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THE ROLE OF SCALE ECONOMIES IN THE COST BEHAVIOR OF POSTS

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Introduction

In this paper we rely on costing methods and cost data that are well tested for estimating the cost behavior of the United States Postal Service (USPS) in Postal Rate Commission proceedings. We use them here to develop an analytic approach to estimate the cost behavior of other posts that do not have applicable publicly available information. In Part I, we explore the effect of fixed cost on average unit costs for the USPS. This is accomplished by adopting a simple linear cost model for postal activities. That model produces a hyperbolic curve that describes the USPS average unit cost as a function of volume per capita. We then extend the analysis by providing evidence that average cost curves for industrial posts are directly proportional to the USPS average cost curve. We further show that the USPS curve provides a way of benchmarking the efficiency of posts in industrial countries relative to the USPS. In Part II, we explore some implications of our findings for the posts of developing and underdeveloped countries.

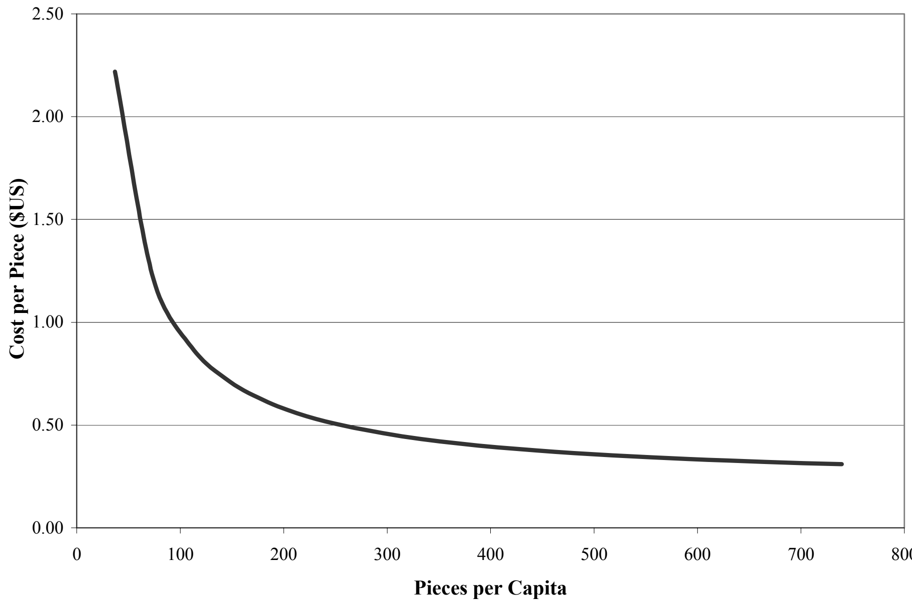
Part I: USPS Cost Behavior

In a previous paper the authors adopted the model of USPS costs as a function of volume and population. (Cohen, Pace, et al., 2002). The model uses USPS accrued costs and cost elasticities (with respect to volume) of its major activities,[1] and assumes constant marginal costs.

The average unit cost function derived from the model reveals the hyperbolic curve (Figure 1) with average unit cost growing at an increasing rate as volume declines and growing very rapidly as volume declines to low levels. The shape results from the fact that the growing proportion of fixed costs must be spread to fewer and fewer pieces as volume declines.

[1] The cost elasticity of a postal activity (e.g., mail processing or delivery) is the marginal (or variable) costs as a share of total costs. It is also equal to the percentage change in cost over the percentage change in volume.

Figure 1: Average Unit Cost Curve



The general shape of the curve comports with intuition. Mail processing costs have a small fixed component (i.e., a high cost elasticity) while delivery has a large fixed component (i.e., a low elasticity). As volume declines, mail processing costs decline almost proportionately but delivery costs decline much more slowly, causing average unit cost to rise at an increasing rate.

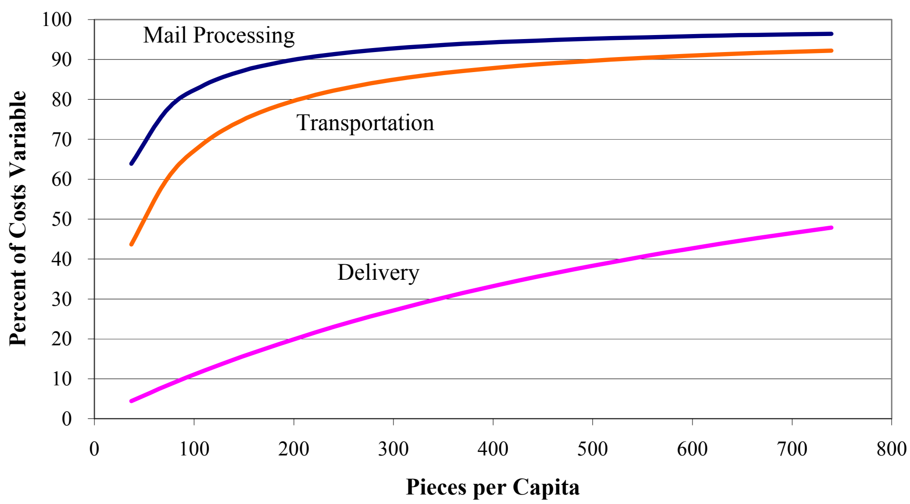
Table 1 displays the percentage of total cost and the cost elasticities for the major USPS activities in 1999. The cost elasticity measures variable costs as a percentage of total costs. Given that the elasticity of delivery was 0.48 in 1999, the fixed percentage of cost in delivery was 52 percent. Window service and "other costs" also have large fixed costs. The cost elasticities in Table 1 are point elasticities (i.e., they show the percent of variable costs at the specific volume level in 1999, 739 pieces per capita). In the Appendix we develop the elasticities equations, which present elasticities as functions of pieces per capita. Figure 2 shows the curves for these elasticity equations. It can be seen that as volume declines, mail processing and transportation costs remain largely variable while delivery becomes increasingly fixed. From this we can infer that delivery cost is a larger and larger share of total costs as volume per capita declines while mail processing and transportation costs become smaller and smaller shares.

