RETURNS TO QUALITY-ENHANCING AND COST-REDUCING RESEARCH: THE CASE OF MOISTURE CONTENT IN PHILIPPINE COPRA

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1. INTRODUCTION

Different types of research are associated with a shift either of the supply or demand curve of a commodity. Research that increases productivity or reduces cost of production causes a downward shift of the supply curve, while research on quality improvement may lead to an upward shift of the demand curve. Studies on welfare effects of research-induced supply shifts have been substantial both at the conceptual and empirical levels. Some of these studies have extended the analysis of research benefits to vertical and horizontal markets, in the context of closed and open economies and distorted markets (Edwards and Freebairn, 1982, 1984; Alston, Edwards and Freebairn, 1988; Alston, 1990; Voon and Edwards, 1991a). In contrast, there are relatively few studies which focus on welfare effects of a research-induced shift of the demand curve and these are mainly on quality improvement. There are several conceptual difficulties involved in measuring welfare effects from research that alters the nature of a commodity which partly explain the paucity of studies on this type of research (Voon and Edwards, 1990). Recently however, increasing attention has been paid to the literature on research that influences the demand side of the market.

Some of the studies on welfare effects of quality-enhancing research concern a single shift of the demand curve without a concomitant shift of the supply curve. Examples are Unnevehr's (1986) measurement of gains to research that improves taste in rice in Southeast Asia, and Voon and Edwards' (1991b) assessment of benefits from research that reduces backfat depth in pigs in Australia. On the other hand, studies which take into account simultaneous shifts in supply and demand curves involve either an upward or downward shift of the supply curve. In Quilkey and Gunawardana's (1990) analysis of the welfare effects of improved fish drying technology in Indonesia, the upward shift of the demand curve is accompanied by a downward shift of the supply curve as the technology reduces cost of drying. In Voon and Edwards' (1991c) evaluation of the benefits from research that increases protein in Australian wheat, the upward shift of the demand curve is associated with an upward shift in the supply curve due to the yield decreasing effect of producing a higher protein wheat. Simultaneuos shifts of supply and demand curves are also found in Lemieux and Wohlgenant's (1989) assessment of the likely impact of the introduction of porcine somatotropin in pigs in the U.S. The supply curve moves downwards due to the improvement in animal weight, feed cost efficiency and greater lean meat production. The demand curve moves upwards due to an increase in consumer demand on leaner pork. The study however, focuses on supply side research. Of the above mentioned studies, the works of Lemieux and Wohlgenant, and Voon and Edwards (1991c) use open economy models.

This paper addresses the measurement of welfare effects from research which both improves the quality of a traded commodity and reduces the cost of producing it. That is, the focus is on research which both lifts the demand curve and lowers the supply curve for a traded commodity. A conceptual framework using the economic surplus approach is provided for conditions of an open economy. The model is applied to the ex-ante measurement of benefits from research that improves the quality of copra in the Philippines and at the same time leads to a more cost efficient processing of copra. In this paper, quality improvement in copra refers to one percentage point decrease in its average level of moisture. The effects of research are traced through the likely changes in price and quantity of copra, and in the welfare of producers, consumers and society. The analysis does not include the investment cost of research due to the difficulty of providing reasonable estimates of research expenditures. Several instances of this approach are found in previous ex-ante research assessment studies (Freebairn, Davis and Edwards, 1982; Lemieux and Wohlgenant, 1989; Quilkey and Gunawardana, 1990; Voon and Edwards, 1991a,b,c).

2. THE QUALITY ISSUE IN PHILIPPINE COPRA

The Philippines is the principal producer of coconut products and the largest source of these products to the world market. In the period 1986 to 1989, the Philippines accounted on average for about 66% and 29% of world trade for coconut oil and copra, respectively (UCAP, 1990); these are the two main coconut product exports. Copra, dried meat of mature nuts, is the major product sold by coconut farmers. A small part (5%) of copra produced in the Philippines is exported, while the major part (95%) is used in the domestic market as raw material in the manufacture of coconut oil (CNO). CNO is both exported and used in the domestic industrial sector as raw input to such products as soap, margarine, cooking oil, lauric acid, fatty acids and methyl ester.

