Labor, however, is required to maintain and fix the cleaner.

Subterminals and Export Elevators

Cleaning soybeans at subterminals and export elevators may require higher initial capital and installation costs. The cost of operating the cleaner would be similar to the 1-million-bushel case for the country elevator. With even greater volumes cleaned, the unit-cost of cleaning may decrease.

Appendix E: Aggregate Costs and Benefits

The costs and benefits of delivering cleaner soybeans were calculated at four points in the marketing channel: farms, country elevators, river elevators and inland subterminals, and export elevators. We assumed that additional soybean cleaning would require producers to reduce FM levels to 0.5 percent, and country elevators, river elevators as well as inland subterminals, and export elevators to lower FM to 1 percent. The costs and benefits of additional cleaning are estimated under both the lower bound and upper bound cost scenarios.

The cost and benefit analysis also assumed that additional cleaning would apply to all soybeans marketed by producers at the farm because they cannot differentiate domestic from export sales. Additional cleaning at country elevators includes two cases: (1) cleaning the volume of soybeans received (1.3 billion bushels under the lower bound cost and 2.0 billion bushels under the upper bound cost), and (2) cleaning a volume equivalent to U.S. exports (654 million bushels under the lower bound cost and 684 million bushels under the upper bound cost). The first case is more realistic for country elevators where the destination of the soybean shipments after handling is not known with certainty. The second case assumes country elevators have perfect knowledge of the destination of their soybean shipments. Additional cleaning at river elevators and inland subterminals applies to the volume received, most of which would be destined for export markets.

The costs and benefits of cleaning soybeans were partially based on estimates made by Hurburgh under the upper bound cost scenario, but an entirely different approach is selected for measuring the costs and benefits under the lower bound cost scenario. Details are discussed in the Methodology section of this report.

Costs

The largest cost component for all locations was the value of weight loss, accounting for two-thirds of total additional costs of cleaning or higher (appendix tables 4 and 5). For a given volume of soybeans to be

Appendix table 4--Aggregate costs and benefits of additional soybean cleaning (lower bound), 1991[1]

Cost or benefit	Farm[2]	Elevator: Country[3] (volume handled)	Elevator: Country[3] (volume exported)	Elevator: River and inland subterminal[3]	Elevator: Export[4]
			Million dollars		
Additional costs:					
Value of weight loss	88.7	74.0	24.6	30.6	121.7
Cost of operating cleaner	44.0	26.9	9.0	7.7	5.7
Transportation of screenings	2.4	4.7	1.6	1.6	3.5
Total additional costs	135.1	105.6	35.2	39.9	130.9
Additional benefits:					
Value of screenings	17.1	31.8	10.7	13.5	33.2
Improved storability	11.1	3.2	NA	NA	NA
Total additional benefits	28.2	35.0	10.7	13.5	33.2
Additional net costs	106.9	70.6	24.5	26.4	97.7

NA = Not applicable.
[1]Assuming volume of soybeans marketed by producers or volume of soybeans handled by inland subterminal, river, and export elevators. Costs and benefits of cleaning all soybeans handled and only export soybeans are presented for country elevators. No segregation cost was calculated. [2]Cleaning from an average of 1-percent FM to 0.5-percent FM; farmers were assumed to clean all soybeans marketed because domestic and export sales cannot be differentiated. [3]Cleaning from an average of 1.5-percent FM to 1-percent FM. [4]Cleaning from an average of 2-percent FM to 1-percent FM. Source: Adapted from Hurburgh (1994).

cleaned, export elevators had the highest value of weight loss because prices received for soybeans at export elevators generally are higher than at any other location and FM content is higher.

Under the lower bound scenario, the value of weight losses was estimated by multiplying the price of soybeans by the volume of screenings removed that can be legitimately considered as weight loss. The price of soybeans varies by market point (appendix table 6). Soybean prices at the farm and country elevators were assumed to be $6.00 per bushel, slightly higher than the $5.58 average price received by producers for the 1991/92 marketing year. Export port prices were FOB (free on board) New Orleans. Screenings removed were estimated to be 2.8 percent of soybeans cleaned on farms, 1.8 percent at country elevators, 2.2 percent at river elevators and inland subterminals, and 3.1 percent at export elevators.

The cost of operating cleaners, under the lower bound scenario, was the highest on farms assuming all soybeans marketed were cleaned ($44.0 million). The average costs of operating cleaners to reduce the FM level to the targeted level for producers and elevators, within the FM range in the Hurburgh study, were taken from an economic-engineering model for soybean cleaning (Hurburgh, 1994). Costs of operating cleaners outside the FM range in the Hurburgh study are based on the on-farm and NGFA elevator surveys. Costs shown in appendix tables 4 and 5 reflect those of additional cleaning from the current level to the targeted, lower FM level. All screenings were assumed to be marketed soon after cleaning, and thus required no storage. Transport costs of screenings were assumed to average 0.6 cent per bushel cleaned on farms and 0.4 cent at country elevators (Hurburgh, 1994).

