PRIMARY PACKAGING COST ANALYSIS FOR FRESH BEEF FROM PACKER TO RETAIL DISTRIBUTION CENTER: A CASE STUDY

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September 1972

TEXAS AGRICULTURAL MARKET RESEARCH AND DEVELOPMENT CENTER
in cooperation with the
Department of Agricultural Economics and Rural Sociology
Texas A&M University, College Station, Texas
and the Transportation and Facilities Research Division
Agricultural Research Service, United States Department of Agriculture
Washington, D. C.

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ACKNOWLEDGMENTS

The author wishes to express appreciation to Mr. Dale Anderson and Mr. Karl E. Hoke, both of the Transportation and Facilities Research Division, Agricultural Research Service, for their many helpful suggestions and general cooperation during the course of this study.

Also, the study would not have been possible without the guidance and cooperation of Dr. Gary Smith and Dr. Zerle Carpenter, both of the Animal Science Department, Texas A&M University. In addition, Dr. Ronald Rea, formerly a graduate student in the Animal Science Department, Texas A&M University, and now with Armour and Company, provided the necessary logistics skills for accomplishment of the test shipments.

This research was partially supported by a grant from the Transportation and Facilities Research Division, Agricultural Research Service, United States Department of Agriculture.

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INTRODUCTION

An important aspect of the distribution channel for beef is its movement from packer to distribution centers of retail grocery outlets or to branch houses. During 1971, approximately 21.7 billion pounds of beef were distributed from packers [1]. This total tonnage, of course, was distributed to both the retail grocery trade and the hotel, restaurant, and institution (HRI) trade.[1/] The majority of beef still moves fresh to the retail grocery segment in the form of hanging quarters, primals, or sub-primals. This particular distribution channel segment is the focus of the research presented in this report.

Farm-retail price spreads for beef have increased 40 percent from 1962 to 1971. Increases in the price spread for beef have accompanied rising marketing costs since 1962. Rising marketing costs during this period were composed of increases in meat packing and processing, employee wages, increases in costs of supplies and services bought by marketing firms, and increases in container and packaging material cost, among

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[1/] See [8] for recent HRI movement.

other cost components [1]. These generally rising marketing costs lend propriety to research concerning possible reduction in the costs of beef distribution.

PREVIOUS WORK

One of the most extensive analyses on costs of the physical distribution system for fresh beef is the Kearney study [4]. This study detailed the costs involved in alternative physical distribution methods for the whole system. A similar study recently completed at Kansas State University dealt with the comparative costs incurred for fresh and frozen meat preparation [3]. Both studies dealt with the entire physical distribution channel.

There are other studies which have concentrated on various aspects of the costs for a particular segment of the physical distribution channel. For example, the centralized processing of fresh beef for retail stores was studied by Volz [9]. Also, A. T. Kearney and Company reported on the feasibility of an analytic physical distribution system model for cattle and beef in 1969 [5].

Even though much work has been done on some aspects of the physical distribution channel and on the costs of the aggregate system, little economic analysis exists on the costs incurred in the utilization of primary packaging materials for fresh beef and from packer to distribution center. The need for an "inexpensive" primary packaging material that would protect fresh beef cuts from contamination and shrinkage that

occurs during transit was suggested by the U.S. Department of Agriculture in a 1966 report [7]. As a consequence of this general situation, the Marketing and Transportation Facilities Branch of the Agricultural Research Service cooperated on the research reported herein.

OBJECTIVES

This report provides the results of the economic phase of a larger research project conducted by the Animal Science Department, Texas A&M University [6]. The specific objectives of the economic phase were:

1. To identify the costs associated with the utilization of primary packaging material for distribution of fresh beef from packer to distribution center or branch house.
2. To evaluate alternative types of primary packaging material with respect to cost and the protection they afford in terms of sanitation and shrink.

METHODOLOGY

A case study approach to the problem was utilized because primary data was collected in conjunction with test shipments. The logistic difficulties involved in attempting to collect data in conjunction with test shipments over a number of packers deemed an approach other than case study infeasible.

Cooperators for the test shipments were established and economic data were collected during 1970 and 1971. Test shipments were made for both hanging quarters and primals in refrigerated truck trailers for

both intermediate and long range hauls. These shipments were monitored with respect to shrinkage, bacterial changes, physical appearance associated with alternative packaging materials, as well as costs involved in utilization of packaging materials.

Five test shipments were conducted from the same origin but to different destinations. For each test load, individual weights were collected for quarters and primals immediately before application of the primary packaging material. The refrigerated truck trailers were loaded by plant workers in the manner customary for normal shipments. Labor time observations were recorded both at the point of origin and destination. A total of 865 primals and quarters were in these test shipments.

At destination, data were collected on individual weights after removal of the primary packaging material. Bacterial samples and subjective scores for physical appearance were recorded for individual cuts at this time. Details on the five test shipments in terms of load size, methods of temperature recording, and the other physical characteristics for the shipments are in Rea [6, pp. 65-130]. Only data pertinent to the economic analysis phase of the research is in this report.

Alternative primary packaging materials (or protective wraps) were evaluated by averaging over test shipments. The alternative treatments were:

1. unwrapped or naked
2. paper bag
3. polyethylene bag
4. polyvinyl chloride (PVC) film

All costs and the savings attributable to a reduction in shrink were ultimately converted to a hundredweight basis. This enables direct comparison of costs at various points in the segment under study as well as direct comparison of costs among treatments. Two categories of beef shipped, primals and quarters, are treated separately throughout the study since significant differences sometimes occurred in the cost elements of these categories. Therefore, aggregation of the data to a single cost or revenue for all fresh beef was considered inadvisable.

COST AND REVENUE IDENTIFICATION

The first objective of the economic phase of the research was to identify the potential costs and revenues if primary packaging material is utilized. For purposes of primary data collection, potential costs were categorized by the point in the system at which they occur (i.e., either origin or destination). The potential cost savings or revenues attributable to primary packaging material were considered separately.

Identification of the potential costs or revenues is outlined as follows:

I. Potential Costs Associated with Material Utilization - Origin

   A. Cost of packaging material

      1. Amount of material used per cut
      2. Cost per unit for the material

   B. Labor cost of applying packaging material

      1. Time requirement (average seconds per cut)
      2. Total labor cost per hour (wage rate plus fringe benefits)

C. Cost of packaging material inventory

1. Storage (cost of space occupied by minimum inventory of material)
2. Opportunity cost on capital invested in packaging inventory material

D. Cost for additional machinery or equipment required for application of packaging material

F. Cost of rewrapping cut after breakage (if any)

G. Cost incurred due to reduction in payload from packaging cuts (represented as an increase in transportation rate on a ton/mile basis)

H. Differences in cooling requirement from packaging cuts compared to naked

II. Potential Costs Associated with Material Utilization - Destination

A. Labor cost of packaging material

1. Time requirement (seconds per cut)
2. Total labor cost per hour (wage rate plus fringe benefits)

B. Packaging material disposal cost

1. Labor cost
   a) Time requirement
   b) Total labor cost per hour
2. Cost of incineration or removal from premises (if any)

III. Potential Cost Savings (or Revenues) from Material Utilization

A. Reduction in shrink attributable while carcass to primary packaging is in transit (between cooler in packing plant and cooler at destination)

B. Extension of shelf life (microbial reduction attributable to primary packaging)

C. Reduction in percent of trim of wrapped versus naked at destination

D. Increase in palatability of wrapped versus naked

A note of explanation concerning palatability is needed. A priori, no significant differences in palatability among cuts attributable to primary packaging were expected. Palatability was considered a necessary condition before any primary packaging material could be considered a viable alternative.

The items in the above list are generally self-explanatory. However, it must be emphasized that some items listed are only potential costs. For example, items such as I, 5 through I, 7 are potential costs that might occur when primary packaging material is utilized. That is, these are costs that can be listed on an a priori basis but by actual observation (or experiment) may not occur. Obviously, other cost items such as I, 1 will occur whenever packaging material is used. The test shipments were monitored for each item in the above list even though some did not occur or were so insignificant that they could not be quantified.

Item I, 5 "cost of rewrapping cut after breakage" needs some explanation. The possibility exists that, after a cut is wrapped it may be inadvertently dropped, breaking or severely damaging the packaging material to the extent that rewrapping is necessary. This was closely checked during the data collection phase.

In terms of revenues from material utilization, all items listed under III represent potential cost savings. However, because of data collection problems involved in measurement of items III, 2 and III, 3 from monitoring test shipments, the only revenue quantified for the test shipments was item III, 1. Obviously, if cost savings from a reduction

in shrink attributable to wrapping exceeds all costs associated with material utilization, then utilization is economic. The only requirement on the remaining items is that there is no significant decrease attributable to packaging material. That is, the wrapped cuts must have equal or greater palatability compared with the naked cuts. This was, in fact, the situation for cuts in simulated laboratory tests [6].

COSTS ASSOCIATED WITH PACKAGING MATERIAL UTILIZATION

The costs associated with primary packaging material utilization are discussed in the approximate order in which they appear in the above outline. For each item, insofar as possible, detailed cost information was collected during the test shipments in the cooperating packing plants and/or distribution centers.

Packaging Material Costs

In order to determine the cost of material for primals and quarters the average amounts of packaging material used per piece were monitored in the packing plant. The primal category included the following cuts:

1. Rounds
2. Chucks
3. Loins
4. Ribs

The quarters category included both forequarters and hindquarters. The sizes and/or amounts of primary packaging material utilized, on the average, differed somewhat by cut (Table 1).