Copra produced in the Philippines has been characterised of poor quality mainly because of high moisture content (NEDA, 1985). It is noted that about 70% of commercial copra produced in the country contains up to 25% moisture (UCAP, 1990). High moisture copra produces low amount of CNO. Moreover, if copra is not dried immediately to at least 14% moisture, it is prone to mold growth and development of aflatoxin which may result to products also laden with aflatoxin (PCA, 1988).[1] Poor quality CNO is extracted from moldy copra and it takes extra purification to improve the oil (PCRDF, 1986). If copra moisture can be reduced to at least 12%, the formation of molds will be minimised (UCAP, 1990). Improvement of moisture content in copra is important as it affects the price received by farmers as well as demand from domestic and foreign markets. The price of copra is largely determined by its moisture content, the higher the moisture the lower the price. Under the new copra classification standards of the Philippine Coconut Authority (PCA), copra with moisture above 12% but not over 14% is given a price discount and those with moisture between 7% and below 12% get a premium. Copra with moisture above 14% and mold infection of more than 10% is rejected (UCAP, 1990).

The quality of copra depends to a large extent on drying procedures (Piggot, 1964). Copra is processed by the farmers themselves using simple tools and equipment with traditional drying procedures, sun-drying or kiln drying. While traditional procedures use low cost equipment and fuel (coconut husk and shell), these result to hardened copra with high (10% to 15%) moisture level due to lack of proper heat control. Traditional drying procedures also involve longer drying period (2 to 3 days); copra produced is contaminated with dirt,[2] have smoky odour and flavour, darkened due to smoke, and scorched from occasional excessive heat and intermittent drying (De Castro, 1977; NEDA, 1985).

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[1] Aflatoxin is a substance that causes cancer. The current acceptable level of aflatoxin in coconut oil is 200 parts per billion (ppb). The EEC, one of the major importing countries, wants to reduce this to 30 ppb and later on to 20 ppb. The implementation of these standards would mean a reduction in export earnings from coconut products of about US$47 million at 30 ppb to US$74 million at 20 ppb (PCA, 1988).

[2] Under the new copra classsification standards of the PCA, copra containing dust, dirt and other foreign matter is also discounted at the rate of 1% for every 1% dust and foreign matter (UCAP, 1990).

Research directed at improving the quality of copra has concentrated on improving drying procedures through the development of low-cost technology copra dryer and the use of chemicals which would prevent the build up of molds. The PCA places emphasis on copra dryers due to safety and cost considerations. Improved drying technology has the following features (De Castro, 1977; NEDA, 1985; PCRDF, 1986): the production of clean, sanitary, smoke free, properly dried and low moisture copra which minimises aflatoxin contamination; low cost fuel requirement as with traditional kiln drying; drying time reduced to several hours only (from 2 to 3 days using traditional methods). The introduction of improved drying technology is expected to result in more uniform quality copra that would be acceptable to traders, millers and processors. The authors are unaware of any quantitative estimates of the probable welfare effects of research on improved drying technology on copra.

3. THE ANALYTICAL FRAMEWORK

Based on goods characteristics or hedonic price models (Lancaster, 1971; Lucas, 1973; Rosen, 1974; Ladd and Suvannunt, 1976), demand for a commodity is determined by the utility provided by the characteristics of that commodity. Improved characteristics or higher quality commodity provides higher utility (Deaton and Muelbauer, 1980). The increase in consumers' utility from each unit of a commodity induces an increase in the quantity demanded of that commodity. Research that improves a certain characteristic or quality of a commodity is then associated with an upward shift of the demand curve (as in Unnevehr, 1986). Quality-enhancing research involves either a constant per unit cost of production, a decrease or increase in the per unit cost, with increase in per unit cost being common. If per unit cost of production stays the same, the supply curve does not shift. The increasing and decreasing cost considerations are represented by upward and downward supply shifts, respectively. The net price effect of the simultaneous shifts of the demand and supply curves depends upon the size of the shifts in both curves and the elasticities of supply and demand. The preceding concepts form the bases for the direction of the research-induced shifts in the demand and supply curves in this paper.