Benefits

Revenues received from screening sales, which partially offset weight loss, were the largest benefit for soybean cleaning on farms and at country elevators if

Appendix table 5--Aggregate costs and benefits of additional soybean cleaning (upper bound), 1991[1]

Cost or benefit	Farm[2]	Elevator			
		Country[3] (volume handled)	Country[3] (volume exported)	River and inland subterminal[3]	Export[4]
	Million dollars				
Additional costs:					
Value of weight loss	342.9	220.4	73.9	91.8	135.1
Cost of operating cleaner	36.7	14.3	4.7	4.7	4.9
Transportation of screenings	2.1	8.1	2.7	2.7	3.7
Total additional costs	381.7	242.8	81.3	99.2	143.7
Additional benefits:					
Value of screenings	25.7	55.1	18.5	23.0	34.7
Improved storability	11.1	3.2	NA	NA	NA
Total additional benefits	36.8	58.3	18.5	23.0	34.7
Additional net costs	344.9	184.5	62.8	76.2	109.0

NA = Not applicable.
[1]Assuming volume of soybeans marketed by producers or volume of soybeans handled by inland subterminal, river, and export elevators. Costs and benefits of cleaning all soybeans handled and only export soybeans are presented for country elevators. No segregation cost was calculated. [2]Cleaning from an average of 1-percent FM to 0.5-percent FM; farmers were assumed to clean all soybeans marketed because domestic and export sales cannot be differentiated. [3]Cleaning from an average of 1.5-percent FM to 1-percent FM. [4]Cleaning from an average of 2-percent FM to 1-percent FM.
Source: Adapted from Hurburgh (1994).

Appendix table 6--Parameters used in calculating cleaning costs and benefits

Parameter	Location	Unit	Value
Price of soybeans	Farm	$/bu	6.00
	Country elevator	Do.	6.00
	River elevator and subterminal	Do.	6.10
	Export elevator	Do.	6.37
Price of screenings	Farm	$/ton	49
	Country elevator	Do.	50
	River elevator and subterminal	Do.	51
	Export elevator	Do.	57
Cost of operating cleaner	Farm	Cents/bu.	2.1
	Country elevator	Do.	0.8
	River elevator and subterminal	Do.	0.8
	Export elevator	Do.	0.8
Cost of storing screenings	All locations	Do.	0
Length of screenings storage	All locations	Month	0
Length of soybean storage	All locations	Months	6
Level of FM	Farm	Percent	0.5
	Country elevator	Do.	1.0
	River elevator and subterminal	Do.	1.0
	Export elevator	Do.	1.0
Value of improved storability	Farm	Cents/bu.	1.9
	Country elevator	Do.	0.8
Volume of soybeans cleaned	Farm	Billion bu.	2.04
	Country elevator	Do.	2.04
	River elevator and subterminal	Do.	0.68
	Export elevator	Do.	0.68

Source: Hurburgh (1994).

all soybeans received are cleaned. Under the lower bound scenario, the value of screening sales offset 19 percent of the weight loss on farms and 27-44 percent at elevators, depending on the location of cleaning.

Revenues from sales of screenings were estimated by multiplying screenings removed by screening prices at each location. According to the NGFA commercial elevator survey, screening prices averaged about $56 per ton in 1991 (Hyberg, Ash, and Just). With additional cleaning, screening prices would likely decline due to an increase in the supply of screenings. Based on nutrient value and transport cost, screening prices were estimated to fall to nearly 60 percent of corn prices at all locations.

Improved storability is the second most important reason for cleaning soybeans at the farm and country elevators. This benefit totaled $11.1 million at the farm and $3.2 million at country elevators if cleaning applies to the total volume handled. These benefits included savings on shrink, aeration, and spoilage, and were derived under the assumption that soybeans would be stored for 6 months after harvest. No appreciable benefit from improved storability would occur if additional cleaning at country elevators was applied to the volume exported because it was assumed that cleaning would apply only to outbound shipments. Benefits from improved storability were not applicable to export elevators because the soybeans cleaned are only stored temporarily at these locations.

The benefits from improved storability were based on the economic-engineering study of soybean cleaning developed by Hurburgh (1994). These benefits were calculated to be 1.9 cents per bushel stored when the FM content was reduced by 0.5 percentage point from 1-percent to 0.5-percent FM at the farm and when soybeans were stored for 6 months following harvest. At the country elevator, it was estimated that reducing the FM level by an additional 0.5 percentage point from 1.5-percent to 1.0-percent FM would result in benefits from improved storability at 0.8 cent per bushel.