Table 1
FY 1999 USPS
Percent of Total Cost and Cost Elasticity
(with Respect to Volume) of the Major Activities[a]

Activity	Percent of Total Cost	Cost Elasticity
Delivery[b]	35	.48
Mail Processing	34	.96
Transportation[c]	7	.92
Window Service	5	.46
Other	18	.23
Total		.63

[a] Source: Postal Rate Commission Docket R2000-1
[b] Includes both in and out of office activities.
[c] Does not include inter city transportation costs.

Figure 2: Cost Elasticity or Variability Curves by Activity



The point elasticities for the USPS along with the total costs by activity for FY 1999 can be used to estimate the average USPS unit costs at lower volume levels. The result is displayed in Figure 1 where average unit costs follow a hyperbolic shape as volume drops. Below approximately 200 pieces per capita there is a dramatic rise in costs. Above approximately 200 pieces per capita the curve is relatively flat.

Costs Behavior of Posts in Other Industrial Countries

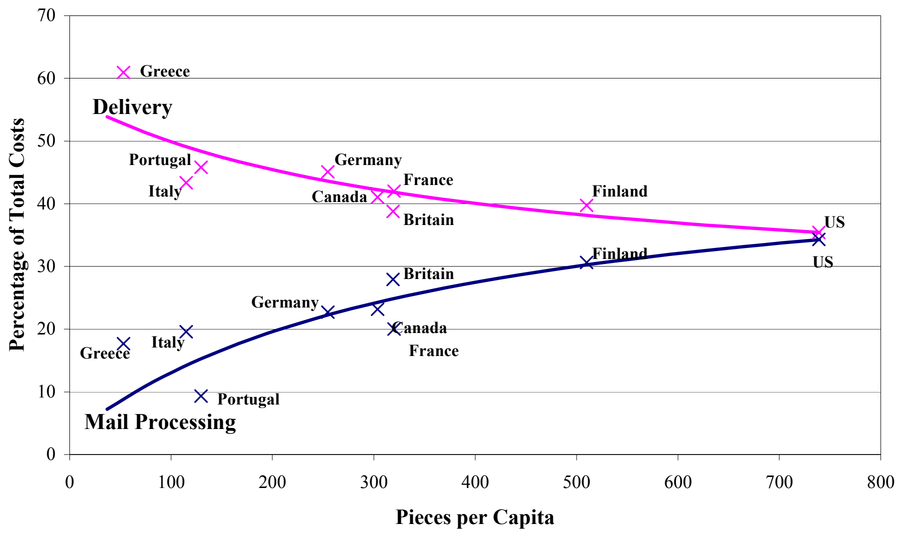
We wish to demonstrate that the curve in Figure 1 generally describes the change in unit cost for many industrial posts. We use volume per capita on the x-axis because the population served by industrial posts varies considerably.

We start with the observation that posts in industrial countries are remarkably similar in their operations. Each major activity (delivery, mail processing, transportation, window service) is conducted using similar methods and technologies. Consequently, it is reasonable to conjecture that the point elasticities of postal activities of different postal administrations are very similar to those of the U.S. at given volume per capita levels. This would mean that they would have a similar ratio of variable to fixed costs at the same volume per capita. Furthermore, the share of total costs by major activity would be very close to the U.S.

The behavior of postal costs at different volume levels largely reflects the behavior of street delivery costs, which are approximately 70 percent fixed for the USPS. As volume drops, the percentage of delivery and total fixed costs grows rapidly. In previous collaborative work with La Poste analysts, the authors found that delivery costs exhibit similar behavior in France and the U.S. (Bernard, Cohen, et al., 2002). After adjusting for pieces per capita, street delivery cost elasticities are similar. This is true despite the quite diverse demographics of the two countries and differences in modes of delivery. For example, nearly all routes in the U.S. are motorized while France has many more foot and bicycle routes. Also, delivery is always to the door even in rural areas whereas in the U.S. rural door delivery is to a roadside box. In contrast to street delivery costs, mail processing and in-office carrier work tends to be mainly variable with volume.

It is nearly impossible to obtain the average unit costs or cost elasticities of industrial country posts, partly due to concerns about the perceived commercial sensitivity of such information. It is, however, possible to obtain information on the share of total costs by major activity. Figure 3, contains the actual shares for posts from nine industrial countries. These points are plotted against the curves that show the expected share of costs by major activity based on the extrapolation of U.S. elasticities to different pieces per capita. The fit between the actual and projected shares is quite close. This indicates that postal cost elasticities for industrial countries are very close to those predicted by the USPS data at the given level of piece per capita. This finding suggests that the USPS elasticity curves in Figure 2 closely approximate the elasticity curves of most posts of industrialized countries.

