# French Quality and Eco-labeling Schemes: Do They Also Benefit the Environment?

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Thomas L. Dobbs, Geneviève Nguyen, Sherry K. Bertramsen, and Bruno Legagneux

**Thomas Dobbs, the contact author, can be reached at**:

Economics Department
Box 504 Scobey Hall
South Dakota State University
Brookings, South Dakota 57007-0895
U.S.
e-mail: Thomas_Dobbs@sdstate.edu

**Geneviève Nguyen and Bruno Legagneux are at:**

INP - École Nationale Supérieur Agronomique de Toulouse
Laboratoire Dynamiques Rurales
Avenue de l'Agrobiopole
Auzeville-Tolosane - BP 107 – F 31326
Castanet-Tolosan Cedex
FRANCE

**Sherry Bertramsen is at:**

National Agricultural Statistics Service
U.S. Department of Agriculture
308 W 21st
PO Box 1148
Cheyenne, Wyoming 82001-3604
U.S.

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Agri-environmental schemes are taking on much greater importance in the overall policy mix for agriculture in European Union (EU) countries. Various schemes have been tried over the last 15 years, and new ones are being introduced in such countries as the United Kingdom (Dobbs and Pretty) and France. The U.S. 2002 farm bill (Farm Security and Rural Investment Act of 2002) introduced a major new agri-environmental scheme—the Conservation Security Program—similar to some of those in Europe. In France, there is a fairly long history of food 'quality' schemes. 'Quality' is used in the French context to denote taste, healthfulness, and conditions of production. One of the best-known French quality schemes is the Label Rouge (LR, or Red Label) scheme, created in 1960. 'Eco-labeling' is a more recent phenomenon on both sides of the Atlantic. Eco-labels are meant to provide consumers with information about a product's environmental impact. Often these labels contain information about the production of the product, as does the organic label (agricultural biologique, in France). Both types of labeling schemes are gaining in importance for food products in Europe and North America, in part because of potential positive impacts on the environment.

As France, other EU countries, and the U.S. place greater emphasis on schemes which reward farmers for environmental stewardship—both through the market and through government stewardship payments—it is important to know whether these 'quality' and 'eco-labeling' schemes do, indeed, provide measurable environmental benefits. If they do, then policies can be implemented to foster and encourage these schemes, in which a substantial portion of the incentive for farmer adoption comes through price premiums consumers are willing to pay. If they do not, a policy conclusion might be that though the schemes have possible health, taste, or other consumer benefits, they should not be relied on for much in the way of environmental benefits. An alternative possible policy conclusion is that perhaps the criteria for eligibility and certification with these schemes should be broadened or strengthened to bring about greater environmental benefits.

In his theoretical analysis of the relationship between food quality and environmental quality, Thiébaut points out three possible levels where the relationship can be observed. At the *territorial level*, there can be joint production of final quality food products and environmental services (e.g., wine and landscape). At the *farmer's level*, there can be simultaneous production of quality food products and environmental goods (e.g., positive externalities, or reduction of negative externalities). Finally, at the *consumer's level*, there can be joint demand for quality food and protection of the environment. Kephaliacos and Robin suggest another way to look at the relationship between food quality and environmental quality. They suggest analyses at the *input level* (e.g., not allowing certain joint inputs) and at the *output level* (e.g., the nature of interdependencies between the quantities or characteristics of the outputs). Our study's main objective was to analyze the extent of the relationship between food quality and output quality at the *farmer's level* by looking at the *production process* and at the nature of *outputs.*

Van Ravenswaay studied some of the challenges facing environmental labeling. She notes that environmental labeling has created two controversies. They involve (1) the potential for consumer deception and (2) whether environmental labels should also serve environmental policy objectives. Consumers' ability to discern whether or not a product has been produced in an environmentally sound manner remains tenuous (Erickson and Kramer-LeBlanc). Lohr notes that there are many certifications—in addition to organic—for environmentally oriented production systems. She indicates that although consumer interest in purchasing food products with 'green' production characteristics is growing, given that existing eco-labels are not well-defined in consumers' minds, there is substantial potential for new labels with vague criteria that are not legally defined to generate confusion. Thiébaut articulates the additional problem of determining whether specially labeled products contribute to both "internal" quality (e.g., taste) and "external" quality (production of positive environmental externalities, or reduction of negative ones).

In this paper, results are reported for analyses we recently conducted to examine the environmental effects of major 'quality' and 'eco-labeling' schemes in use in the Midi-Pyrenees region of the south of France. Schemes analyzed are described in the next section. Following that, the data and methods of analysis are explained. Next, results of statistical analyses are presented. These results are complemented by qualitative results drawn from in-depth case studies of three food quality schemes. Conclusions and policy implications are presented in the last section of the paper.

**Quality and eco-labeling schemes examined**[i]

One 'eco-label' and three 'quality' categories were examined in this study. The eco-label included in the study was *Agriculture Biologique (AB)*, organic agriculture. France officially recognized organic agriculture in 1980, and allowed farmers to use the label "product made from organic agriculture" and created public standards to regulate the industry (Ministère de l'Agriculture et de la Pêche). Although we refer here to the French AB as an 'eco-label', in reality, it has always been considered a regular food 'quality' label like others described below. Most French consumers think that the AB label guarantees not only the non-use of chemical inputs, but also the taste and health nature of the resulting food product.