The framework developed follows the partial equilibrium, aggregate trade model by Voon and Edwards (1991c). The focus of interest is on the welfare effects on the exporting country. The demand and supply curves of the importing sector are not specified, and no estimates are provided of research benefits in that sector; hence the choice of an aggregate trade model. This paper differs from Voon and Edwards (1991c) in associating an upward shift in the demand curve due to quality improvement with a downward (rather than upward) shift in the supply curve.

The likely effects of a quality research-induced upward movement of the demand curve for copra together with a downward shift of supply curve are illustrated in Figure 1. The demand and supply curves for the commodity are assumed linear as in Quilkey and Gunawardana (1990) and Voon and Edwards (1991a,b,c). In the absence of research, the total demand curve is given by D_{t0}; D_{t0} comprises of domestic demand, D_{d0}, and export demand, Deo (not shown in Figure 1). The export demand is represented by an excess demand, the horizontal difference between D_{t0} and D_{d0}. The domestic and total demand curves for production in the exporting country are assumed to have a common intercept, B, on the price axis. The supply curve in the exporting country is given by S_0. The initial equilibrium price and quantity are $\bar{P}_0$ and $\bar{Q}_{s0}$, respectively.

Research causes the total demand curve D_{t0} to shift in parallel upwards by z dollars per unit output to D_{t1}. The shift in the total demand curve is the result of a rise by y dollars per unit in the valuation of copra by domestic consumers and a rise of u dollars per unit in the export demand curve. The initial domestic supply curve also shifts in parallel but downwards by x dollars per unit output, from S_0 to S_1. The equilibrium price increases from $\bar{P}_0$ to $\bar{P}_1$. Domestic consumption increases from $\bar{Q}_{dd0}$ to $\bar{Q}_{dd1}$. Export quantity also increases from $\bar{Q}_{s0}-\bar{Q}_{dd0}$ to $\bar{Q}_{s1}-\bar{Q}_{dd1}$. The upward movement of demand curves in both domestic and external markets represents a consumer preference for the higher quality commodity. Domestic and foreign consumers may value the quality improvement differently, permitting different price intercepts in the 'with research' situation.

The parallel shift of the demand curve implies identical valuations of consumers of quality improvement in the commodity. The parallel shift of the supply curve signifies uniform rate of adoption and cost reduction of the improved technology across adopters. In the case of supply curve, if there is no sufficient information of the true shift, the assumption