Figure 3: Percentage of Total Costs by Activity



Establishing general elasticity curves however, is not sufficient to establish a universal average cost curve. Even if another postal administration fits precisely on the curves in Figure 3, its average costs can still be different from that shown in Figure 1. For example, consider posts A and B which are identical in every regard except that every cost of A is twice that of B (such as when all input costs are doubled). Then these posts would have the same cost elasticity (for each activity and in total) but A's unit cost would be double that of B. Its average cost curve would have a proportional relationship to Figure 1 by a factor of two.

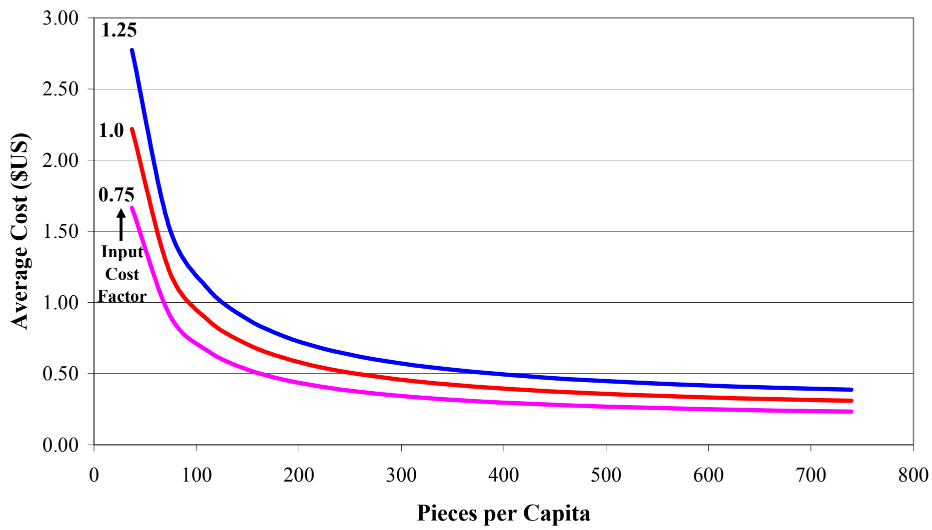
We show that if industrial posts' mail processing and delivery costs as a percentage of total costs match those implied by the USPS elasticities, the points on any industrial post's average cost curve must be the same as the points on the U.S. cost curve multiplied by some constant (proportionality factor).[2]

This conclusion can be used to develop a family of hyperbolic curves. Figure 4 presents average costs curves for proportionality factors of 0.75, 1 and 1.25. The

[2] See the Appendix for the proof.

proportionality factor has the effect of raising or lowering the overall cost level of a post relative to that of the USPS. Thus, the curves in Figure 4 might be thought of as the average unit costs for a post with three quarters of the cost level of the USPS, the same cost level as the USPS, and one and a quarter times the cost level of the USPS, respectively. The three curves in Figure 4 are reasonable bounds on the cost behavior of posts in industrialized countries.

Figure 4: Family of Average Unit Cost Curves
with Proportional Adjustment Factor = 0.75, 1.0, 1.25



The immediate implication of the closeness of the curves describing the cost behavior of industrial posts is the consistently large impact of volume changes on average costs as volume per capita drops below the range of 200 to 100 pieces.[3] Thus, even without a cost level adjustment, the USPS curve provides meaningful insight to the impact of volume losses for posts in industrial countries.

Model Applications

The average unit cost curves are useful for measuring the impact of liberalization. For example, using 1992 USPS mail volumes and costs, Cohen and Chu (1997) have shown that an alternate provider of delivery services that captures half of

[3] For any per capita volume, the percentage increase in average unit cost resulting from a given volume loss is the same regardless of the cost level factor.

the U.S. market would result in an increase in costs of approximately six billion dollars. That analysis was restricted to a duplication of the delivery activities with each service handling half of the mail volume. This is a measure of the impact of the loss of economies of scale from liberalization that would have to be offset by other benefits of increased efficiency and innovative services.

For 1999, the impact of liberalization can be derived from the cost function for the USPS. Assuming the loss of half of the volume to an equally efficient provider, the projected new average cost for both providers would be 40.99 cents. This is the cost per piece from Figure 1 corresponding to 370 pieces per capita. The cost per piece for the USPS delivering all the volume was 30.94 cents per piece. Thus each piece would have cost approximately 10.06 cents more to handle. For 201.6 billion pieces, this equates to an increase in costs of $20.6 billion. If the impact of liberalization were limited to the delivery activity, as in the Cohen and Chu analysis, then the impact would be about half at $10.3 billion. This is due to the fact fixed delivery costs are about half of current total fixed costs.

The universal cost curve can also be used to benchmark postal administration efficiency relative to the USPS. The input prices of the USPS are publicly available from the Postal Rate Commission Decisions (*see* www.prc.gov). The ratio of another postal administration's input prices to the USPS value can be used as a proportional factor in the cost function that generates Figure 1 to predict average unit costs relative to the USPS. The ratio of the actual average costs to the predicted average unit cost will determine the postal administration's efficiency relative to the USPS.[4] This predicted value provides a benchmark relative to the USPS. If the actual average cost for a country is less than the predicted value, then it is likely that the country is more efficient than the USPS. Conversely, a higher actual unit cost at the given pieces per capita indicates less efficient operations than the USPS.