The cost of each type of packaging material was also collected (Tables 2, 3, 4). The prices utilized to compute these costs reflect

TABLE 1

Sizes or Amounts of Packaging Material Utilized, by Cut

Cut	Type of Packaging Material		
	PVC Film	Polyethylene Bag	Paper Bag
		-inches-	
Forequarter	48 X 80	40 X 52	40 X 52
Hindquarter	48 X 80	31 X 61	31 X 61
Rounds	48 X 40	25 X 44	31 X 39
Chucks	40 X 60	25 X 44	31 X 39
Loins	40 X 60	25 X 39	25 X 39
Ribs	48 X 48 sheet	25 X 30	25 X 30

Source: Primary data.

TABLE 2

Utilization and Cost of PVC Film, by Cut

Cut	Average Amount Used Per Cut	Cost Per Cut*
	- Square Inches -	- cents -
Quarter	3840	8.4
Round	1920	4.2
Chucks	2400	5.3
Loins	1600	3.5
Ribs	1440	3.2

*Based on $37.80 per 48" X 3000' roll and $31.80 per 40" X 3000' roll or 2.1875¢/1000 square inches and 2.2083¢/1000 square inches respectively. Prices reflect quantity discounts.

Source: Primary data.

TABLE 3

Cost of Polyethylene Bags, by Cut

Cut	Size of Bag	Cost Per 500 Bags*	Cost Per Bag*
		-dollars-	-cents-
Forequarter	40 X 52	28.18	5.6
Hindquarter	31 X 61	25.88	5.2
Round & Chuck	25 X 44	23.00	4.6
Loins	25 X 39	19.00	3.8
Ribs	25 X 30	15.00	3.0

*Prices reflect quantity discounts.

Source: Primary data.

TABLE 4

Cost of Paper Bags, by Cut

Cut	Size of Bag	Cost Per 1000 Bags*	Cost Per Bag*
		-dollars-	-cents-
Chuck & Round	31 X 39	$54.30	5.4
	25 X 30	34.05	3.4
	25 X 39	54.65	5.5
Hindquarter	31 X 61	79.70	8.0
	31 X 58	76.45	7.6
	28.5 X 52	66.25	6.6
Forequarter	40 X 52	88.25	8.8
	40 X 39	68.40	6.8

*Prices reflect quantity discounts.

Source: Primary data.

quantity purchase discounts. Prices would be somewhat higher than those shown for small volume purchasers.

The average cost of each type of primary packaging material by category was derived using the information in Tables 2, 3, and 4 along with the average weights of cuts over all these shipments. The average cost of the packaging material was computed on a per 100 pound basis (Table 5). The packaging material cost on a cents per hundredweight basis was similar across types of material for quarters. For primals, however, the cost for material was lowest for the polyethylene bags and about the same for paper bags or PVC film (Table 5).

Labor Cost

Labor time observations were taken for both the application and removal of each type of protective wrap and recorded by cut. The labor time observations were actually taken in terms of number of cuts wrapped per unit time, but were converted to seconds per cut for expository purposes. Of course, the labor time recorded represented an average time over a number of cuts. These times were subsequently averaged into two categories, primals and quarters (Table 6).

Since the basic unit on labor time observations was seconds per cut, these basic units were converted to minutes per 100 pounds (minutes / cwt.) which allows for the ultimate conversion of all cost data to cents per hundredweight. Minutes per 100 pounds were computed as:

Minutes / cwt. =

[((seconds / cut) / (pounds / cut))100] / 60

TABLE 5

Average Cost of Packaging Material, by Type, for Primals and Quarters

Packaging Material Type	Category	
	Primals	Quarters
	-¢/cwt.[a/]-	
PVC Film	5.12	6.40
Polyethylene Bags	3.33	6.43
Paper Bags	4.83	6.03

[a/] Costs based on cooperating firm's own experience. Cost is particular average over all weights of cuts having a particular treatment shipped in test shipments.

Source: Primary data.

TABLE 6

Average Application and Removal Labor Time for Primals and Quarters, by Type of Packaging Material

Packaging Material Type	Category[a/]	
	Primals	Quarters
	-Seconds Per Cut-	
PVC Film		
Application	23.2 ± 2.0	39.2 ± 5.5
Removal	16.6 ± 1.7	15.2 ± 2.0
Polyethylene Bags		
Application	27.2 ± 1.8	61.1 ± 16.5
Removal	11.4 ± 2.0	8.9 ± 2.5
Paper Bags		
Application	27.8 ± 1.3	46.4 ± 5.7
Removal	11.0 ± 2.1	12.9 ± 0.8

[a/] All times are mean averages with one standard error.

Source: Primary data.

Results of this conversion show application time generally about three to five times greater than removal time for polyethylene and paper bags (Table 7). For the PVC film, however, application time was generally less but removal time more than with either type bag. The greater removal time was attributable to the method required for removal of the PVC film. It is most efficiently removed by unwrapping in the same pattern as it was applied. This generally took more time.

Of course, the two components of labor cost involved in the utilization of primary packaging material are the costs of application and removal. To obtain a labor cost per hundredweight for application and removal, the prevailing union scale wage for wrappers during 1970 was used: $4.04 per hour with $1.41 fringe benefits per hour and employee contributions of $0.22 per hour FICA-FUI-SUI. Thus, total application and removal labor cost was computed using a per hour rate of $5.67, or 9.45 cents per minute.

These costs are additive to total labor cost associated with material utilization, since they are in the same units, cents per hundredweight (Table 8). The total mean labor cost is similar over material types for primals and is also similar over material types for quarters. The labor cost for primals ranged between eight and nine cents per hundredweight while, for quarters, the labor cost ranged between six and seven cents per hundredweight.

TABLE 7

Average Application and Removal Labor for Primals and Quarters, by Type of Packaging Material

Packaging Material Type	Category			
	Primals		Quarters	
	Application	Removal	Application	Removal
	-Minutes / cwt.-			
PVC Film	0.51	0.34	0.47	0.17
Polyethylene Bags	0.70	0.20	0.62	0.12
Paper Bags	0.73	0.21	0.50	0.15

Source: Primary data.

TABLE 8

Average Labor Cost of Application and Removal for Primals and Quarters, by Type of Packaging Material

Packaging Material Type	Category	
	Primals	Quarters
	-¢ / cwt.-	
PVC Film		
Application	4.8	4.4
Removal	3.2	1.6
Total	8.0	6.0
Polyethylene Bags		
Application	6.6	5.8
Removal	1.9	1.1
Total	8.5	6.9
Paper Bags		
Application	6.9	4.7
Removal	2.0	1.4
Total	8.9	6.1

Source: Primary data.

Material and Labor Costs

The foregoing analysis allows the separate costs for material and labor to be aggregated into a single cost (Table 9). An interesting relationship is established by the aggregation of material and labor costs. For both PVC film and paper bags, the cost for primals exceeded the cost for quarters (on a cents per cwt. basis). However, for the polyethylene bag, the cost was greater for quarters than primals. This latter relationship may be primarily attributed to the relatively high application time for the polyethylene bag to quarters (Table 6). Often workers experienced difficulty in applying the polyethylene bag to quarters which accounts for the relatively greater application time and subsequent relationship for material and labor cost of primals versus quarters (Table 9).

On the average, material and labor cost for primals ranged between about twelve and fourteen cents per hundredweight, depending on the type of packaging material. For quarters, this same cost ranged from about twelve to thirteen cents per hundredweight.

Material Inventory Cost

Another cost associated with the utilization of primary packaging material, which cannot be ignored from an economic standpoint, is the cost of keeping some inventory of the material. There are two cost components involved. One cost is the storage cost of space occupied by warehousing a material inventory. The second is the opportunity cost incurred on the capital invested in inventory. Dollars invested in

TABLE 9

Average Material and Labor Cost
for Primals and Quarters, by Type

Packaging Material Type	Category	
	Primals	Quarters
	- ¢ / cwt.-	
PVC Film	13.1	12.4
Polyethylene Bags	11.8	13.3
Paper Bags	13.7	12.1

Source: Primary data.

material inventory represent dollars which cannot be invested elsewhere. Even though this latter cost is comparatively small its existence should be recognized.

To obtain estimates of these two costs on a hundredweight basis, a simplistic inventory model was used which involves assumptions concerning the packaging material inventory cycle. Assumptions involved are 1) that a firm never wants to deplete the packaging material inventory completely, 2) that the administrative costs of ordering are such that an arrangement can be made with material suppliers to ship some amount of wrapping material periodically, and 3) that the cost of space needed to store the material inventory on hand during the "inventory cycle" is imputed from the cost of new building construction. These are all viable assumptions and lead to the inventory model depicted graphically in Figure 1.

The posited inventory model leads to a cost for inventory storage based upon the average amount of material in inventory per unit time. This average amount in inventory is denoted as "a" in Figure 1 while "b" denoted some small non-zero amount held in reserve inventory for contingency. The average amount in inventory is, of course, a function of the number of pounds of beef wrapped per unit time.

The cost of storage space for the material inventory was imputed at the rate of $5.80 per cubic foot. This cost is derived from data provided by firms cooperating in the study. Using this cost for storage and the inventory model depicted in Figure 1, a total cost of packaging material inventory was computed.