One of the quality label categories included in the study was the *Official Sign of Quality (SOQ)*. SOQ products receive an official government label that requires producers to follow specific guidelines for production of the product. Included in this category are the Appellation d'Origine Contrôlée (AOC, controlled origin label) and the Label Rouge.[ii] The French controlled origin label was established in 1919 for the wine sector. It then spread to milk products and, in 1990, to all other agricultural food products. The AOC label implies more than horizontal differentiation; it also testifies that the product has been produced from local raw products in a place-specific mode, and that its high quality characteristics are the result of substantial long-term collective and individual investments (Kilkenny and Daniel). The Label Rouge was created for products that possess specific characteristics and enjoy a superior level of quality that distinguish them from other similar products (Ministère de l'Agriculture et de la Pêche). It guarantees a better taste and high standards of production, while the AOC guarantees primarily the origin of the product. The Label Rouge is a nationwide structure that ties highly localized groups of producers and their supplier and processing networks together to deliver consumer products that differ from industrial products. The differences supposedly are distinguishable with regard to intrinsic quality, food safety, environmentally sound production practices, and product image (Westgren).

Another quality label category included in the study is referred to here as *Other Cahier des Charges (CDC).* These products are not under an official government label, but they are produced in a quality way under specific guidelines from a cooperative, supermarket, or agricultural supplier. The cahier des charges is the formal document that specifies the agreed production guidelines.

Also included in the study were *Official Sign of Quality of Transformed Food (SOQT)* products. While SOQ products concern raw materials, the SOQT category pertains to the outputs of food industries, including cooperatives. It includes the LR and the AOC. The guidelines do not directly concern farmers; instead, they apply to processing or manufacturing of food. An example of this designation is AOC Roquefort. The quality label specifies the cheese's production process, rather than the process of producing the milk.

Finally, we included an *In Process (IP)* category. Producers in this category were just starting to switch over to an eco-label (AB) or quality (SOQ, CDC, or SOQT) approach.

**Data and methods of analysis**

Data analyzed in this study were collected by researchers from three different agencies—SOLAGRO (a private agricultural and environmental association), the Regional Chamber of Agriculture of the Midi-Pyrenees, and the Department of Agriculture of the Haute-Garonne. The data were made available to a research team at the

École Nationale Supériere Agronomique de Toulouse (ENSAT), in France. The original data set contained information on farmers' practices and on factors that could be scored from an environmental standpoint. Farmers were called and asked if they were involved in any agri-environmental schemes, eco-labeling programs, and quality labeling programs. The usable data set covered 107 farm operations in the Midi-Pyrenees region of the south of France. The categorization of these farms is shown in Table 1. Fifty of those farms were participating in one of the eco- or quality label programs (including three that were *In Process*).

Table 2 constitutes a glossary of environmental scores used in the analyses. This is not an exhaustive list of the environmental scores that were recorded for farms in the data set, but the list does include the scores most often used in our analyses. Environmental scores consisted of eight components. One set of aggregate scores (PS1 and PS2) was based on two broad components: (1) overall diversity of production; and (2) appropriate use of inputs such as synthetic chemical fertilizer. A second set (PE1 through PE6) was based on a more detailed breakdown, consisting of six components: (1) water use; (2) soil fertility and erosion; (3) plant and animal diversity; (4) air quality (e.g., emissions of greenhouse gases); (5) resource consumption (e.g., net production of renewable energy); and (6) waste management. Analyses were carried out using various individual components and combinations of components.

Farm size variables referred to in the results section below are defined as follows:

SAU—Score equal to one full-time employee on a farm;

UTH—Number of hectares on the farm; and

MBS—An index of the economic size of a farm (a measure of the difference between the regional standard value of all production on a farm and the regional standard production costs).

We carried out analyses with this data set to determine the correlation between a farmer's participation in any of the eco-labeling and quality labeling schemes and the environmental score of his or her farming system. In other words, we wished to examine whether the production of quality food was associated with the production of any environmental goods. Using the Statistical Package for the Social Sciences (SPSS), we carried out factor analyses, regression analyses, and analyses of variance. Due to space limitations in this paper, we focus primarily on the analyses of variance. We report briefly on one of the factor analyses, but ignore the regression analyses here.

**Results of statistical analyses**[iii]

Factor analyses were conducted to identify a small number of factors that may be used to represent relationships among sets of interrelated variables. The goal was to identify groups of farmers that share similar characteristics—such as high environmental grades, size of farm, income, eco-label or quality approach followed, or number of workers—to determine if a particular eco-label or quality approach can be characterized in a certain way. One of the factor analyses is explained next. Then, we turn to the analyses of variance.

**Factor analysis**

For purposes of the factor analyses, eco-labeling and quality approaches were ordered from presumed least environmental impact to presumed highest environmental impact, based on the level of environmental quality that each approach was thought to demand. Farmers not participating in any eco-labeling or quality approach were assigned a rank of 1 (one), IP farmers were given a 2 (two), those following an SOQT approach were given a 3 (three), those following a CDC approach were given a 4 (four), those following an SOQ approach were given a 5 (five), and AB farmers were given a 6 (six).

One of the factor analyses was designed to determine if either large or small farms tend to be associated with high total environmental scores or if either large or small farms are especially likely to be involved in quality or eco-labeling schemes. Two distinct clusters were identified in this analysis (Figure 1). One cluster was composed of farmers with relatively small farms, low environmental scores (PS1 + PS2) and a low level of participation in quality and eco-labeling schemes (i.e., not participating at all, IP, or participating in a scheme thought, a priori, to provide less environmental benefit than some others). The other cluster also was composed of relatively small farms, but these farms had high total environmental scores and participated in schemes thought, a priori, to provide greater environmental benefits (e.g., AB). Larger farms were split in a similar fashion, with about half engaged in higher-level quality or eco-labeling schemes and having high environmental scores, and the other half having low total environmental scores and participating in no or lower-level quality and eco-labeling schemes. On average, farms participating in a quality scheme have significantly higher environmental scores than the non-participating farms.