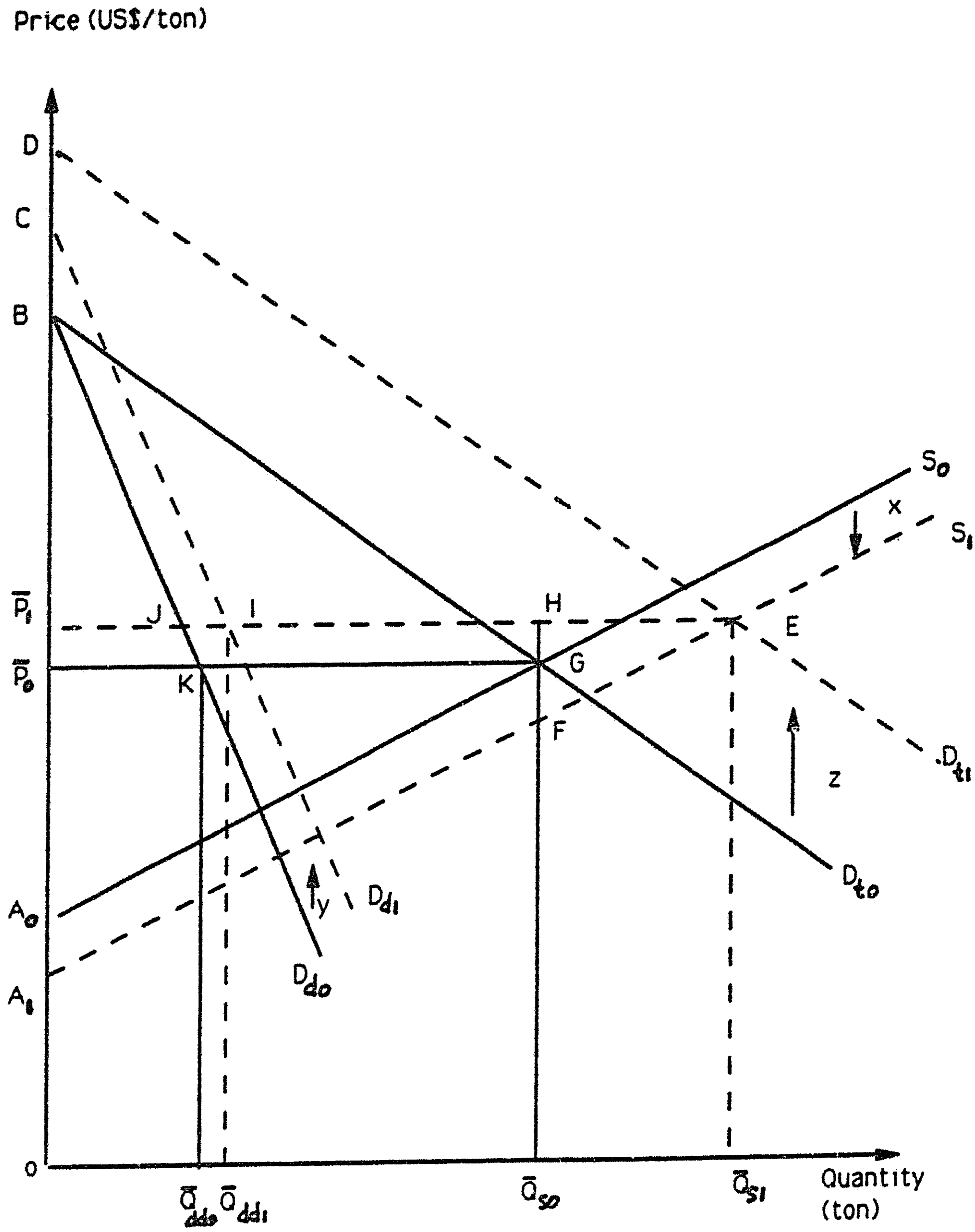

Figure 1. Welfare effects on producing country of quality improvement in copra.

of a parallel shift is a convenient and reasonable one as it minimises the error of approximating research benefits (Lindner and Jarrett, 1978; Rose, 1980; Edwards and Freebairn, 1982; and Davis and Bantilan, 1991).

Figure 1 can be used to indicate the changes in welfare effects of research that improves quality of a commodity in the exporting country. Domestic producer surplus (PS) increases by area $\overline{P}_1HG\overline{P}_0 + HEF + A_0GFA_1$ (*area* $\overline{P}_1EA_1-\overline{P}_0GA_0$). The domestic consumer surplus (CS) increases by area $BCIJ - \overline{P}_0\overline{P}_1JK$ (*area* $\overline{P}_1CI-\overline{P}_0BK$). The total change in domestic surplus (TS) is the sum of the changes in domestic producer and consumer surpluses. Producer surplus increases as demand becomes more elastic and supply becomes more inelastic.

Alternatively, the changes in price and quantity are used to measure total welfare effects of research and its distribution into domestic producers and consumer surpluses. Following Edwards and Freebairn (1984) and Voon and Edwards (1991c) the equations for linear supply and demand functions characterising initial market conditions before research, and equilibrium changes with the incidence of quality-enhancing research are specified in the following equations.