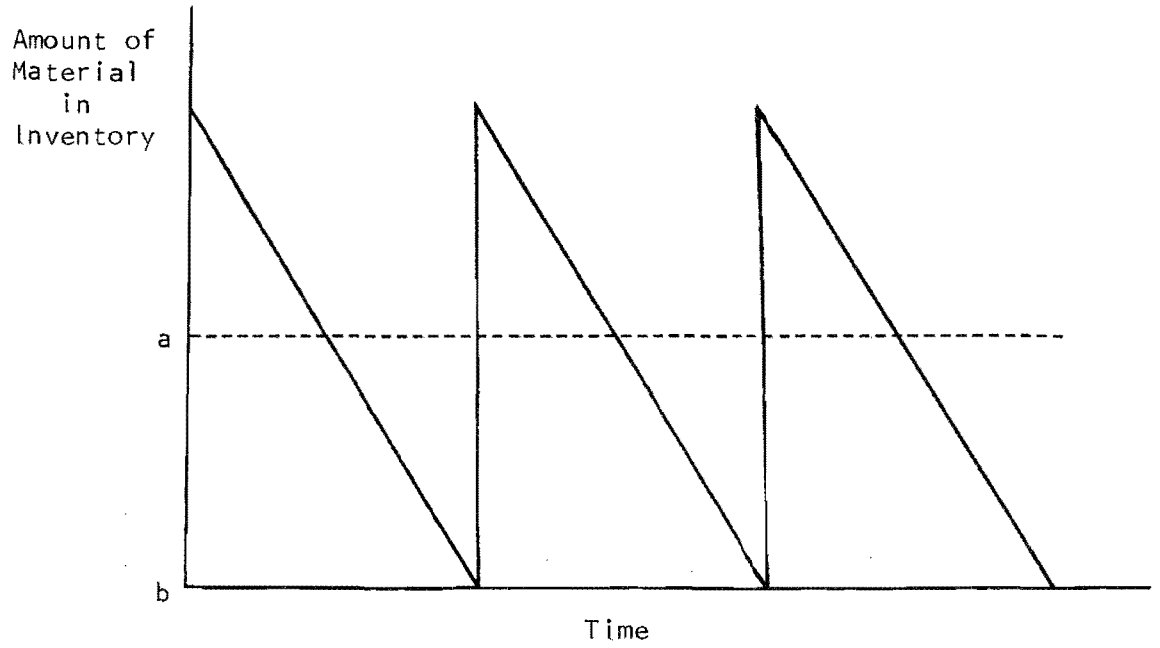

Figure 1. Inventory Model of Packaging Material

For each of the three primary packaging materials included in this study, the value of "a" in the inventory model was computed to be approximately six rolls of PVC film, six boxes of polyethylene bags, and six bales of paper bags. This amount was determined assuming an average plant output of 1,750 hundredweight per week of quarters and 750 hundredweight per week of primals. This also yields a minimum inventory level ("b" in Figure 1) of three rolls, boxes, and bales for the various materials. The inventory cycle was computed for a weekly basis.

Given this inventory model, the cost of storage for the minimum inventory level is approximately 0.28 cents per hundredweight, based on the occupancy of approximately 2,100 cubic inches by the minimum inventory.

The opportunity cost portion of the material inventory cost was also based on the inventory model of Figure 1. This opportunity cost incurred on capital invested in inventory was computed for the minimum inventory at a rate of 10 percent simple interest per annum. This cost was such a small amount (about one cent per million pounds) that it is ignored in the subsequent analysis.

Additional Capital Equipment Cost

Additional capital equipment required for the utilization of primary packaging material was minimal except for one treatment. For any of the three treatments, additional capital equipment in the form of staplers, staples, and two-wheel hand trucks were required for application of the

material. The cost of one hand truck to move packaging material from the point of storage to the point of use was $250. Approximately another $100 worth of capital equipment was involved in the application of the material. All capital equipment cost was computed on the basis of amortization over a five year period with zero salvage value and a straight-line depreciation schedule.

The only treatment which required additional investment in capital equipment in the form of a machine was the PVC film. The machine is a portable device which aids the wrapper through utilization of a hot wire to sever from a roll the amount of material needed to wrap one cut. The cost of such a machine during 1970 was $675. The machine - labor relationship is one man per machine.

A man and machine have an average wrapping capacity of approximately 80 hundredweight per hour for primals and approximately 140 hundredweight per hour for quarters. These are capacity figures and allow for no down-time attributable to either man or machine. Assuming $100 maintenance over the life of a machine and asset amortization computed on a zero salvage value five year straight-line basis, investment in the machine would be approximately 0.05 cents per hundredweight for quarters and 0.09 cents per hundredweight for primals. This, of course, is an average cost per hundredweight if the machine were operated at capacity. Consequently, these costs would be somewhat higher for less than capacity volume.

Other Packaging Costs

On an a priori basis, potential costs for rewrapping a cut after accidental breakage, potential decrease in payload, potential differences in cooling requirement, and material disposal cost at destination were all listed (see outline above). However, these costs were either so negligible that they could not be quantified, or did not exist.

Through observation of material disposal operations at destination, it was determined that material removal from the premises was performed with other customary disposal operations. Consequently, the amount of cost which could be attributed to material disposal was impossible to separately quantify.

Other potential costs such as rewrapping, reduction in payload and differences in cooling did not exist.

TRANSPORTATION, LOADING, AND UNLOADING COSTS

The costs associated with loading a truck trailer at origin, transportation from packer to distribution center, and unloading at destination has no direct bearing on a comparative cost analysis for various types of primary packaging material. This is true since these costs are not a function of whether or not the meat is wrapped. Conceivably, there could be minute differences in loading or unloading labor time if wrapped cuts were more difficult to handle. Observation of actual operations, however, showed that wrapped cuts were treated identically to naked cuts and were not more difficult to handle.

Despite the fact that costs associated with the above functions have no direct bearing on the comparative cost analysis contained herein, some data were collected on these costs solely as a matter of interest. Transportation costs, of course, are readily available from the Interstate Commerce Commission's published transportation rates.

The average total labor cost of loading or unloading a trailer containing 35,000 pounds of hanging primals and quarters (mixed load) was computed to be 0.24 cents per hundredweight. This figure includes both wages and fringe benefits. This yields an average total cost per trailer of $84.

COST SAVINGS (REVENUES) ASSOCIATED WITH PACKAGING MATERIAL UTILIZATION

As previously noted, there are four potential cost savings or revenues from utilization of primary packaging material. The potential cost savings to the system of wrapping compared to shipping naked are:

1. Reduction in shrinkage while carcass is in transit between cooler in packing plant and cooler in distribution center.
2. Extension of shelf life (microbial reduction attributable to packaging).
3. Reduction in percent trim at distribution center (may not be any differences among treatments).
4. Increase in palatability.

From the test shipments on which this study was based, the last three items of the above list were observed to be as good for wrapped cuts as those shipped naked. That is, surface microbial count was no more for wrapped cuts, percent trim was no more for wrapped cuts, and

palatability was no less for wrapped cuts. This situation then allows the comparative analysis of revenues to be simplified to just differences in percent shrink over treatments. This, of course, may yield a conservative estimate of revenues.

Shrink and Hours In-Transit

Over all test shipments, the average percent shrink as a function of hours in transit reveals the differences in utilizing primary packaging materials (Table 10). These relationships are not particularly important by themselves since costs are not considered and since the estimated coefficients are aggregated over both quarters and primals. However, the coefficients give a gross preview of the revenues attached to utilizing primary packaging material.

Shrink - Quarters and Primals

A more detailed analysis of actual in-transit shrink from packer to distribution center is needed for evaluation of revenues. The mean shrink over all test shipments by treatment and type of cut was calculated (Table 11). The mean for each treatment by cut is reported with its standard error. All means are significantly different from zero at the .05 level.

As expected, primal shrink was generally greater for any treatment than quarter shrink. The exception was for the PVC film treatment where the means were about the same. For either category, unwrapped cuts shrank most while PVC film wrapped cuts shrank least.

TABLE 10

Simple Linear Regressions of Percent Shrink as a Function of Hours in Transit, Average Over All Test Shipments, By Type of Packaging Material

Type of Packaging Material	Estimated Coefficients			
	a	b	t	r
		(percent/hour)		(percent)
Naked	0.378	0.015	3.98**	75.4
Paper Bag	0.097	0.011	4.24**	80.1
Polyethylene Bag	0.170	0.007	2.35*	59.7
PVC Film	0.093	0.006	2.46*	59.6

*Significant at the .05 level.
**Significant at the .01 level.

Source: Primary data.

TABLE 11

Average Shrink Over All Test Shipments,
by Type of Packaging Material, for Quarters and Primals

Packaging Material Type	Quarters		Primals	
	Mean	Standard Error	Mean	Standard Error
	-percent-			
Naked	1.023	0.181	1.375	0.320
Paper Bag	0.705	0.152	0.918	0.274
Polyethylene Bag	0.590	0.070	0.662	0.274
PVC Film	0.443	0.129	0.442	0.149

Source: Primary data.

A question of obvious importance is whether or not the means for various treatments, by cut, are statistically significantly different from each other. This suggests a t test on each of the six possible comparisons of means (Table 12). Note that the mean average shrink for naked was significantly different from polyethylene bag and PVC film for both quarters and primals. In addition, for primals, the mean average shrink for paper bag was significantly different from PVC film.

These statistical comparisons need to be kept in mind when the final comparative analysis of costs and revenues is made.

COMPARATIVE ANALYSIS OF TREATMENTS

After detailed consideration of both the costs and revenues associated with utilization of primary packaging material, a comparative analysis of treatment for quarters and primals can be accomplished. The comparative analysis is best conveyed in tabular as well as graphic form.