**Analyses of variance**

Numerous Analysis of Variance (ANOVA) tests were run to examine impacts of particular quality and eco-labeling schemes on various environmental indicators. In one test, quality and eco-labeling schemes were compared on the basis of mean aggregate environmental scores using the first set (of two) components (PS1 and PS2). Farmers participating in SOQT schemes had the highest mean score, and farmers involved in AB and SOQ programs were next highest, but substantially below the mean for SOQT farmers (Figure 2). The majority of farmers using SOQT labels raise sheep on extensive farming systems, producing milk for cheese industries. The types of farming systems they use have effects on environmental scores independent of farmers' particular environmental practices. Farmers not involved in any eco-label or quality programs, as expected, did have the lowest average aggregate environmental scores, but that score was only slightly lower than the average for farmers in CDC schemes. The mean environmental score for SOQT farmers was significantly higher (at the 5% level) than the mean scores for farmers in all other categories—including farmers not participating in any quality or eco-labeling programs (symbolized by *N*)—except for farmers in the AB and IP categories

A similar ANOVA test is shown in Figure 3, but here the quality and eco-labeling categories are compared with respect to mean environmental scores based on the sums of individual components PE1 through PE6. N farmers again had the lowest mean score, but in this case AB farmers had the highest score. This is what was originally expected. SOQT farmers, as in the first test, performed relatively well environmentally, and IP and SOQ farmers were not far behind. Once again, CDC farmers did not perform as well as farmers in other quality and eco-labeling programs. Multiple comparisons of the mean scores show that AB farmers performed significantly[iv] better than farmers in all other categories except for those in the SOQT and IP categories.

Among the additional ANOVA analyses conducted were some in which quality and eco-label categories containing a limited number of observations were combined. The N, AB, and SOQ categories remained separate, but the SOQT, CDC, and IP categories were combined into a new category labeled *O*, for *Others*. One ANOVA was conducted with this grouping to examine the relationship between quality/eco-label categories and farm size, as measured by the MBS variable. Results in Figure 4 indicate that the AB farms are smallest in terms of this economic 'value added' measure, and SOQ farms are the largest. Farmers not involved in any quality or eco-labeling program are the second largest, on average, by this measure. The mean differences between SOQ farms and farms in all other categories are significant, but the differences between farms in the other categories are not significant. The relatively high value for economic output on SOQ farms was not unexpected, because products with SOQ labels, including those with the Label Rouge, often generate substantial price premiums. Westgren indicated that Label Rouge products can command prices up to 300% over conventional prices. It was somewhat surprising that AB farmers had the lowest mean MBS value. However, the MBS index is more an indicator of farm size than of the real level of farm income. Organic farmers in the study had fewer hectares under production, on average, than did SOQ farmers.

Another ANOVA, with the same quality category grouping, was conducted to isolate effects on soil fertility and erosion, as measured by PE2. AB, SOQ, and O farms had significantly better PE2 performance, on average, than did farms not participating in any of these programs (Figure 5).

Farms participating in quality and eco-labeling programs also performed significantly better, on average, on the environmental indicator for plant and animal diversity (PE3) than did non-participating farms (Figure 6). AB farms performed best, but not significantly better than SOQ and O farms.

**Results of qualitative analyses**

In order to complement the above quantitative results and to get more insight on the nature of the relationship between quality practices and environmental practices, in-depth interviews were conducted with a limited number of farmers participating in three SOQ programs: CCP "*Covapi*" for fruits, LR "*Poulet Roux du Gers*" for poultry, and LR "*Veau de l'Aveyron et du Ségala*" for cattle. The farmers' SOQ organizations and guidelines were also studied (Table 3).

The analysis showed that the relationship between food quality and the environment appears mainly through inclusion in the SOQ guidelines of environmental practices that have an impact on the quality and the image of the product—reduction in the use of chemical inputs, preservation of natural habitats in fields, preservation of the land's natural characteristics, and respect for animal well being. Farmers participate in quality schemes, first, for economic reasons. The schemes allow farmers to occupy specific market niches and they do, indeed, help assure a minimum income. Farmers' sensitivity to environmental concerns may grow, however, as a result of having to follow the environmental guidelines embedded in the schemes.

The extent of changes in farming system and practices induced by SOQ guidelines varies with the SOQ. The respect for animal well being required of poultry producers under the LR "*Poulet Roux du Gers*" label mainly involves certain building specifications and small changes in breeding practices. In contrast, changes in fruit production practices could be significant in the case of the CCP "*Covapi*" label, because farmers have to adopt new chemical and other production practices. In this case, farmers tend to become more sensitive to environmental issues and naturally develop new environmental practices independently of the SOQ guidelines. Technicians for the SOQ organizations play an important role in developing farmer sensitivity to environmental issues.

The analysis revealed two other major determinants of the adoption of environmental practices by farmers: the impact of these practices on the farm's productivity and the opportunities for their monetary reward. We observed that certain environmental practices have been adopted because they help reduce yield risks or lower operating costs. Farmer behavior towards the environment is also very dependent of consumer attitudes. It is easier for farmers participating in the CCP "*Covapi*" to stop using chemicals because they can be compensated by a price premium consumers sensitive to healthy products are willing to pay. Similarly, to improve their image to consumers and make their territory more attractive for tourism, farmers participating to the LR "*Veau d'Aveyron and du Ségala*" have decided, in addition to satisfying the SOQ guidelines, to preserve the natural environment surrounding their farms. Farmers selling products directly to consumers—like "*Covapi*" fruit producers or producers of "*Veau d'Aveyron and du Ségala*" meat—will, indeed, be more sensitive to environmental concerns, due to their close contact with consumers. The difficulty in commanding price premiums for environmental practices less visible to consumers in SOQ schemes makes those practices less attractive to farmers.