<u>Without research</u>

Domestic demand:	$Q_{ddo} = a-\alpha P_o$	(1)
Export (excess) demand:	$Q_{edo} = b-\beta P_o$	(2)
Total demand:	$Q_{tdo} = Q_{ddo}+Q_{edo}$	(3)
	$Q_{tdo} = c-\delta P_o$	(4)
Supply:	$Q_{so} = d+\varpi P_o$	(5)
Market clearing equilibrium:	$Q_{so} = Q_{tdo}$	(6)

where **P** is price, the subscript **o** denotes 'without research', **a,b,c,d** are the intercept *terms,* $\alpha, \beta, \delta, \varpi$ *are the demand, price slopes, where* $c = a+b$, $\alpha = \eta_{dd}\frac{Q}{P}$, $\beta = \eta_{ed}\frac{Q}{P}$, $\delta = \alpha+\beta$, $\varpi = \epsilon\frac{Q}{P}$, *where* η_{dd} *is price elasticity of demand,* η_{ed} *is price elasticity of export demand,* ϵ *is price elasticity of supply.*

Equations 1 to 6 can be solved for the 'without research' price and quantity, $\overline{P}_0$ and $\overline{P}_1$.

With research

Domestic demand:	$Q_{dd} = a+\alpha y-\alpha P_1$	(7)
Export (excess) demand	$Q_{ed1} = b+\beta u-\beta P_1$	(8)
Total demand:	$Q_{td1} = Q_{dd1}+Q_{ed1}$	(9)
	$Q_{td1} = c+\delta z-\delta P_1$	(10)
Supply:	$Q_{s1} = d-\varpi x+\varpi P_1$	(11)
Market clearing equilibrium:	$Q_{s1} = Q_{td1}$	(12)

where all terms are as defined above, the subscript '1' denotes post research conditions, where z = (yQddo + uQedo)/Qso. Equations 7 to 12 can be solved for the 'with research' equilibrium price and quantity, $\overline{P}_1$ and $\overline{Q}_{s1}$, and to measure changes in total surplus (TS) and its distribution to domestic producers (PS) and consumers (CS). In algebraic terms, the benefits to research can be represented as follows:

$$PS = \overline{Q}_{so}(\overline{P}_1-\overline{P}_o) + 1/2[(\overline{P}_1-\overline{P}_o) + x](\overline{Q}_{s1}-\overline{Q}_{so}) + x\overline{Q}_{so} \tag{13}$$

$$CS = 1/2(\overline{Q}_{ddo}+\overline{Q}_{dd1})\ [y-(\overline{P}_1-\overline{P}_0)] \tag{14}$$

$$TS = PS + CS \tag{15}$$

where the 'with' research equilibrium price and quantities are:

$$\overline{P}_1 = \overline{P}_o+\frac{\varpi x+\delta z}{\varpi+\delta}, \qquad \overline{Q}_{s1} = \overline{Q}_{so}+\frac{\varpi\delta z-\delta\varpi x}{\varpi+\delta}, \qquad \overline{Q}_{dd1} = \overline{Q}_{ddo}+\alpha y-\alpha\frac{\varpi x+\delta z}{\varpi+\delta}$$

4. MODEL APPLICATION AND PARAMETER VALUES

This section discusses the assumptions in applying the above model and the estimates of the parameters required. The values of the parameters are listed in Table 1. Due to limited available data, a range of values is assumed for each of four parameters to determine the sensitivity of the results to these parameters: elasticity of supply (ϵ), total or aggregate elasticity of demand (η_{td}), relative shift in domestic and export demand (y/u), and relative shift in domestic supply and aggregate demand (x/z).