The basis for the comparative analysis was average net savings from packaging (Tables 13 and 14). To obtain net savings for each treatment, a cost of shrink per hundredweight must be computed from the percent shrink, average weight of all cuts in a category, and some assumption about average price weighted by type of cuts composing the test shipment loads. Note that this latter assumption is <u>not</u> a crucial one in a comparative analysis since it affects only the level of net savings, not the ranking of treatment by net savings. Thus, nearly any price quotation for cuts in the test shipments could be used since it would not be crucial to the comparative analysis.

TABLE 12

Statistical Significance of Means for Shrink Compared by Treatment.[a/]

Means Compared For	Value of "t" for	
	Quarters	Primals
Naked to Paper Bag	1.37	1.05
Naked to Polyethylene Bag	1.60*	1.93**
Naked to PVC Film	2.63**	2.60**
Paper Bag to Polyethylene Bag	0.50	0.80
Paper Bag to PVC Film	1.31	1.64*
Polyethylene Bag to PVC Film	0.74	1.00

a/Null hypothesis: $\overline{X}_1 - \overline{X}_2 \leq 0$; one - tailed t test, pooled variance.

*Signigicantly different at the .10 level.
**Significantly different at the .05 level.

Source: Primary data.

TABLE 13

Average Net Savings From Packaging Quarters, by Type of Packaging Material

Item	Type of Packaging Material			
	Naked	Paper Bag	Polyethylene Bag	PVC Film
In Transit Shrink, (%)	1.028	0.705	0.590	0.443
Weight Lost in Transit, (lb./piece)	1.62	1.11	0.93	0.70
Cost of Shrinkage, (¢/piece)	91.21	62.49	52.36	39.41
Cost of Shrinkage, (¢/cwt.)[a/]	57.96	39.71	33.27	25.04
Cost of Packaging, (¢/cwt.)	0	6.03	6.43	6.40
Cost of Labor, (¢/cwt.)	0	6.10	6.90	6.00
Cost of Inventory, (¢/cwt.)	0	0.28	0.28	0.28
Total Unit Variable Cost of Wrapping (¢/cwt.)	0	12.41	13.61	12.68
Machine Cost, (¢/cwt.)	0	0	0	0.05
Other Capital Equipment Cost for Wrapping (¢/cwt.)	0	0.02	0.02	0.02
Average Total Fixed Cost of Wrapping, (¢/cwt.)[b/]	0	0.02	0.02	0.07
Total Cost of Wrapping, (¢/cwt.)	0	12.43	13.63	12.75
Cost of Shrinkage Plus Cost of Wrapping, (¢/cwt.)	57.96	52.14	46.90	37.79
Net Savings From Packaging, (¢/cwt.)	0	5.82	11.06	20.17

[a/] Cost of shrinkage based upon an average weight at origin of 157.38 pounds for all quarters monitored in test shipments and a weighted average price of 56.3 cents per pound for quarters from National Provisioner, January 8, 1972.

[b/] Assumes capacity of one unit of equipment is 5,600 cwt. per week.

Source: Primary data.

TABLE 14

Average Net Savings From Packaging Primals, by Type of Packaging Material

Item	Type of Packaging Material			
	Naked	Paper Bag	Polyethylene Bag	PVC Film
In Transit Shrink, (%)	1.375	0.918	0.662	0.422
Weight Lost in Transit, (lb./piece)	0.85	0.57	0.41	0.26
Cost of Shrinkage, (¢/cwt.) ¢/piece	55.25	37.05	26.65	16.90
Cost of Shrinkage, (¢/cwt.)[a/]	89.59	60.08	43.21	27.40
Cost of Packaging, (¢/cwt.)	0	4.83	3.33	5.12
Cost of Labor, (¢/cwt.)	0	8.90	8.50	8.00
Cost of Inventory, (¢/cwt.)	0	0.28	0.28	0.28
Total Unit Variable Cost of Wrapping, (¢/cwt.)	0	14.01	12.11	13.40
Machine Cost, (¢/cwt.)	0	0	0	0.09
Other Capital Equipment Cost for Wrapping, (¢/cwt.)	0	0.04	0.04	0.04
Average Total Fixed Cost of Wrapping, (¢/cwt.)[b/]	0	0.03	0.03	0.13
Total Cost of Wrapping, (¢/cwt.)	0	14.04	12.14	13.53
Cost of Shrinkage Plus Cost of Wrapping, (¢/cwt.)	89.59	74.12	55.35	40.93
Net Savings from Packaging, (¢/cwt.)	0	15.47	34.24	48.66

[a/] Cost of shrinkage based upon an average weight at origin of 61.67 pounds for all primals monitored in test shipments and a weighted average price of 65.0 cents per pound for primals from National Provisioner, January 8, 1972.

[b/] Assumes capacity of one unit of equipment is 3,200 cwt. per week.

Source: Primary data.

Of course, as previously noted, the revenue attributable to packaging will emerge as a reduction in cost of shrink. This revenue or cost savings is clear from the "Cost of Shrinkage" line in Tables 13 and 14.

The next component of average net savings from packaging is the cost of wrapping. This component was analyzed in terms of fixed and variable cost. The variable cost for wrapping, of course, depends on the number of hundredweight wrapped, whereas the fixed cost does not. Variable cost, or unit variable cost for linear total cost functions, was composed of the cost of packaging, the cost of labor, and the cost of inventory (Tables 13 and 14).

The fixed cost is shown in tabular form as average total fixed cost under the assumption of capacity operation for one unit of capital equipment employed in the wrapping operation. As previously noted, these capacity figures are 5,600 cwt. per week for quarters and 3,200 cwt. per week for primals. Thus, the average fixed cost shown in tabular form, according to the above assumption, is the low point on the average cost function. However, the average cost function is presented in graphic form also. This function shows adjustments in average fixed cost to be made for smaller or larger hundredweight per week figures than are assumed in the tabular presentation. This same statement applies for the total cost functions.

The final component of average net savings needed for the comparative analysis is a simple combination of cost and revenue. Note from the tabular analysis that, for any treatment, net savings per hundredweight is greater

for primals than for quarters. This is primarily attributable to the larger observed shrink for primals and consequent relatively greater savings from shrink reduction by utilizing packaging material. Note also that for either quarters or primals the greatest net savings accrued to utilization of PVC film, followed by polyethylene bag, then paper bag.

These relationships are presented in the form of bar charts to aid interpretation. The average cost of shrink is shown by treatment for quarters and primals (Figures 2 and 3, respectively). The magnitude of difference in these bar charts show the revenues attributable to packaging. The total costs of each primary packaging material for quarters and primals is shown in this fashion, as well as the cost of shrink plus cost of wrapping (Figures 4 through 7).

The most general relationship for the data is in the form of average and total cost functions (Figures 8 through 11). These functions were graphed over the 1,000 to 5,600 cwt. per week output range for quarters and over the 500 to 3,200 cwt. per week range for primals, under the assumption that total cost is linear for this range. As previously indicated, this range is really determined by the "capacity" for one unit of equipment for each category.