## Conclusions and policy implications

This research showed that organic farms and farms enrolled in various quality labeling programs in France do provide some environmental benefits to society. However, they do not necessarily perform better than other farms on all environmental measures. This is not surprising for French food quality labels, as most of those labels were not originally designed for environmental purposes. Most originally were intended to enhance marketability through appeals to such consumer values as taste and health. Although an SOQ approach involves farmers in organizational and contractual relationships, quality food products are private goods by nature. In contrast to many environmental goods, their production does not necessarily require any collective action or any specific coordination scheme among farmers in a territory. It is difficult to incorporate such collective action or coordination in standard SOQ guidelines. However, there do appear to be opportunities to strengthen certification criteria to enhance environmental quality provided by the various French labeling schemes.

There have been a few efforts by farmer organizations in France to develop specific "eco-labels". These are commercial labels, not SOQ labels. They are, for the moment, too new to provide specific lessons. However, eco-labels may not constitute an efficient signal to consumers about farmers' environmental stewardship, due to an asymmetric information problem associated with the great increase in the number of all sorts of official and non-official quality labels; it is difficult for consumers to access and understand all the guidelines and to sort out the highly heterogeneous guidelines regarding prescribed environmental measures and their likely efficacies. As the EU continues with reforms in its Common Agricultural Policy, a critical issue is what mix of government direct payments and market mechanisms to use in fostering expanded use of environmental practices. The resolution of that issue depends greatly on the extent to which quality and eco-labels can send clear and reasonably reliable market signals to consumers who are willing to pay for environmental goods provided jointly with food products.

One lesson from the French experience with quality labels for U.S. eco-labeling schemes is that schemes need to be very clear about what the expectations are and what guidelines must be followed in order for producers to qualify for a particular label. This will help prevent producers and consumers from suffering the consequences of misinformation, such as distrust in the agricultural sector to provide accurate information about a product's environmental impacts. Labeling a food product as "natural", "produced with reduced use of chemicals", or "South Dakota grown", for example, does not assure that the production methods used are, on balance, beneficial to the environment. Implied claims need to be backed up by transparent and verifiable standards. Other than the organic label, few eco-labels in the U.S. yet do this.

Another lesson is that as U.S. value-added agriculture and rural development efforts begin to place more emphasis on foods with regional identities, environmental criteria should be built in at the outset. There is a long history of foods with regional identities in France, but environmental objectives and criteria were not originally incorporated in many of the regional and other 'quality' food labels there. With growing environmental concerns in France and elsewhere in Europe, there is policy interest in trying to simultaneously achieve both (a) regional economic and (b) environmental objectives with 'quality' and 'eco-labels'. If this approach is to be used, it is best to build both objectives into labeling schemes at the outset, as the Midwest Food Alliance has attempted to do (Midwest Food Alliance).

Finally, U.S. policy makers may wish to broaden selected government agri-environmental schemes to explicitly incorporate rural development objectives, as do schemes like France's Contrat Territoriale d'Exploitation (CTE, or Territorial Contract of Farming). We are thinking, in particular, of the new Conservation Security Program (CSP). Although rules are yet to be finalized for the CSP[v], it is widely assumed that many, if not most, organically certified farms will, without great difficulty, be able to qualify for payments under one of the CSP's higher two tiers. If some other eco-labeling schemes become rigorous enough, perhaps farmers participating in some of those schemes also will be able to demonstrate sufficient positive environmental actions or results to qualify. Were the CSP to also include rural development objectives, as does France's CTE, than farmers participating in food labeling schemes that combine both rural development and environmental objectives might receive special support. Then, farmers could receive incentives to alter their production systems through both market-driven price premiums and government payments.

## Endnotes

[i] See Bertramsen, Nguyen, and Dobbs for a brief comparison of 'quality' and 'eco-labeling' schemes in France and the United States.
[ii] The AB belongs to the SOQ category.
[iii] For more complete and detailed results of the empirical analyses, see Bertamsen.
[iv] All references to significant differences, henceforth, refer to the 5% level.
[v] As of mid-May 2003.

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**Table 1. Distribution of farms by quality code**

| Quality code | Quality approach | Number of farms |
|---|---|---|
| AB | Organic agriculture | 8 |
| SOQ | Official sign of quality | 25 |
| CDC | Other cahiers des charges | 9 |
| SOQT | Official sign of quality of transformed food | 5 |
| IP | In process | 3 |
| N | Nothing | 57 |
| Total | | 107 |

**Table 2. Breakdown of environmental scores**

| |
|---|
| PS1: This score, worth 70 total points, defines the mix of the farm and the diversity of production. It includes plant diversity (30 points), animal diversity (22 points), and natural elements and space (18 points). |
| |
| PS2: This score, worth 30 points, defines the rational use of inputs on the farm. It includes the use of nitrogen (7.5 points), phosphorous (3.0 points), water (6.0 points), phytosanitaries (7.5 points), and energy (6.0 points). |
| |
| PE1: This score, worth 100 points, describes the quality and quantity of water used on the farm. It includes nitrogen discharges (14 points), phosphorous discharges (14 points), management of water (14 points), phytosanitary residue (15 points), effluent discharges (14 points), protection by organization of farm space (15 points), and protection by natural elements (14 points). |
| |
| PE2: This score, worth 100 points, describes soil fertility and erosion. It includes management of organic material (35 points), risk of erosion (45 points), and quality of soil and pollutants in the soil (20 points). |
| |
| PE3: This score, worth 100 points, describes plant and animal diversity on the farm or ranch. It includes natural elements (25 points), permanent prairies that are not fertilized very much (20 points), spaces with weak potential, such as dry or wet areas (10 points), zones of biological interest (15 points), absence or limited use of pesticides (20 points), threatened animal breeds (5 points), and old varieties of plants (5 points). |
| |
| PE4: This score, worth 100 points, describes the quality of air on the farm or ranch. It includes emissions of greenhouse gases (35 points), emissions of ozone-depleting and acetic gases (15 points), emissions of phytosanitaries (25 points), smell nuisances (10 points), and production of oxygen (15 points). |
| |
| PE5: This score, worth 100 points, describes the consumption of resources on the farm or ranch. It includes direct energy consumption (20 points), indirect energy consumption (15 points), phosphates bought (15 points), potassium bought (15 points), water consumed (15 points), and net production of renewable energy (20 points). |
| |
| PE6: This score, worth 100 points, describes the storing and handling of waste on the farm or ranch. It includes the handling and storing of dangerous wastes (50 points), the handling and storing of potentially dangerous wastes (20 points), and the handling and storing of plastic and metal wastes (30 points). |