Research that introduces a change in a characteristic of a commodity results in heterogeneity of that commodity. Such research may also result in substitution between different classes of that commodity. The commodity with the higher valued characteristic provides higher utility will be preferred and substituted for the lower valued characteristic commodity. A key assumption made in applying the model to the gains in quality improvement in copra - i. e. reduction in moisture content - is noted here. Copra is assumed to be a homogenous commodity before and after research. Before research, the quality of copra produced by farmers is uniformly low, i.e. high moisture level. The introduction of an improved drying technology leads to a uniform reduction in moisture content - that is, an identical improvement in the quality of all Philippine copra. Such assumption implies zero product substitution. The non-substitution between farm product and non-farm inputs in the processing of copra is also assumed. These assumptions are abstractions from the true market situation for copra which serve to simplify the theoretical framework.

Initial price and quantities. Values for the initial price and quantities of copra are inferred from time series data compiled yearly by the PCA and the United Coconut Association of the Philippines (UCAP). Farm price of copra (US$214/ton), quantity supplied (1,913 thousand tons), domestic demand (1,832 thousand tons) and export demand quantity (103 thousand tons), refer to the averages for the years 1981 to 1989. This is the post-levy period, a levy on copra sold by farmers having been abolished in 1980.

Elasticities. Studies on the elasticities of supply and demand for copra are limited. The elasticity of supply of copra is related to the elasticity of supply of coconut from which

Table 1. Parameter Values for Philippine Copra

Parameter	Description	Value
Q_{so}	Commercial production of copra 1/	1,913 thousand tons
Q_{ddo}	Domestic demand for copra 1/	1,832 thousand tons
Q_{edo}	Export (excess) demand for copra 1/	103 thousand tons
P_0	Domestic average farm price of copra 1/	US$214/ton
ϵ	Price elasticity of farm supply of copra 2/	0.96, 2
η_{td}	Price elasticity of aggregate demand for copra 3/	-2, -5, -20
y	Value of one percentage point for the quality improvement in copra, i.e. one percent reduction in moisture level, in the domestic sector 4/	US$2.14/ton
y/u	Ratio of domestic and export consumer valuation of the quality improvement in copra 5/	0.5, 1.0, 1.5
x/z	Ratio of the supply and demand shifts 5/	0.1, 0.5

1/ From Coconut Statistics, 1989, 1990 publication.

2/ The lower value is from Estrada and Bantilan, 1991 and the higher value is provided by the authors.

3/ Weighted average of elasticities of domestic and export demand based on assumed values.

4/ Based on the initial farm price of copra (Po) and the price premium on lower moisture copra by the Philippine Coconut Authority (PCA).

5/ The relative shifts in domestic and export demand, and in supply and aggegate demand are parameterised.

copra is produced. Of the total nuts harvested, about 90% is processed into copra, the rest being used by dessicating companies and as food nuts. Based on experts' subjective estimates of elasticities of agricultural commodities in the Philippines compiled by Estrada and Bantilan (1991), the price elasticity of supply of coconut in the country is 0.96. The sensitivity analysis conducted uses elasticity of supply of 0.96 (inelastic) and 2 (elastic).

Librero (1971) has empirically estimated price elasticities of copra demand (domestic, export, and aggregate) by associating the demand for its joint products, CNO and copra meal. Using time series data for the years 1950 to 1967, the results from Librero's empirical estimation point to inelastic demand for copra: export demand (ned), -0.387 to -0.514; domestic demand (ndd), -0.593 to -0.855; and aggregate demand (ntd), -0.464 to -0.610. The inelastic estimates, as Librero suggests, is a short-run phenomenon. An elastic demand best describes the prevailing market for copra due to the following reasons. First, the Philippines is a price taker in the world market for coconut products due to increasing competition from other coconut producing countries, and from substitutes of CNO (main product of copra) such as U.S. soybean oil and Malaysian palm oil. Second, CNO comprises only 4% of the total world market for oils. Assumed values of η_{td}= -2, -5, -20 are used in the empirical analysis in this paper. The values are weighted averages also of assumed values η_{ed} = -3, -7, -23 and η_{dd} = -1.95, -4.9, -19.85. The share of quantities of copra export (5%) and for domestic use (95%) are used as weights.