[4] For example, if the pieces per capita are 300 and input costs are 75% of USPS input costs, the predicted, benchmark average costs is approximately 34.3 cents since 0.75(0.2089 +74.31(1/300)) = 0.34245. Actual unit costs greater than 34.3 cents implies less efficient operations relative to USPS benchmark.

Model Basis and Calibration

The model is the same as that used by Cohen, Pace, et al. (2002) except that we now present it in a more general form. The model assumes that there are two primary determinants of cost for a postal system: volume and the size of the network. For each activity a post performs, there are volume-driven (attributable) costs and network-driven (institutional) costs.

To create a total cost function, we use FY 1999 U.S. Postal Service data to define the relationship between costs and cost drivers. Table 1 presents the distribution of USPS costs by activity, and the cost elasticities (the share of costs that are volume-variable) for each activity.

Within each postal activity (mail processing, delivery, etc.) the elasticities are applied to the total cost to identify the attributable costs.[5] These costs are divided by total volume to obtain an estimate of the marginal cost. This is used as the coefficient for volume in the model. The remaining costs (institutional) are primarily driven by the size of the network. Population is a reasonable proxy for the size of the network and therefore institutional costs are divided by the U.S. population to obtain the average cost per person. The result is used as the coefficient for population in the model.

Since all costs are variable in the long run, it is reasonable that non-delivery institutional costs would decline over the large volume range we explore with this model. For purposes of this analysis we assume that 25 percent of non-delivery institutional costs would be volume variable.[6]

No portion of delivery institutional costs is considered to be volume variable, however, because route structure does not change as volume drops. As long as coverage is relatively high, carriers will have to cover their entire route. Thus, fixed delivery costs would not be expected to drop until volume per capita were so low that the resulting very low coverage allowed carriers to skip parts of their routes.

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[5] Attributable costs using the PRC cost treatment are slightly greater than volume variable costs or marginal costs.

[6] The results are not very sensitive to this assumption as can be seen in Cohen, Pace, et al. (2002).

The resulting cost function in U.S. dollars is:

		Variable		Institutional
Mail Processing	=	0.1032V	+	2.10P
Delivery	=	0.0525V	+	42.24P
Transportation	=	0.0200V	+	0.92P
Window Service	=	0.0092V	+	4.64P
All Other costs	=	0.0241V	+	24.41P
Total costs	=	0.2089V	+	74.31P

Where V = Volume and P = Population

It can be seen that the total cost of providing postal service in the U.S. for FY 1999 was 20.89 cents per piece plus $74.31 per person. The total cost function can be used to generate the average unit cost curve shown in Figure 1 by dividing the terms by V:

$$\text{Average Unit Cost} = 0.2089 + (74.31\ P / V)$$

this can be restated in terms of V / P, or pieces per capita (ppc) as:

$$\text{Average Cost} = 0.2089 + (74.31 / ppc)$$

The model assumes constant unit variable costs. Thus, when volume is reduced total variable cost is reduced by the same percentage. At lower per capita volumes, the ratio of fixed to variable cost increases and the cost elasticities decrease (because a greater proportion of total costs are fixed). Similarly, the model assumes a constant coefficient for population.

The U.S. cost elasticities in Table 1 determine the coefficients in the cost function, which in turn generate the unique shape. Further, these coefficients determine the percent of total cost that comes from mail processing and delivery at a specific volume per capita.

Adjustments

The test of our hypothesis involves predicting the percentage of total cost devoted to mail processing and delivery. The percentages of mail processing costs need to be adjusted if worksharing, automation, or mail mix had significantly different impacts on mail processing costs. We have adjusted mail processing costs for La Poste and Posti Finland.

Both France and Finland include the costs of cancellation and mail preparation in their counter costs. Because the U.S. Postal Service classifies these costs as part of mail processing, we adjust the percentages of mail processing costs upward for France and Finland to reflect a similar treatment. This has no effect on total costs, and therefore only affects the mail processing percentage.

The number of deliveries per week varies among the posts in the sample (Canada, Finland, Greece, and Portugal deliver 5 times per week, Great Britain delivered 12 times weekly in urban areas and 6 in rural areas in 1999). Consequently, it is necessary to adjust the percentage of delivery cost for these posts to the level it would be with six deliveries per week (as in the U.S.) When the percentage of delivery cost is increased or decreased for a given post, the percentage of mail processing cost is decreased or increased accordingly.[7]

Confirming the Hypothesis

Data

The percentages of delivery and mail processing costs (relative to total costs) were supplied to us by Canada Post, Finland Post, La Poste, Royal Mail, CTT Correios de Portugal and Hellenic Post. The authors supplied the data for Poste Italiane. La Poste delivers unaddressed mail separately from normal mail. Consequently, the volumes and percentages of total cost for La Poste do not include unaddressed mail. Unaddressed mail is included in the calculations for other posts.