**Table 3. Selected qualitative results of the study of three SOQ schemes**

| | **LR "Poulet Roux du Gers" (poultry)** | **LR "Veau du Ségala et de l'Aveyron" (cattle)** | **CCP "Covapi" (fruits)** |
|---|---|---|---|
| **Type of participation in the quality scheme** | Through the cooperative | Through the cooperative | Individual |
| **Motivations of farmers to participate in the scheme** | Economic (value-added + better conditions of work) | Economic (value-added, reduction of market risks and price variations) | Economic (value-added) |
| **Environmental practices specified in guidelines** | Animal well-being: building norms, number of animals per unit of surface, planting of plants to provide shade | Animal well-being : building norms, number of animals per unit of surface | Reduction of chemicals<br>Preservation of biodiversity<br>Preservation of the soil's characteristics |
| **Any additional environmental practices adopted independently of the guidelines** | | Improvement of the farm's surrounding: management of waste, preservation of the natural environment | Reduction of the traditional practice of cutting trees to accelerate fruit maturation |
| **Sensitivity of farmer to environmental issues** | No | Yes, important to improve the image of agriculture and attract tourists | Yes, important to improve the image of the product for consumers and to improve the quality of life |
| **Additional factors contributing to the adoption of environmental practices** | | Dynamism of the farmer SOQ organization (collective action) | Role of the SOQ organization's technicians |

## Figure 1. Factor analysis of quality codes, SAU, UTH, MBS, and PS1+PS2

**Communalities**

| | Initial | Extraction |
|---|---|---|
| Quality code | 1.000 | .711 |
| SAU | 1.000 | .619 |
| UTH | 1.000 | .747 |
| MBS | 1.000 | .782 |
| PS1+PS2 | 1.000 | .626 |

Extraction Method: Principal Component Analy

**Total Variance Explained**

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 1.998 | 39.96 | 39.96 | 1.998 | 39.96 | 39.96 |
| 2 | 1.487 | 29.73 | 69.69 | 1.487 | 29.73 | 69.69 |
| 3 | .743 | 14.86 | 84.56 | | | |
| 4 | .475 | 9.496 | 94.06 | | | |
| 5 | .297 | 5.939 | 100.00 | | | |

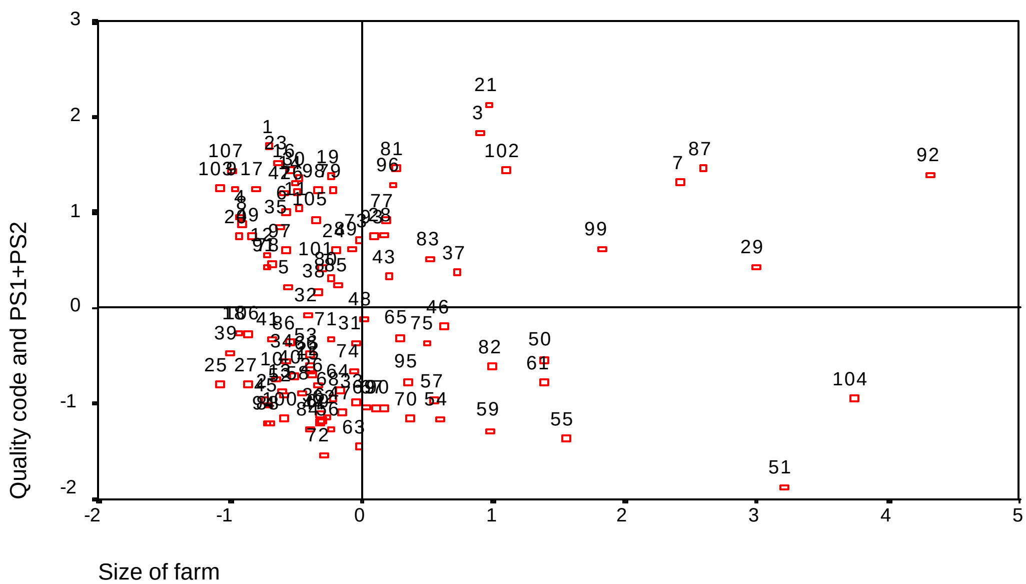
Extraction Method: Principal Component Analysis.

**Component Matrix[a]**

| | Component | |
|---|---|---|
| | 1 | 2 |
| Quality code | 5.67E-02 | .841 |
| SAU | .740 | -.268 |
| UTH | .789 | .352 |
| MBS | .884 | 3.60E-02 |
| PS1+PS2 | -.209 | .763 |

Extraction Method: Principal Component Analysis.

a. 2 components extracted.