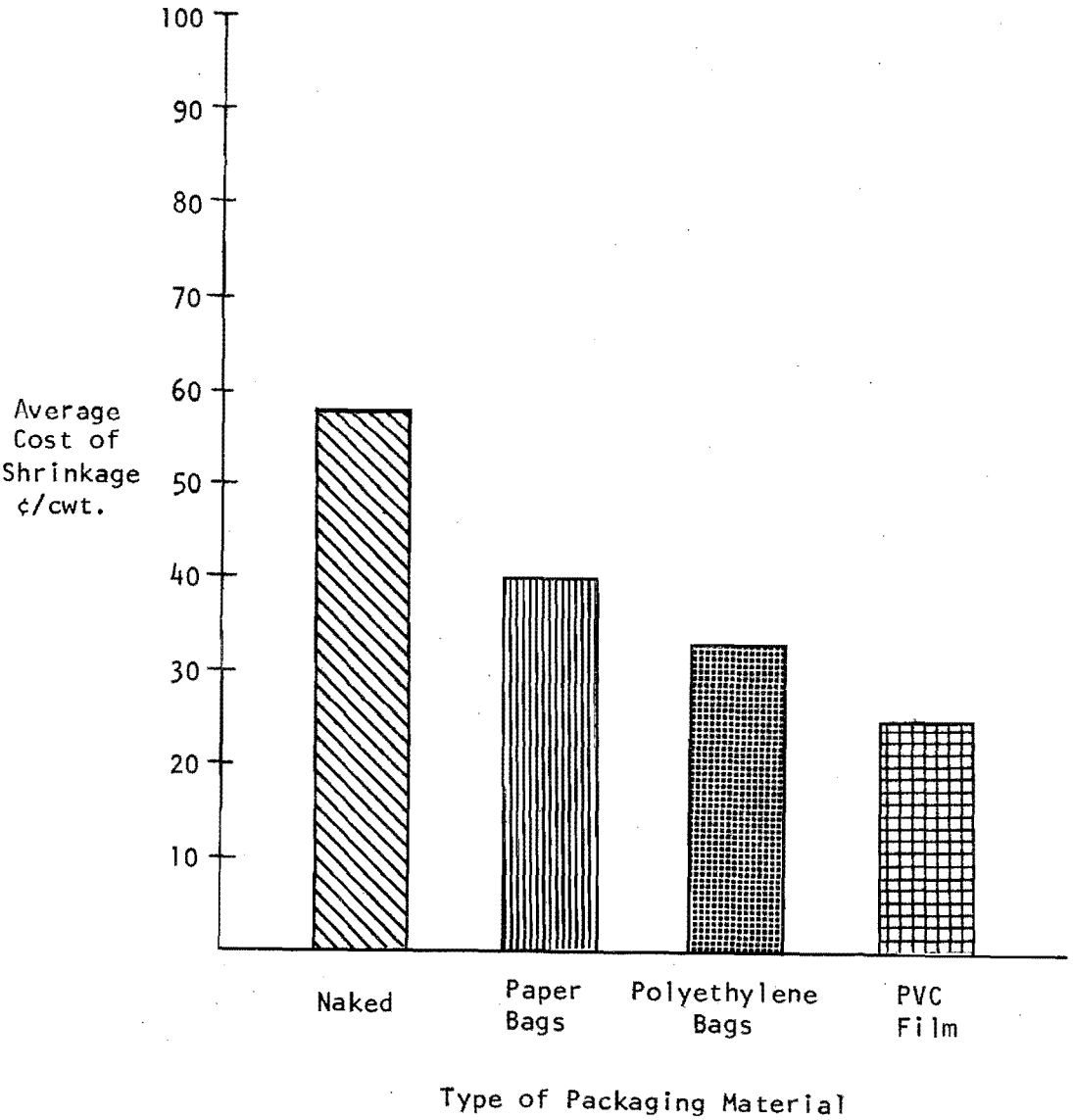

Figure 2. Average Cost of Shrinkage by Type of Packaging Material, Quarters

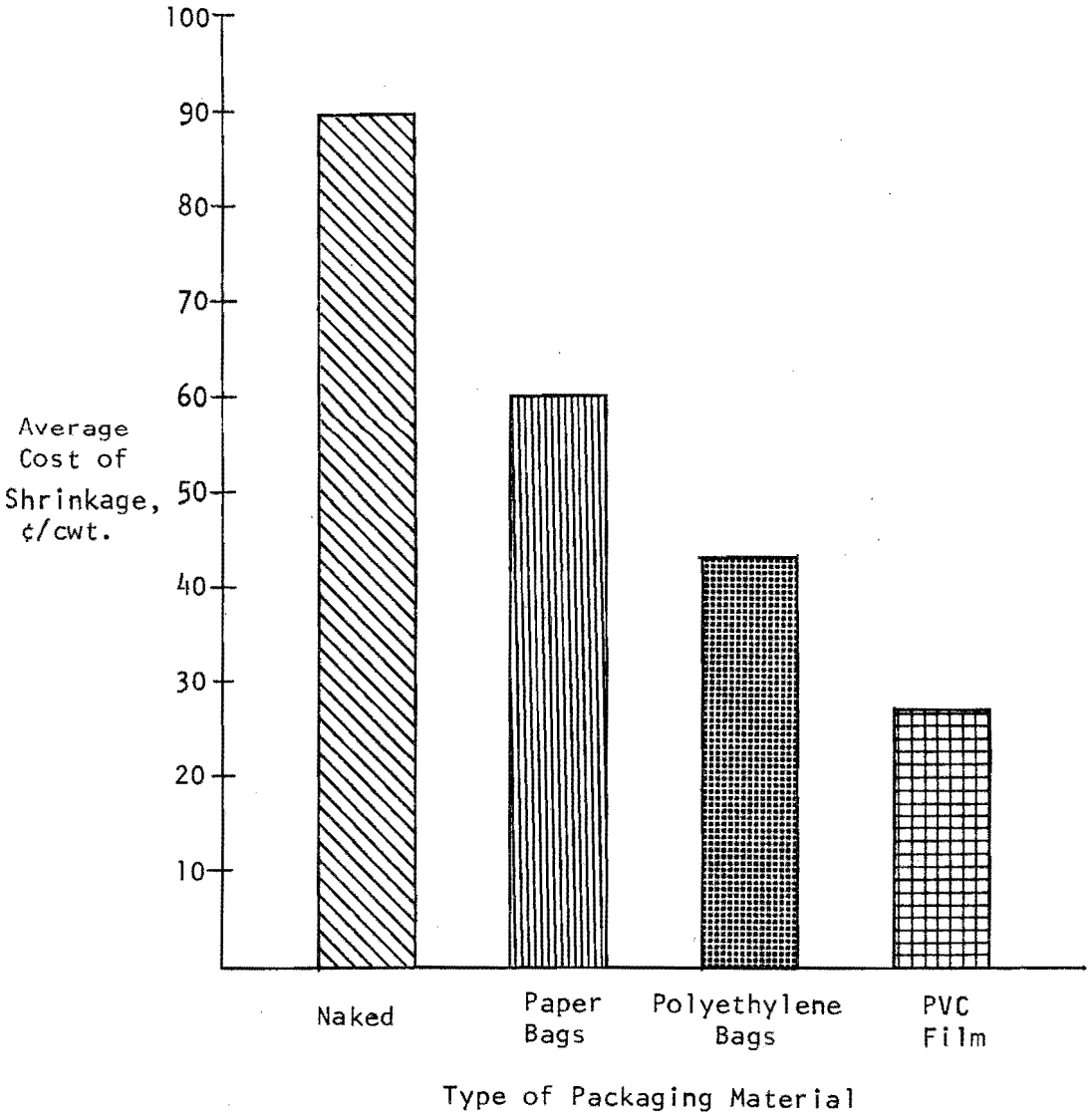

Figure 3. Average Cost of Shrinkage by Type of Packaging Material, Primals

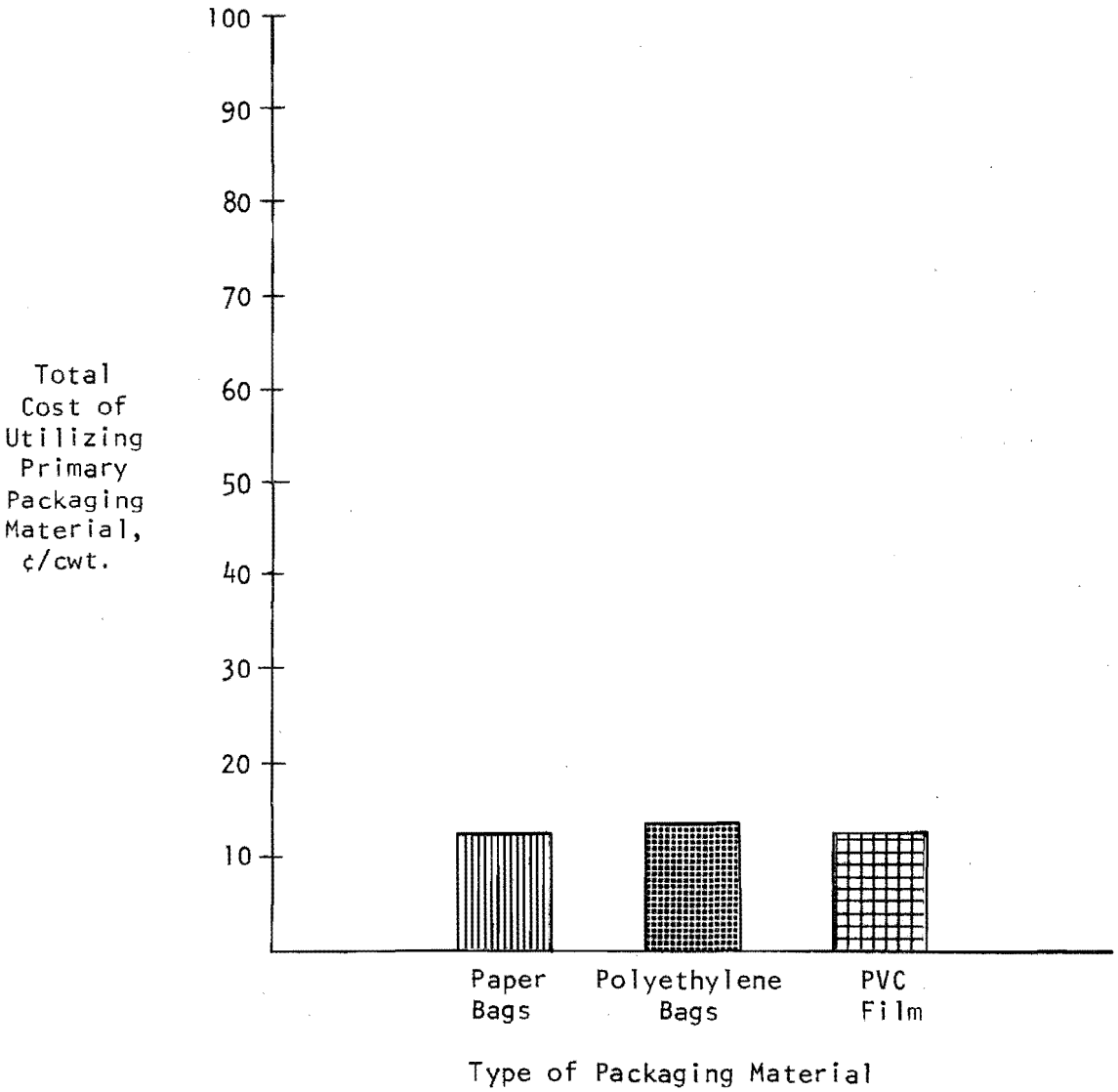