The cost percentages reflect labor and non-labor costs, except for Germany. The Deutsche Post percentages are derived from workforce full time equivalents contained in its annual report for FY 2001 and an internal Post Italiane study on German delivery operations developed in part from meetings with Deutsche Post management. The Deutsche Post annual report provides the total number of full time equivalents

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[7] The population density (or more specifically the postal density—the average time it takes to travel between addresses) of a country has an impact on street delivery costs. Ideally we could adjust for this if data were available. (*See* Bernard, Cohen, et al., 2002).

involved in postal operations and the Poste Italiane document provides the number involved in delivery operations. While this is a proxy for labor and non-labor costs, it is considered realistic since in the U.S., use of workforce full time equivalents provide estimates within a few percentage points of those calculated with labor and non labor costs.

Empirical Findings

Figure 3 presents the findings of this empirical investigation. The top line represents delivery cost percentage (of total cost) as a function of pieces per capita as predicted by our cost model. The bottom line represents the same for mail processing costs.

With the exception of the low volume posts (Greece, Italy and Portugal) the model's predicted percentages are close to the actual percentages.[8] A downward adjustment would improve Italy and Greece's relation to the mail processing prediction but move Portugal further away.

Some of the deviation for Italy and Portugal may be due to the fact that they have much larger retail operations involving collection and acceptance than the U.S. and other posts. For example, Portugal retail post office operations, account for 21 percent of total costs, while in the U.S., they account for approximately six percent. Poste Italiane also has a relatively large percentage of costs in collection and acceptance, 15 percent. Postal administrations' expense for retail outlets as a percentage of total expenses varies widely in the industrial world, reflecting different numbers of offices per capita. This in turn reflects the USO in each of the countries, as does the frequency of delivery. Our model would be improved if adjustments were made for differences in retail outlets per capita.

A significant virtue of these curves is that they are independent of labor costs. Thus, we are able to avoid the need for obtaining productive hourly costs translated into dollars using purchasing power parities.

It appears that other factors, which are not adjusted for, do not cause significant differences from the model results. This could be because these factors do not vary

[8] The sampled posts with very low per capita volume do not fit the curves as well as those with higher volume levels. This result is not surprising given that the curves are based on USPS elasticities estimated at a very high volume level.

from the U.S. significantly, the factors do not drive costs significantly, or a combination of factors may cancel each other out.

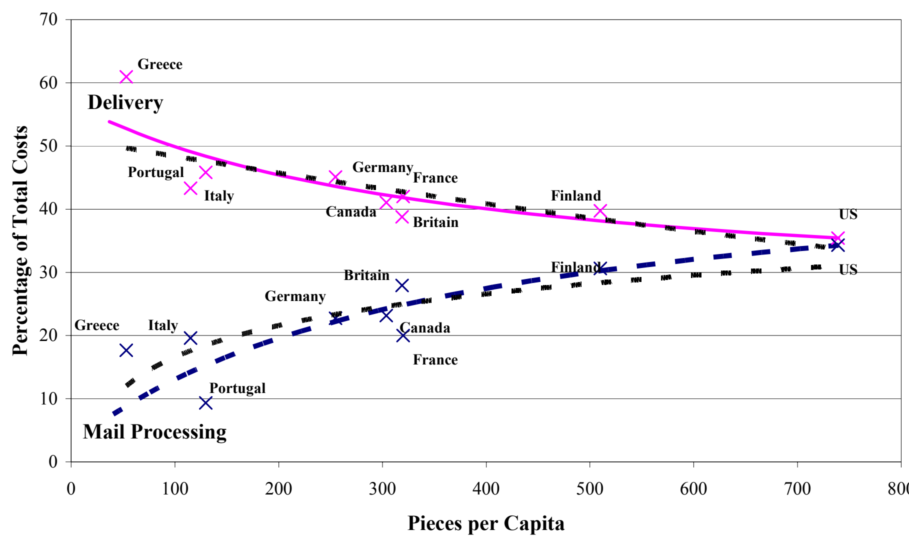
Trend Analysis

The dotted lines in Figure 5 display trend curves for the actual processing and delivery cost percentages from the test countries.[9] These curves were generated using Excel, and they have virtually the same shape as the curves predicted by the model and further confirm the fit between the model and the data. As with the model curves, the low volume posts do not fit well with the trend lines. These disparities at low volumes reinforce our belief that the model is less useful in predicting costs for low volume posts than it is for medium to high volume countries. It is to be expected that the accuracy of predictions will diminish as the range increases over which the predictions are made.

A Generalized Average Cost Equation

In comparing the cost behavior predicted by the USPS model to the empirical data, we have assumed that a fit with the predictions of the USPS model is a validation

Figure 5: Percentage of Total Costs by Activity
with Trend Lines



[9] These trend lines were selected because they best fit the data. The line for delivery is defined as: $y = 51.184e^{-0.0006x}$ with an $R^2 = 0.6239$; for mail processing: $y = 7.23Ln(x) – 16.722$ with an $R^2 = 0.6158$.

of the functional form of the model. While average unit cost models of a different form might produce a similar result, the underlying logic and the results of the empirical comparisons lead us to conclude that the USPS model can be generalized to describe the average unit cost behavior of most posts in industrial countries.