## Figure 2. ANOVA for quality codes and PS1+PS2
## F-test

**Descriptives**

PS1+PS2

| | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound | | |
| 1 N | 57 | 41.121 | 15.899 | 2.106 | 36.902 | 45.339 | 16.23 | 88.57 |
| 2 IP | 3 | 50.167 | 27.872 | 16.092 | -19.071 | 119.405 | 29.30 | 81.82 |
| 3 SOQT | 5 | 72.450 | 7.045 | 3.151 | 63.703 | 81.197 | 60.81 | 77.99 |
| 4 CDC | 9 | 41.606 | 13.050 | 4.350 | 31.574 | 51.637 | 25.13 | 63.24 |
| 5 SOQ | 25 | 55.860 | 16.391 | 3.278 | 49.094 | 62.625 | 25.87 | 79.47 |
| 6 AB | 8 | 57.898 | 13.594 | 4.806 | 46.532 | 69.263 | 44.08 | 79.18 |
| Total | 107 | 47.577 | 17.748 | 1.716 | 44.175 | 50.979 | 16.23 | 88.57 |

PS1+PS2

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 8377.616 | 5 | 1675.523 | 6.766 | .000 |
| Within Groups | 25011.52 | 101 | 247.639 | | |
| Total | 33389.13 | 106 | | | |

**Multiple Comparisons**

Dependent Variable: PS1+PS2
LSD

| (I) Quality code | (J) Quality code | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1 N | 2 IP | -9.0461 | 9.3215 | .334 | -27.5375 | 9.4453 |
| | 3 SOQT | -31.3295* | 7.3398 | .000 | -45.8896 | -16.7693 |
| | 4 CDC | -.4850 | 5.6445 | .932 | -11.6821 | 10.7121 |
| | 5 SOQ | -14.7391* | 3.7749 | .000 | -22.2275 | -7.2506 |
| | 6 AB | -16.7770* | 5.9413 | .006 | -28.5630 | -4.9910 |
| 2 IP | 1 N | 9.0461 | 9.3215 | .334 | -9.4453 | 27.5375 |
| | 3 SOQT | -22.2833 | 11.4923 | .055 | -45.0811 | .5144 |
| | 4 CDC | 8.5611 | 10.4910 | .416 | -12.2503 | 29.3725 |
| | 5 SOQ | -5.6929 | 9.6152 | .555 | -24.7669 | 13.3810 |
| | 6 AB | -7.7308 | 10.6537 | .470 | -28.8649 | 13.4032 |
| 3 SOQT | 1 N | 31.3295* | 7.3398 | .000 | 16.7693 | 45.8896 |
| | 2 IP | 22.2833 | 11.4923 | .055 | -.5144 | 45.0811 |
| | 4 CDC | 30.8444* | 8.7774 | .001 | 13.4324 | 48.2565 |
| | 5 SOQ | 16.5904* | 7.7093 | .034 | 1.2972 | 31.8836 |
| | 6 AB | 14.5525 | 8.9712 | .108 | -3.2440 | 32.3490 |
| 4 CDC | 1 N | .4850 | 5.6445 | .932 | -10.7121 | 11.6821 |
| | 2 IP | -8.5611 | 10.4910 | .416 | -29.3725 | 12.2503 |
| | 3 SOQT | -30.8444* | 8.7774 | .001 | -48.2565 | -13.4324 |
| | 5 SOQ | -14.2540* | 6.1173 | .022 | -26.3891 | -2.1190 |
| | 6 AB | -16.2919* | 7.6466 | .036 | -31.4607 | -1.1232 |
| 5 SOQ | 1 N | 14.7391* | 3.7749 | .000 | 7.2506 | 22.2275 |
| | 2 IP | 5.6929 | 9.6152 | .555 | -13.3810 | 24.7669 |
| | 3 SOQT | -16.5904* | 7.7093 | .034 | -31.8836 | -1.2972 |
| | 4 CDC | 14.2540* | 6.1173 | .022 | 2.1190 | 26.3891 |
| | 6 AB | -2.0379 | 6.3922 | .751 | -14.7183 | 10.6425 |
| 6 AB | 1 N | 16.7770* | 5.9413 | .006 | 4.9910 | 28.5630 |
| | 2 IP | 7.7308 | 10.6537 | .470 | -13.4032 | 28.8649 |
| | 3 SOQT | -14.5525 | 8.9712 | .108 | -32.3490 | 3.2440 |
| | 4 CDC | 16.2919* | 7.6466 | .036 | 1.1232 | 31.4607 |
| | 5 SOQ | 2.0379 | 6.3922 | .751 | -10.6425 | 14.7183 |

*. The mean difference is significant at the .05 level.

# Figure 3. ANOVA for quality codes and PE1+PE2+PE3+PE4+PE5+PE6

## F-test

**Descriptives**

PE1+PE2+PE3+PE4+PE5+PE6

| | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound | | |
| 1 N | 57 | 280.692 | 69.140 | 9.158 | 262.346 | 299.037 | 187.08 | 519.09 |
| 2 IP | 3 | 321.093 | 94.795 | 54.730 | 85.611 | 556.576 | 225.53 | 415.10 |
| 3 SOQT | 5 | 352.688 | 98.741 | 44.158 | 230.085 | 475.291 | 202.32 | 443.52 |
| 4 CDC | 9 | 292.527 | 42.582 | 14.194 | 259.795 | 325.258 | 201.95 | 351.76 |
| 5 SOQ | 25 | 320.293 | 73.807 | 14.761 | 289.827 | 350.759 | 186.44 | 446.65 |
| 6 AB | 8 | 386.676 | 49.361 | 17.452 | 345.410 | 427.943 | 328.79 | 482.02 |
| Total | 107 | 303.361 | 74.803 | 7.231 | 289.024 | 317.698 | 186.44 | 519.09 |