Figure 4. Total Cost of Utilizing Primary Packaging Material, Quarters

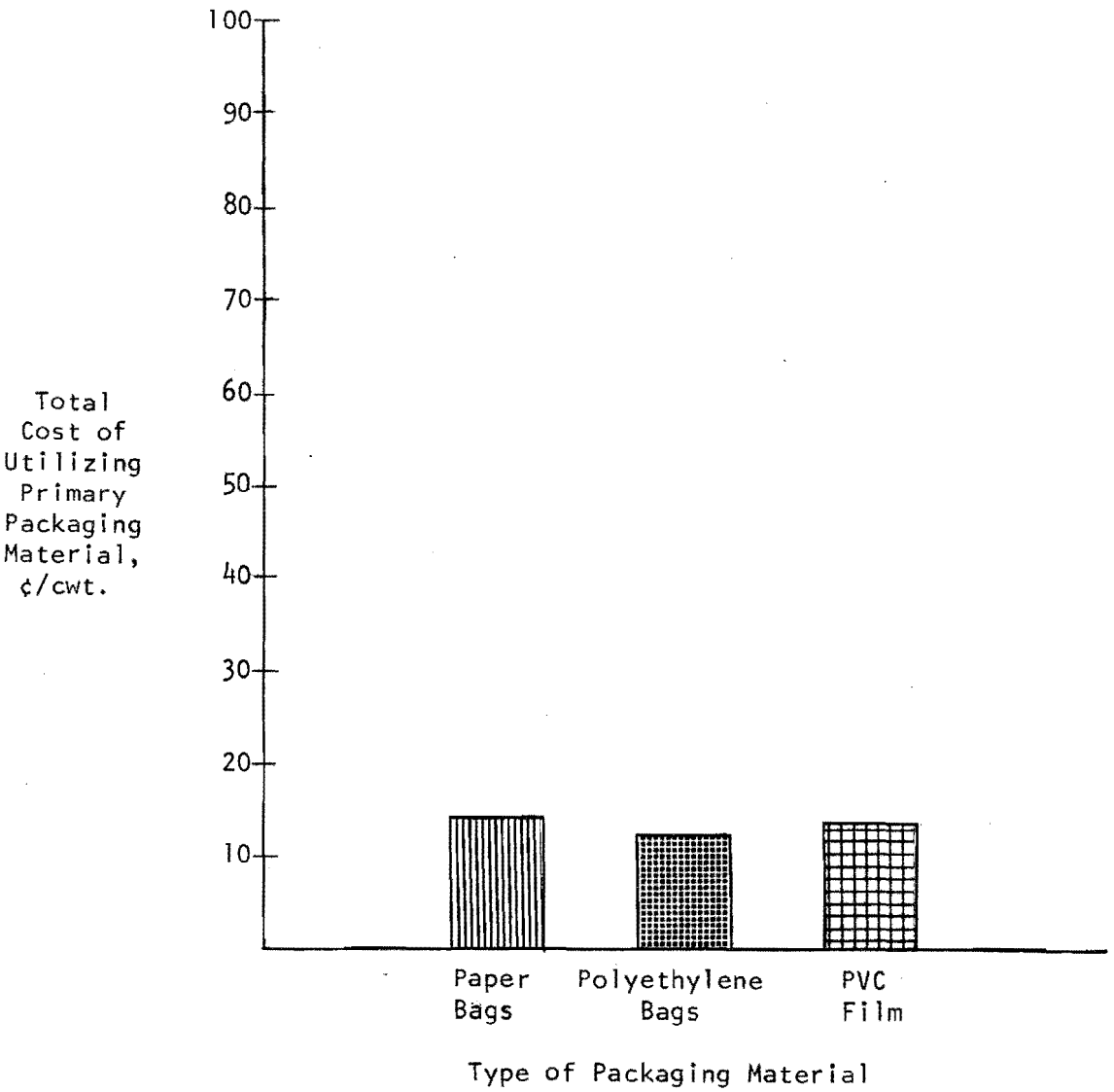

Figure 5. Total Cost of Utilizing Primary Packaging Material, Primals

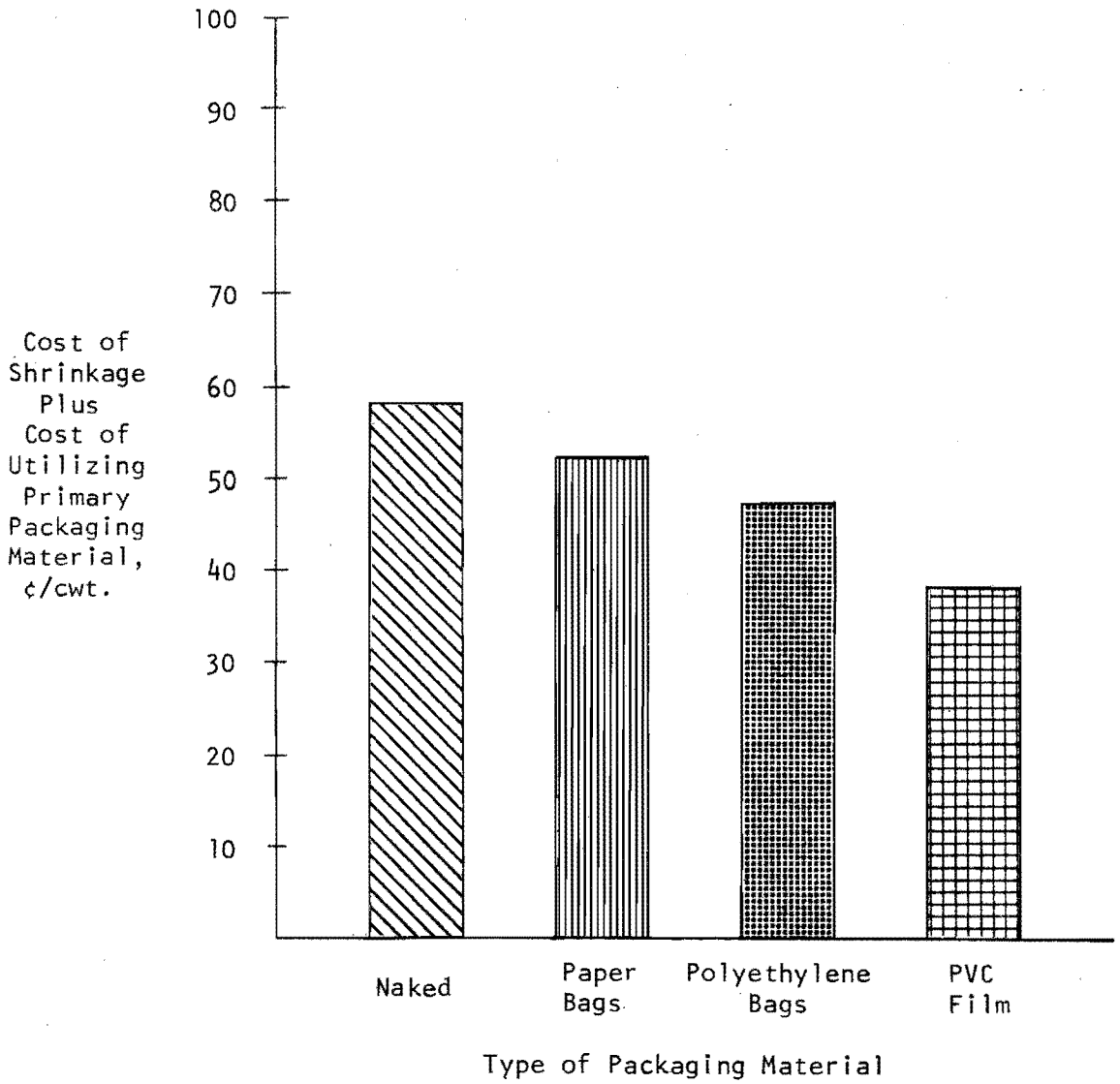

Figure 6. Cost of Shrinkage Plus Cost of Utilizing Primary Packaging Material, Quarters