The generalization starts with the premise that, as with the USPS, total and activity costs for other postal administrations consist of variable and fixed components. Furthermore, the cost of a particular postal administration "X" can be represented with the same general form. That is,

Delivery Costs	=	$a_1V + b_1P$ for some constants a_1 and b_1
Mail Processing Costs	=	$a_2V + b_2P$ for some constants a_2 and b_2
Other Costs	=	$a_3V + b_3P$ for some constants a_3 and b_3
Total Costs	=	$aV + bP$ for some constants a and b

with $a = a_1 + a_2 + a_3$ and $b = b_1 + b_2 + b_3$

The a's and b's could be derived from the variable and fixed costs of the particular postal administration X in 1999. Thus, for the specific volume of mail handled and population served, these equations give the activity and total costs, respectively, for postal administration X in 1999. Also, the terms involving the a's give the variable costs and the terms involving the b's give the fixed costs, respectively. As with the USPS equations, these generalized equations are assumed to predict the costs the postal administration would experience at other volumes than the 1999 levels. Consequently, once the a's and b's are known, it is possible to generate the average cost and elasticity curves for the postal administration as a function of pieces per capita. In particular, the average cost curve would be given by

Average Cost = $a + b(1/V)P$

and the elasticity of total costs by

Elasticity[10] = $a/(a + b(1/V)P)$

This assumes the constant unit volume variable costs with appropriate adjustments to reflect the assumption that 25 percent of the non-delivery activity costs are volume variable.

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[10] Substitute the respective a's and b's for elasticities of functional activity costs.

Unfortunately it is not feasible to estimate the a's and b's through econometric research since most postal administrations do not publish detailed cost data. It is possible, however, to estimate the a's and b's for industrial posts relative to the values for the USPS. Because the activity shares of total costs in the sample countries appear to conform with those derived from the USPS coefficients, it is reasonable to assume that this behavior holds for the posts of many industrialized countries. That is, for delivery costs, we conclude that

$$(a_1V + b_1P)/(aV + bP) \quad = \quad (0.1032V + 2.10P)/(0.2089V + 74.31P)$$

for all V and P.

The existence of this identical activity proportions for delivery costs implies that each of the a's and b's are proportional to the corresponding USPS values, respectively, by some factor "k". That is,

$a_1 = 0.1032\ k$

$b_1 = 2.10\ k$

$a = 0.2089\ k$

$b = 74.31\ k$

This is proven in the Appendix.[11] This then implies that for the particular postal administration, average costs are proportional to the USPS average costs. That is,

Average Cost = k (0.2089 + (74.31 / pieces per capita)).

Since the k factor affects all costs, it is reasonable to think of it as reflecting differences in the price of all input factors. Because labor is the bulk of expenditure of most posts, a proxy for k is the ratio of the labor cost of the particular administration to the labor costs of the USPS.

[11] Allow the k's to be different for the a's and b's, *i.e. l, m, n* and *p* respectively for the equation. Then substituting in the proportionate equation, cross multiplying terms and simplifying results in the equation

$$(l\text{-}n)(0.0525 \times 0.2089)V^2+(l\text{-}p)(0.0525 \times 74.31)P+(m\text{-}n)(42.24 \times 0.02089)P+(m\text{-}p)(42.24 \times 74.31)P^2 = 0.$$

The left side can only be zero if each of the terms in parenthesis equals zero which requires that the terms in the parenthesis be equal, *i.e. l =m = n = p = the common k.* See Appendix for full proof.

Implications of Proportionate Cost Curves

The immediate implication of the proportional curves describing the cost behavior of the industrial posts is the consistently large impact of volume changes on average costs as volume per capita drops below approximately 200 pieces. Because of proportionality, the percentage impact of volume losses on average unit costs at any given volume per capita is the same for posts in industrial countries even without a cost level adjustment.

For industrial countries with volumes of less than about 200 pieces per capita, the impact of a volume loss is much larger than in the higher volume countries. This implies that special protections may have to be introduced along with liberalization in the small volume countries to avoid graveyard spirals. One option could be to preserve sufficient portions of the monopoly to maintain current volumes. Another alternative would be to adjust operations to reduce fixed costs. This would most likely mean reducing the universal service obligation. The authors have estimated that USPS costs could be reduced as much as $1.1 billion for each day of delivery service eliminated. (Cohen, Robinson, et al., 2002). The savings come primarily from the elimination of route costs, which are fixed. New entrants would be expected to do this in most cases.

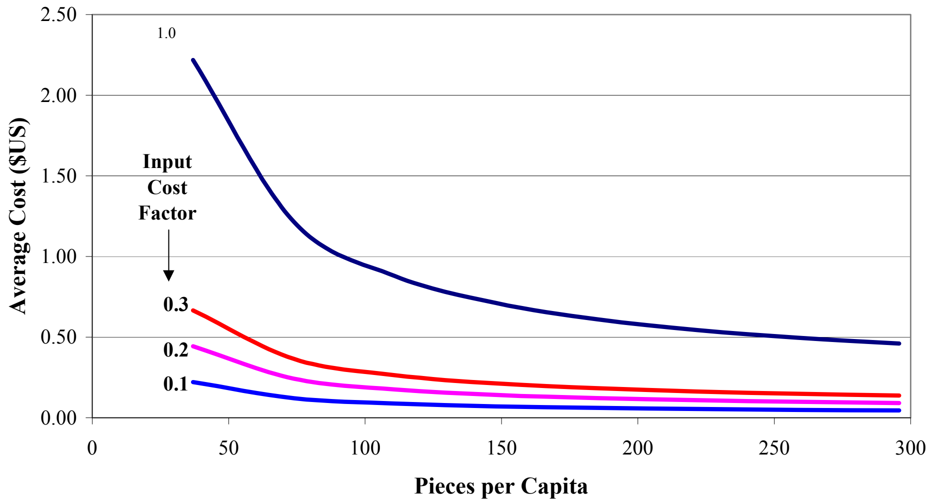
Part II: Accession Country Posts

We believe that lower volume posts (40 to 100 pieces per capita) have similar service standards and organizational arrangements as industrialized posts.[12] It may well be that they have a similar cost curves as exhibited in Figure 4. Labor costs in the accession countries, except Malta and Slovenia, are in the range of 10 to 30 percent of USPS labor costs. The lower input prices for these posts would imply a much lower value for the proportional factor k.