<u>Supply and demand shifters</u>. Hedonic price studies on quality of copra in the Philippines are not available. In this paper, the value of one percentage point reduction in moisture content in Philippine copra to domestic consumers, y, is based on the copra pricing scheme by PCA. The PCA pricing scheme reflects to some extent the domestic consumer preference for lower moisture copra. For a 0.1% decrease in moisture below the base level of 12%, i.e. 11.9%, a premium of 0.6% is provided. A price premium at the rate of 0.1% is given for succeeding 0.1% decrease in moisture level. Copra with moisture level of 7% and below has the highest premium of 5.5%. The premium rate of 0.1% for every 0.1% decrease in moisture is applied to the average farmgate price of copra (US$214/ton x 0.001 = US$0.214 /ton) to arrive at the valuation of domestic consumers of one percentage point reduction in moisture content (US$ 0.214 x 10 = US$2.14/ton). In the importing sector, consumer valuation

of the improvement in moisture content of copra, u, maybe different from domestic consumer valuation in the Philippines. In the empirical analysis, u is parameterised relative to the value of y (0.5y, 1.0y, 1.5y). The shift in the aggregate demand curve is measured by $z=(yQ_{ddo}\ uQ_{edo})/Q_{so}$.

The cost reduction effect (x) of research on improved and low-cost copra dryer technology has not been formally studied. In ex-ante measurement of research benefit, Rose (1980) suggests that the cost effect or the size of the supply shift maybe determined at the initial price and quantity with an estimate of the percentage change in cost. For illustrative purposes, the vertical shift in the supply curve, x, is also parameterised (0.1z, 0.5z) relative to the value of the vertical shift in aggregate demand z.

5. RESULTS

Welfare effects to the domestic sector of a one percent reduction in the moisture level of copra are shown in Table 2. Initially, the ratios y/u and x/z are held constant at 0.5 and 0.1, respectively. If supply is inelastic, e=0.96 and demand is elastic, η_{td}= -2, the annual total surplus is US$4.5 million at current prices. Producer share of total surplus is 79%. As aggregate demand becomes more elastic, -5, total surplus increases slightly (US$4.53 million), producer share also rises to 92%. As aggregate demand becomes very elastic, -20, total surplus increases also slightly (US$4.55 million), producer share goes up, 102%; and there is a consumer surplus loss. With a very elastic demand (-20) and if y/u remains at 0.5, if the decrease in moisture content of copra is obtained at greater cost reduction (supply shift is x=0.5z) total surplus increases (US$6.30 million or by 38%). Producer share increases slightly to 103% and consumer surplus loss becomes larger.

In general, if the valuation of consumers from both domestic and importing sectors are similar (y=u), i.e. size of vertical shift in both demand curves is the same, the expected total surplus falls, regardless of the relative shift in supply and demand. Total surplus falls further, although not significantly, as valuation of domestic consumers is greater than the valuation of consumers in the importing sector, u=1.5y. The share of producers to total surplus decreases and consumer surplus becomes larger.

If supply of copra is elastic (-2), expected total surplus is slightly smaller than the expected surplus if supply is inelastic, 0.96, and if demand is elastic (-2) and more elastic (-5). If demand is very elastic (-20), total surplus increases but only slightly. The share of producers to total surplus is smaller as supply becomes elastic.

Table 2. Effects of Supply Elasticity (ϵ), Aggregate Demand Elasticity(η_{td}), the Relative Shift in Domestic and Export Demand (y/u), and the Relative Shift in Supply and Aggregate Demand (x/z), on the Size and Distribution of Philippine Benefits from Quality Improvement Research in Copra*