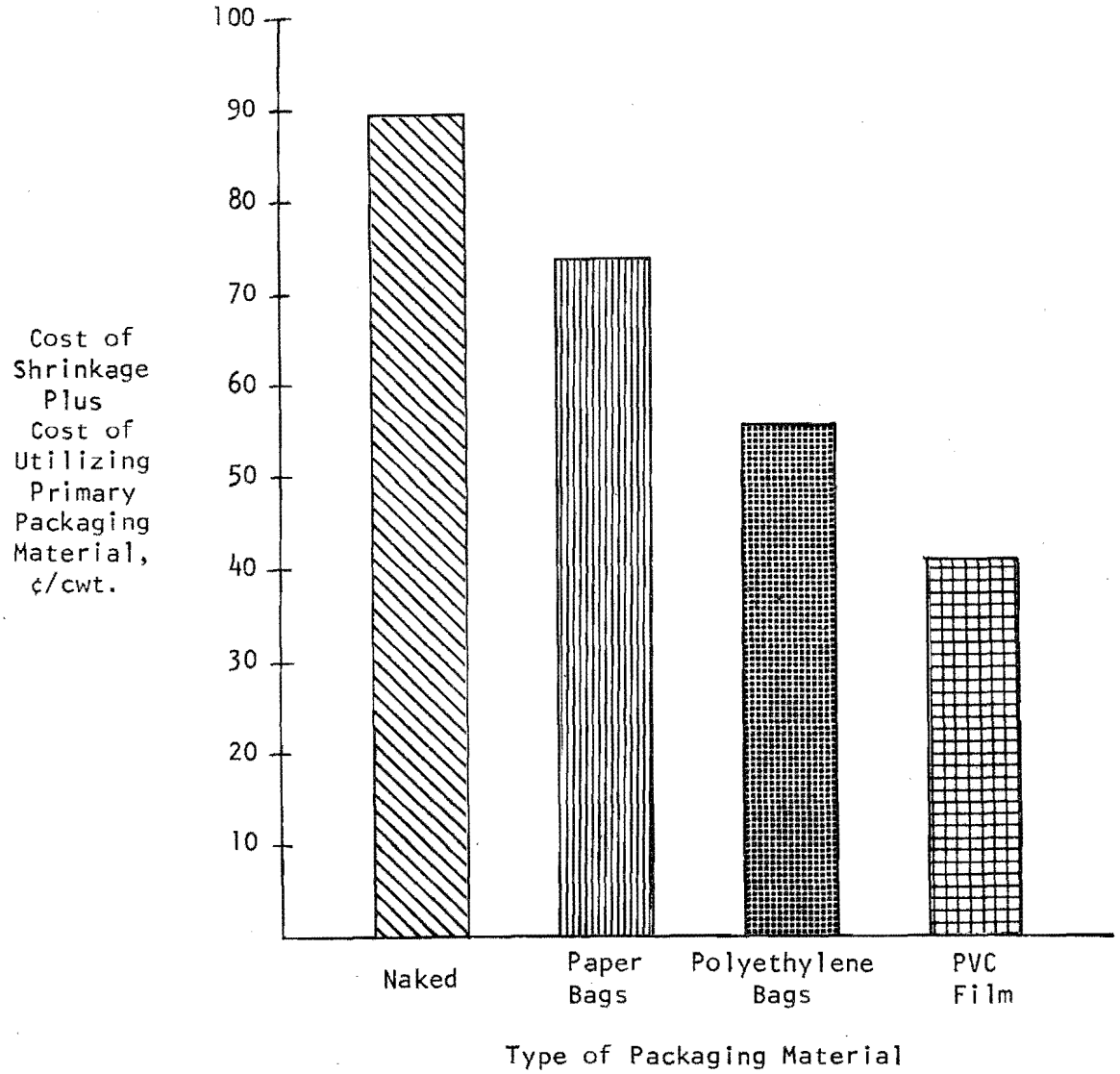

Figure 7. Cost of Shrinkage Plus Cost of Utilizing Primary Packaging Material, Primals

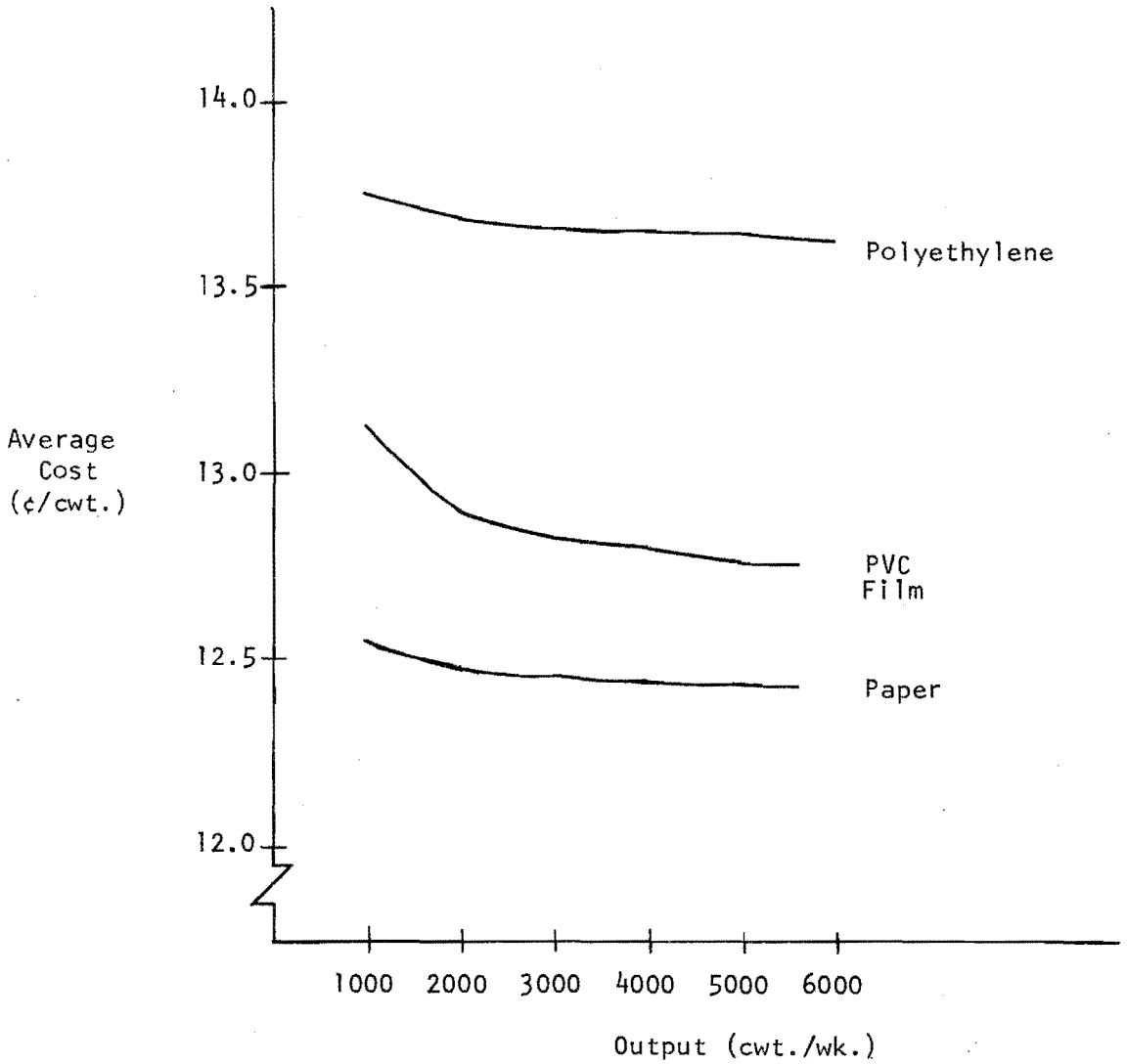

Figure 8. Average Cost Function for Utilization of Packaging Material, by Type of Material, Quarters

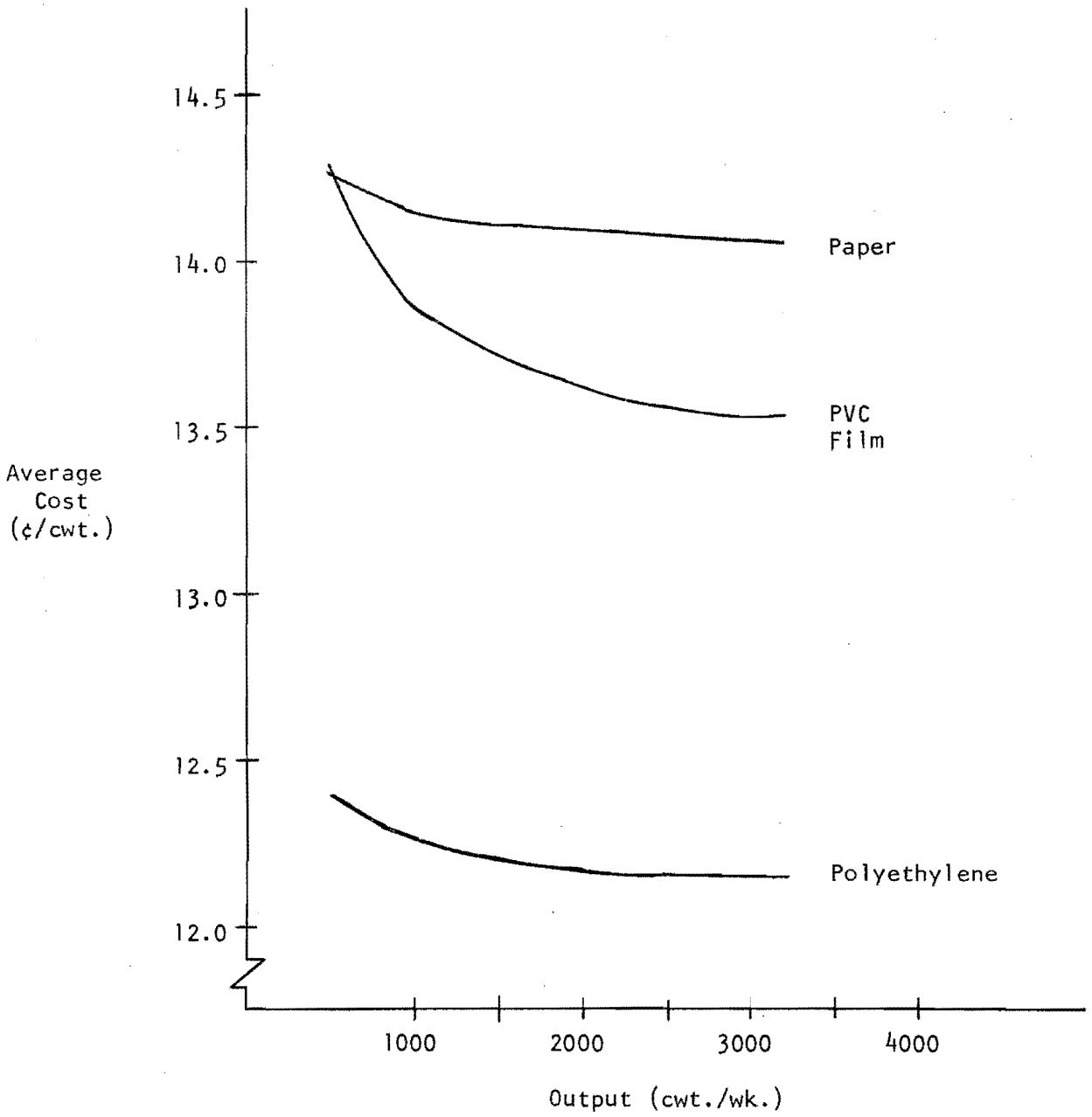

Figure 9. Average Cost Function for Utilization of Packaging Material, by Type of Material, Primals