Figure 6 displays average unit cost curves corresponding to postal administrations with labor costs that are 10, 20 and 30 percent of USPS labor costs. These represent probable cost curves for the posts of EU accession countries.

[12] We recognize that the volume for some accession countries exceeds 100 pieces per capita.

Figure 6: Family of Average Unit Cost Curves
with Proportional Adjustment Factor = 0.1, 0.2, 0.3



It can be seen that lower input prices flatten the cost curve. In absolute terms, costs for accession country posts would not increase as much as in the industrialized countries as volume drops. On a percentage basis, the impact would be equal.[13] Consequently, the impact of volume loss on lower per capita volume posts with low input costs could be just as great as for the low volume post of industrialized countries.

Implication of Findings for Low Per Capita Posts

Some postal observers argue that entry is unlikely in low per capita volume posts precisely because of their low volumes not being economically attractive for cream skimming. On the other hand, it is likely that the distribution of postal volume is bimodal in these countries. Businesses and upper income households are likely to receive much more mail than the remaining population. Moreover, these large volume recipients are likely to be concentrated in one or two cities. For example, Italy has large differences in income between regions (e.g., North and Central vs. South) and displays a bimodal volume distribution. Milan has about 150 to 200 pieces per capita while the Southern regions (accounting for 40 percent of the population) have about 40 pieces per capita. The volume per capita for all of Italy is a little over 100. Thus, considering

[13] If plotted on a logarithmic scale, the curves would be parallel.

the probable bimodal distribution of volume and regional concentration in most low volume countries, they may well have sufficient volume to attract entrants.

Entry has both positive and negative aspects. On the positive side, competition spurs innovation giving more choices to consumers. In addition the incumbent will be driven to cut costs and to improve efficiency and service. On the other hand, entry will cause a loss of scale economies. The family of unit costs curves we have presented above shows that this loss of scale economies will cause a steep rise in unit costs. Thus, society could wind up paying much more for postal services if entry is allowed and sufficient offsetting efficiencies are not achieved. The issue is whether the potential gains from entry in innovation, efficiency, and service quality outweigh the costs of entry. The same general problem pertains to larger per capita volume posts, but it is not so acute.[14] Our family of cost curves show that in the volume range of 200 to 250 pieces and above the increase in unit cost from entry will be minimal.

It could turn out that the benefits from entry in small per capita volume posts are not as great as the cost. In order to make a preliminary assessment of this trade-off, the volume of contestable portion of mail and the likely efficiency gains in the incumbent post must be estimated.

It should also be noted that entry could cause prices to be lower than average for the highly profitable mail that becomes the target of cream skimmers. Prices on the remaining less profitable mail would have to increase to make up for the incumbent's lost profits. This could effectively de-average prices to better reflect costs. An internal estimate by the Poste Italiane shows that stamp prices for Southern regions would have to increase by more than 50 percent to cover costs. Entry could make the USO's geographical cross subsidies impossible to maintain. [15,16]

Implications for Very Low Volume Postal Administrations

Evaluating the scale economies of postal administrations with very low volume levels presents a unique set of challenges. Very little information is available about their

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[14] See Cohen and Chu (1997) for a discussion of whether the gains in efficiency could outweigh the loss of scale economies in the U.S.

[15] See Spadoni and Visco Comandini (2005).

[16] Entry might also highlight the classic postal issue in small volume countries of who has to bear burden of the USO (i.e., single piece mailers, bulk mailers or taxpayers).

costs, operations, the available technology or the nature and quality of the services provided. They can vary widely from post to post.

Consistent with the behavior of costs observed in larger volume posts, very low volume posts should have relatively low cost elasticities. A cross-sectional analysis of Universal Postal Union (UPU) data from 2002 provides results consistent with this expectation. After dividing postal administrations into quartiles by volume per capita, the elasticity of the number of full time staff with respect to postal volume is calculated for each quartile. We use this as a proxy for the cost elasticity. The results are presented in Table 2.

Table 2
Elasticity of Full-time Staff
146 Countries Ranked by Pieces per Capita
(2002)

Quartile	Pieces per Capita	Elasticity w.r.t. Volume	R^2
First	0.05 - 1.91	0.53	0.39
Second	1.93 - 12.61	0.84	0.84
Third	14 - 64	0.93	0.92
Fourth	67 - 8,203	0.91	0.94

The elasticity for the lowest volume quartile is much lower than for the other posts, implying a larger share of fixed costs. Unlike posts with higher volumes, fixed costs in delivery do not necessarily drive this result. Many of these postal administrations provide very limited (if any) delivery outside the principle city. At extremely low volume levels, operations with high elasticities (e.g., mail processing) become such a small part of the enterprise that fixed costs in retail operations and administration can contribute significantly to the proportion of total costs that is fixed.