- In US million dollars per year -

ϵ	0.96						2.0					
y/u	0.5		1.0		1.5		0.5		1.0		1.5	
x/z	0.1	0.5	0.1	0.5	0.1	0.5	0.1	0.5	0.1	0.5	0.1	0.5
η_{td} = -2												
PS	3.55	5.85	3.37	5.56	3.31	5.46	2.86	5.47	2.72	5.20	2.67	5.10
CS	0.95	0.42	1.10	0.59	1.15	0.65	1.62	0.78	1.73	0.94	1.77	1.00
TS	4.50	6.27	4.47	6.15	4.46	6.11	4.48	6.25	4.45	6.14	4.44	6.10
PS/TS(%)	0.79	0.93	0.75	0.90	0.74	0.89	0.64	0.88	0.61	0.85	0.60	0.84
η_{td} = -5												
PS	4.19	6.21	3.98	5.89	3.90	5.79	3.71	5.95	3.52	5.65	3.46	5.54
CS	0.34	0.07	0.52	0.27	0.59	0.34	0.81	0.34	0.97	0.52	1.02	0.58
TS	4.53	6.28	4.50	6.16	4.49	6.13	4.52	6.28	4.49	6.16	4.48	6.12
PS/TS(%)	0.92	0.99	0.88	0.96	0.87	0.95	0.82	0.95	0.78	0.92	0.77	0.91
η_{td} = -20												
PS	4.64	6.46	4.40	6.13	4.33	6.02	4.48	6.38	4.25	6.05	4.18	5.95
CS	-0.09	-0.16	0.12	0.04	0.18	0.11	0.08	-0.07	0.28	0.13	0.34	0.20
TS	4.55	6.30	4.52	6.18	4.51	6.13	4.56	6.31	4.53	6.18	4.52	6.15
PS/TS(%)	1.02	1.03	0.97	0.99	0.96	0.98	0.98	1.01	0.94	0.98	0.92	0.97

* The figures refer to the benefits of one percent reduction in the moisture level of copra. The valuation of the quality improvement in copra by consumers in the domestic sector, y, is held constant at US$2.14/ton. The valuation of consumers in the importing sector, u, is allowed to vary by the values 0.1y, 0.5y and 1.5y.

6. SUMMARY AND CONCLUSION

This paper extends application of the aggregate trade model by Voon and Edwards (1991c), in measuring benefits that lifts the demand curve with a combined shift of the supply curve. The main difference is in associating a downward (instead of an upward shift) of the supply curve. The main findings of the empirical analysis are : the size of aggregate benefits to research is slightly sensitive to the price elasticities of supply and demand,and the distribution of benefits is largely affected by changes in these two parameters; the share of producers to aggregate benefits decreases as supply becomes more elastic and increases as demand becomes more elastic; if consumers in the domestic sector have greater valuation of the quality improvement in copra relative to the valuation of consumers in the importing sector, aggregate benefits and share of producers decrease; and producer benefits increase as quality improvement is obtained at lesser cost.

The framework developed in this paper has some limitations given simplifying assumptions. Its merit can be viewed as a tool in quantifying the welfare effects of a quality enhancing and cost reducing research for a traded commodity in the producing country. There are possible extensions or revisions to the framework. First, allowing for substitution effects between different classes of that commodity where quality improvement occurs, as well as input substitution in the production of the commodities. Second, extending the analysis to account for the demand and supply shifts in the importing sector under conditions of price and technology effects. Third, analysis of the distribution of benefits in a multi-market system and joint products. Demand for copra is a derived demand for its joint products, coconut oil (CNO) and copra meal. Also, because of the large trading sector in copra, some of the benefits to quality research is shared by domestic traders and exporters.

Another aspect which merit some attention in the analysis would be the inclusion of research cost which would match the aggregate benefits. Such area may be of primary interest to agencies accountable for public expenditures.

One of the implications of the empirical analysis is the direction of research, whether research on quality improvement should place emphasis on low cost technology or higher cost technology. In an economy where small producers comprise the majority low cost technology is desirable for equity consideration. In the Philippine coconut industry, small farms predominate in number (about 90% of total number of farms) although their total landholdings comprise only one third of the total coconut land area in the country (Habito and Intal, Jr., 1990). From a micro point of view, such technology could provide higher incomes to small farmers due to better prices. From a macro point of view, there would be a general improvement in the quality of copra produced in the Philippines which may increase general welfare.

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