PE1+PE2+PE3+PE4+PE5+PE6

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 106156.6 | 5 | 21231.312 | 4.404 | .001 |
| Within Groups | 486967.3 | 101 | 4821.459 | | |
| Total | 593123.9 | 106 | | | |

**Multiple Comparisons**

Dependent Variable: PE1+PE2+PE3+PE4+PE5+PE6
LSD

| (I) Quality code | (J) Quality code | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1 N | 2 IP | -40.4018 | 41.1308 | .328 | -121.9941 | 41.1906 |
| | 3 SOQT | -71.9964* | 32.3864 | .028 | -136.2423 | -7.7505 |
| | 4 CDC | -11.8351 | 24.9059 | .636 | -61.2417 | 37.5715 |
| | 5 SOQ | -39.6012* | 16.6567 | .019 | -72.6436 | -6.5588 |
| | 6 AB | -105.9847* | 26.2158 | .000 | -157.9898 | -53.9795 |
| 2 IP | 1 N | 40.4018 | 41.1308 | .328 | -41.1906 | 121.9941 |
| | 3 SOQT | -31.5947 | 50.7094 | .535 | -132.1885 | 68.9992 |
| | 4 CDC | 28.5667 | 46.2911 | .539 | -63.2625 | 120.3959 |
| | 5 SOQ | .8005 | 42.4265 | .985 | -83.3623 | 84.9634 |
| | 6 AB | -65.5829 | 47.0089 | .166 | -158.8359 | 27.6701 |
| 3 SOQT | 1 N | 71.9964* | 32.3864 | .028 | 7.7505 | 136.2423 |
| | 2 IP | 31.5947 | 50.7094 | .535 | -68.9992 | 132.1885 |
| | 4 CDC | 60.1613 | 38.7300 | .123 | -16.6685 | 136.9911 |
| | 5 SOQ | 32.3952 | 34.0169 | .343 | -35.0852 | 99.8756 |
| | 6 AB | -33.9882 | 39.5850 | .393 | -112.5143 | 44.5378 |
| 4 CDC | 1 N | 11.8351 | 24.9059 | .636 | -37.5715 | 61.2417 |
| | 2 IP | -28.5667 | 46.2911 | .539 | -120.3959 | 63.2625 |
| | 3 SOQT | -60.1613 | 38.7300 | .123 | -136.9911 | 16.6685 |
| | 5 SOQ | -27.7661 | 26.9921 | .306 | -81.3113 | 25.7790 |
| | 6 AB | -94.1496* | 33.7402 | .006 | -161.0810 | -27.2181 |
| 5 SOQ | 1 N | 39.6012* | 16.6567 | .019 | 6.5588 | 72.6436 |
| | 2 IP | -.8005 | 42.4265 | .985 | -84.9634 | 83.3623 |
| | 3 SOQT | -32.3952 | 34.0169 | .343 | -99.8756 | 35.0852 |
| | 4 CDC | 27.7661 | 26.9921 | .306 | -25.7790 | 81.3113 |
| | 6 AB | -66.3834* | 28.2053 | .021 | -122.3352 | -10.4317 |
| 6 AB | 1 N | 105.9847* | 26.2158 | .000 | 53.9795 | 157.9898 |
| | 2 IP | 65.5829 | 47.0089 | .166 | -27.6701 | 158.8359 |
| | 3 SOQT | 33.9882 | 39.5850 | .393 | -44.5378 | 112.5143 |
| | 4 CDC | 94.1496* | 33.7402 | .006 | 27.2181 | 161.0810 |
| | 5 SOQ | 66.3834* | 28.2053 | .021 | 10.4317 | 122.3352 |

*. The mean difference is significant at the .05 level.

## Figure 4. ANOVA for combined quality codes and MBS

**F-test**

**Descriptives**

MBS

| | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean Lower Bound | 95% Confidence Interval for Mean Upper Bound | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|
| 1 N | 57 | 74842.97 | 71141.04 | 9422.86 | 55966.71 | 93719.23 | 11368 | 423998 |
| 2 O | 17 | 56225.65 | 27794.69 | 6741.20 | 41934.94 | 70516.36 | 15895 | 115550 |
| 3 SOQ | 25 | 141487.1 | 156763.08 | 31352.62 | 76778.52 | 206195.76 | 21270 | 654112 |
| 4 AB | 8 | 31455.56 | 25349.83 | 8962.52 | 10262.57 | 52648.54 | 8421 | 83950 |
| Total | 107 | 84212.23 | 97741.72 | 9449.05 | 65478.57 | 102945.89 | 8421 | 654112 |

MBS

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 1.2E+11 | 3 | 4.087E+10 | 4.729 | .004 |
| Within Groups | 8.9E+11 | 103 | 8641452539 | | |
| Total | 1.0E+12 | 106 | | | |

**Multiple Comparisons**

Dependent Variable: MBS
LSD

| (I) Combined quality | (J) Combined quality code | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval Lower Bound | 95% Confidence Interval Upper Bound |
|---|---|---|---|---|---|---|
| 1 N | 2 O | 18617.32 | 5689.01 | .470 | -32330.77 | 69565.41 |
| | 3 SOQ | -66644.17* | 2299.38 | .004 | 110869.74 | -22418.60 |
| | 4 AB | 43387.42 | 5096.81 | .219 | -26218.83 | 112993.66 |
| 2 O | 1 N | -18617.32 | 5689.01 | .470 | -69565.41 | 32330.77 |
| | 3 SOQ | -85261.49* | 9222.92 | .004 | 143218.25 | -27304.73 |
| | 4 AB | 24770.09 | 9856.02 | .536 | -54274.92 | 103815.11 |
| 3 SOQ | 1 N | 66644.17* | 2299.38 | .004 | 22418.60 | 110869.74 |
| | 2 O | 85261.49* | 9222.92 | .004 | 27304.73 | 143218.25 |
| | 4 AB | 110031.58* | 7760.29 | .004 | 35142.95 | 184920.22 |
| 4 AB | 1 N | -43387.42 | 5096.81 | .219 | 112993.66 | 26218.83 |
| | 2 O | -24770.09 | 9856.02 | .536 | 103815.11 | 54274.92 |
| | 3 SOQ | 110031.58* | 7760.29 | .004 | 184920.22 | -35142.95 |

*. The mean difference is significant at the .05 level.