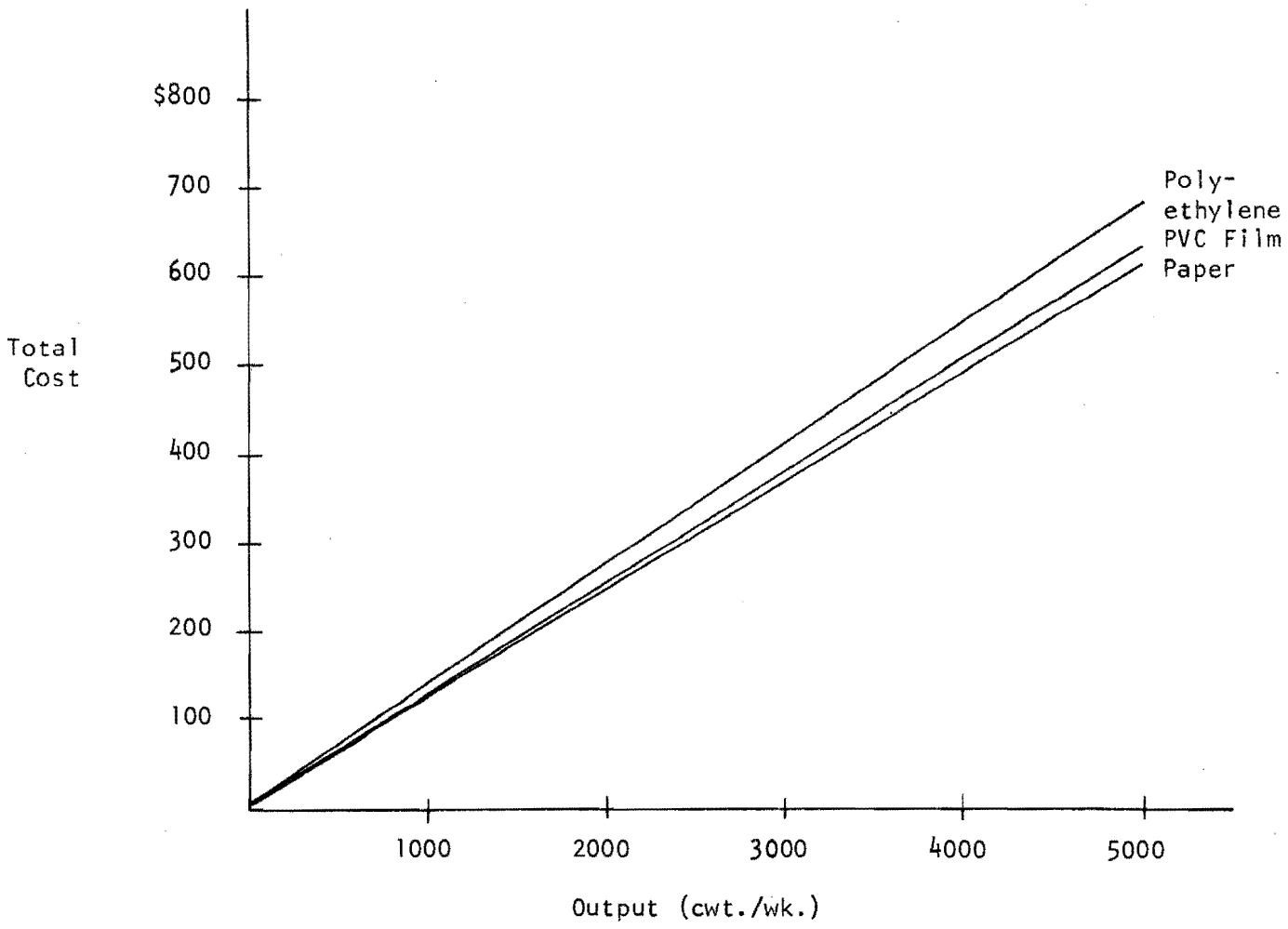

Figure 10. Total Cost Function for Utilization of Packaging Material, by Type of Material, Quarters

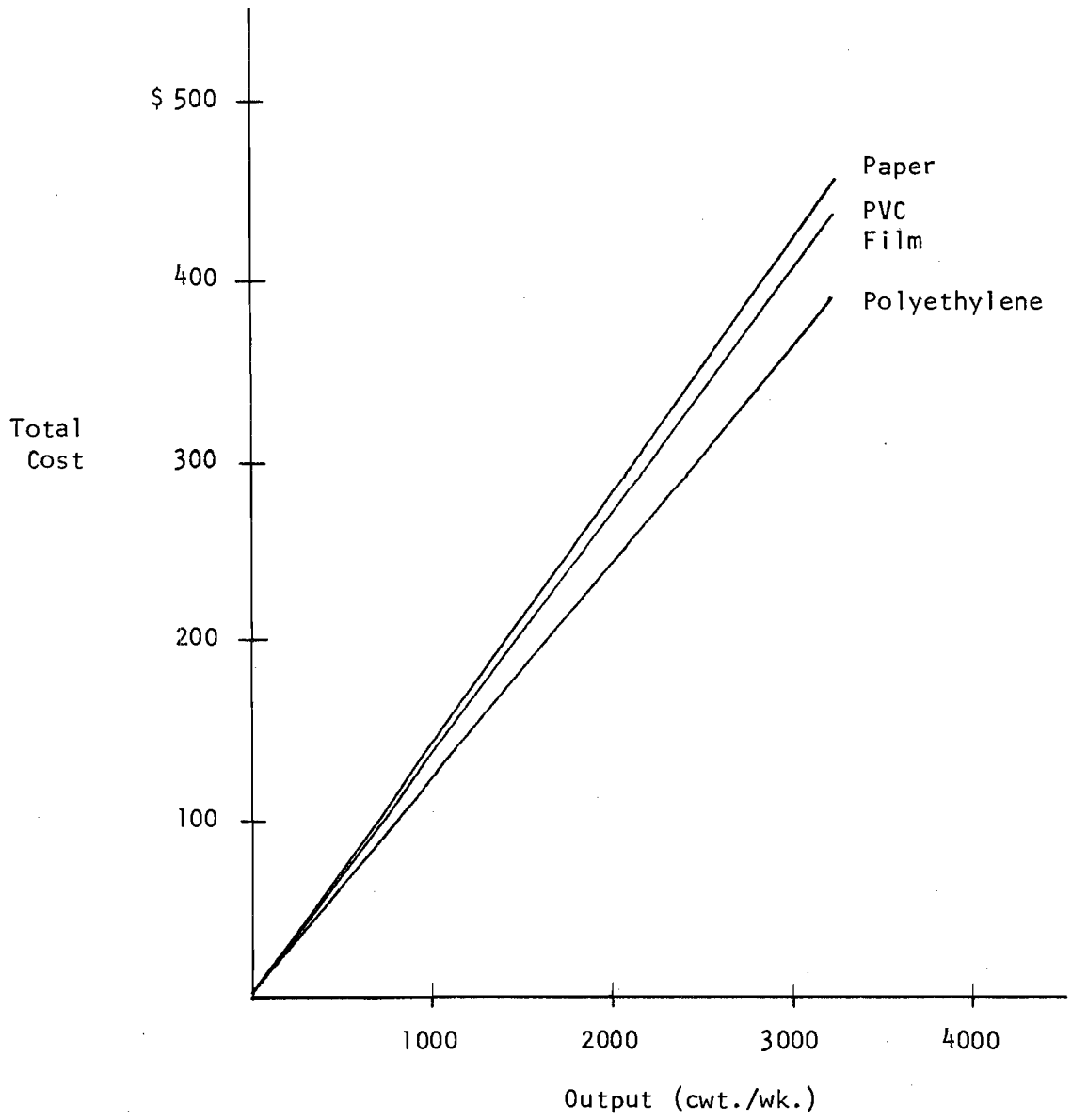

Figure 11. Total Cost Function for Utilization of Packaging Material, by Type of Material, Primals

CONCLUSIONS AND IMPLICATIONS

The conclusions are clear from the comparative analysis. First, either polyethylenene bags or polyvinyl chloride film, used as a primary packaging material on quarters or primals, paid for their use in terms of shrink alone. This is without regard to other savings such as reduction in percent trim or extended shelf-life that could accrue from utilization of the packaging material. Based upon the statistical significance of shrink means by treatment, paper bags would not be considered a viable alternative primary packaging material from an economic standpoint (Table 12).

Secondly, net savings were greatest from PVC film, for either quarters or primals, than any other type of material. Also, net savings from utilizing PVC film on primals were greater than for quarters. This implies that for a relatively large plant with output of 50,000 primal hundredweight per week, the net savings of 48.66 cents per hundredweight would be $24,330 per week, given the price of primals assumed in Table 14. For the same size plant the net savings for quarters of 20.17 cents per hundredweight would be a total savings of $10,085 per week, given the price of quarters assumed in Table 13. Thus, potential savings for a relatively large plant from using PVC film would range from about $10,000 to $24,000 per week, depending on the composition of output in terms of primals and quarters.

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