## Figure 5. ANOVA for combined quality codes and PE2

### F-test

**Descriptives**

PE2

| | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound | | |
| 1 N | 57 | 53.538 | 16.143 | 2.138 | 49.255 | 57.821 | 32.39 | 100.00 |
| 2 O | 17 | 66.974 | 19.891 | 4.824 | 56.747 | 77.200 | 40.21 | 98.64 |
| 3 SOQ | 25 | 69.899 | 20.212 | 4.042 | 61.556 | 78.242 | 32.66 | 99.04 |
| 4 AB | 8 | 69.231 | 20.940 | 7.404 | 51.725 | 86.738 | 45.36 | 100.00 |
| Total | 107 | 60.669 | 19.447 | 1.880 | 56.941 | 64.396 | 32.39 | 100.00 |

PE2

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 6290.714 | 3 | 2096.905 | 6.390 | .001 |
| Within Groups | 33798.04 | 103 | 328.136 | | |
| Total | 40088.76 | 106 | | | |

**Multiple Comparisons**

Dependent Variable: PE2

LSD

| (I) Combined quality code | (J) Combined quality code | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1 N | 2 O | -13.4356* | 5.0059 | .008 | -23.3636 | -3.5076 |
| | 3 SOQ | -16.3613* | 4.3454 | .000 | -24.9793 | -7.7433 |
| | 4 AB | -15.6934* | 6.8391 | .024 | -29.2572 | -2.1295 |
| 2 O | 1 N | 13.4356* | 5.0059 | .008 | 3.5076 | 23.3636 |
| | 3 SOQ | -2.9257 | 5.6945 | .609 | -14.2194 | 8.3681 |
| | 4 AB | -2.2577 | 7.7665 | .772 | -17.6608 | 13.1454 |
| 3 SOQ | 1 N | 16.3613* | 4.3454 | .000 | 7.7433 | 24.9793 |
| | 2 O | 2.9257 | 5.6945 | .609 | -8.3681 | 14.2194 |
| | 4 AB | .6680 | 7.3582 | .928 | -13.9252 | 15.2611 |
| 4 AB | 1 N | 15.6934* | 6.8391 | .024 | 2.1295 | 29.2572 |
| | 2 O | 2.2577 | 7.7665 | .772 | -13.1454 | 17.6608 |
| | 3 SOQ | -.6680 | 7.3582 | .928 | -15.2611 | 13.9252 |

*. The mean difference is significant at the .05 level.

## Figure 6. ANOVA for combined quality codes and PE3

**F-test**

**Descriptives**

PE3

| | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean Lower Bound | 95% Confidence Interval for Mean Upper Bound | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|
| 1 N | 57 | 19.034 | 17.264 | 2.287 | 14.453 | 23.615 | 1.35 | 89.00 |
| 2 O | 17 | 30.178 | 21.298 | 5.166 | 19.228 | 41.129 | 1.02 | 70.95 |
| 3 SOQ | 25 | 30.887 | 21.510 | 4.302 | 22.008 | 39.766 | 1.47 | 67.53 |
| 4 AB | 8 | 41.899 | 12.501 | 4.420 | 31.448 | 52.350 | 27.67 | 70.00 |
| Total | 107 | 25.284 | 19.852 | 1.919 | 21.479 | 29.089 | 1.02 | 89.00 |

PE3

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 5626.918 | 3 | 1875.639 | 5.345 | .002 |
| Within Groups | 36147.05 | 103 | 350.942 | | |
| Total | 41773.97 | 106 | | | |

**Multiple Comparisons**

Dependent Variable: PE3
LSD

| (I) Combined quality cc | (J) Combined quality code | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval Lower Bound | 95% Confidence Interval Upper Bound |
|---|---|---|---|---|---|---|
| 1 N | 2 O | -11.1440* | 5.1769 | .034 | -21.4112 | -.8768 |
| | 3 SOQ | -11.8530* | 4.4938 | .010 | -20.7655 | -2.9405 |
| | 4 AB | -22.8645* | 7.0728 | .002 | -36.8918 | -8.8373 |
| 2 O | 1 N | 11.1440* | 5.1769 | .034 | .8768 | 21.4112 |
| | 3 SOQ | -.7090 | 5.8891 | .904 | -12.3886 | 10.9707 |
| | 4 AB | -11.7205 | 8.0319 | .148 | -27.6499 | 4.2089 |
| 3 SOQ | 1 N | 11.8530* | 4.4938 | .010 | 2.9405 | 20.7655 |
| | 2 O | .7090 | 5.8891 | .904 | -10.9707 | 12.3886 |
| | 4 AB | -11.0116 | 7.6096 | .151 | -26.1033 | 4.0802 |
| 4 AB | 1 N | 22.8645* | 7.0728 | .002 | 8.8373 | 36.8918 |
| | 2 O | 11.7205 | 8.0319 | .148 | -4.2089 | 27.6499 |
| | 3 SOQ | 11.0116 | 7.6096 | .151 | -4.0802 | 26.1033 |

*. The mean difference is significant at the .05 level.