The low R^2 result for the first quartile also suggests that many factors besides volume influence employment (and costs) for very low volume posts. This probably reflects the heterogeneous nature of the postal operations in these countries. The number of retail offices per capita and their geographic distribution, the extent of delivery in rural areas, and the condition of the country's internal transportation infrastructure are all cost driving factors that are more likely to vary widely among developing countries than among industrial countries.

Because of this diversity, it would be best to consider each country with very low volume individually. However, any post with high fixed costs – including very low volume posts – is more likely to incur significant increases in average unit costs as a result of volume losses.

Conclusions

- Scale economies appear to be the most important determinant of cost behavior for posts in industrial countries.
- Postal administrations with volumes above approximately 200 pieces per capita are unlikely to experience large increases in average unit cost as a result of mild or moderate loss of volume.
- Postal administrations with volumes below approximately 200 pieces per capita are likely to experience large increases in average unit cost as a result of mild or moderate loss of volume. The percentage increase is independent of the overall cost level of the post.
- For low volume posts, the benefits of liberalization may not outweigh the costs of lost scale economies.
- For very low volume posts (below 2 pieces per capita), factors other than volume play a more significant role in determining costs. Nevertheless, the relatively large fixed costs in these posts suggest that they may be vulnerable to large increases in average unit costs if volume is lost.

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Technical Appendix: Cost Model

Model Overview

The model assumes that the cost of each activity performed by a postal system is a function of two variables: mail volume and the size of network (e.g. population of the country).

Notation and definitions

i = Denotes one of the activities performed by a postal system (i.e., mail processing, delivery etc.) ($i = 1,2,3,...,n$)

n = Number of activities performed by a postal system

j = Denotes a postal system ($j = 1,2,3,...,m$)

m = Number of postal systems

C_{ij} = Cost of activity i performed by postal system j $(C_{ij} > 0)$

C_j = $\sum_{i=1}^{n} C_{ij}$ = Total cost of postal system j

Q_j = Mail volume handled by postal system j $(Q_j > 0)$

P_j = Population of the country served by postal system j $(P_j > 0)$

ppc_j = $\frac{Q_j}{P_j}$ = Pieces per capita in the country served by postal system j

a_{ij} = Unit attributable cost (i.e., a proxy for marginal cost) of activity i performed by postal system j $(a_{ij} > 0)$

a_j = $\sum_{i=1}^{n} a_{ij}$ = Unit attributable cost of postal system j

b_{ij} = Per capita institutional (i.e., fixed) costs of activity i performed by postal system j $(b_{ij} > 0)$

b_j = $\sum_{i=1}^{n} b_{ij}$ = Per capita institutional (i.e., fixed) costs of postal system j

Cost Functions for Postal Activity $i\ (i = 1,2,3,...,n)$

It is assumed that the cost of each activity performed by a postal administration is represented by a simple linear function in volume and population. That is

C_{ij} = $a_{ij}Q_j + b_{ij}P_j$ = Cost function for activity i performed by postal system j

MC_{ij} = $\frac{\partial C_{ij}}{\partial Q_j}$ = a_{ij} = Marginal cost with respect to volume or unit attributable cost for activity i performed by postal system j

AC_{ij} = $\frac{C_{ij}}{Q_j}$ = $\frac{a_{ij}Q_j + b_{ij}P_j}{Q_j}$ = $a_{ij} + b_{ij}(1/ppc_j)$ = Functional form of average unit cost curve for activity i performed by postal system j

$\frac{d(AC_{ij})}{d(ppc_j)} = -b_{ij}(1/ppc_j^2)$ = Slope of average unit cost curve for activity i performed by postal system j

E_{ij} = $\frac{MC_{ij}}{AC_{ij}}$ = $\frac{a_{ij}}{(a_{ij}Q_j + b_{ij}P_j)/Q_j}$ = $\frac{a_{ij}}{a_{ij} + b_{ij}(1/ppc_j)}$ = Cost elasticity with respect to volume or variability of activity i performed by postal system j

Cost Functions for Postal System $j\ (j = 1,2,3,...,m)$

The total cost of each postal system is also assumed to be represented by the same simple linear function in volume and population. That is

C_j = $a_jQ_j + b_jP_j$ = Total Cost function for postal system j

MC_j = $\frac{\partial C_j}{\partial Q_j}$ = a_j = Marginal cost with respect to volume or unit attributable cost for postal system j

AC_j = $\frac{C_j}{Q_j}$ = $\frac{a_jQ_j + b_jP_j}{Q_j}$ = $a_j + b_j(1/ppc_j)$ = Function of average unit cost curve for postal system j

$\frac{d(AC_j)}{d(ppc_j)} = -b_j(1/ppc_j^2)$ = Slope of average unit cost curve for postal system j

$$E_j = \frac{MC_j}{AC_j} = \frac{a_j}{(a_j Q_j + b_j P_j)/Q_j} = \frac{a_j}{a_j + b_j (1/ppc_j)}$$ = Overall cost elasticity with respect to volume or variability of postal system j

Activity Proportions or Shares of Total Cost for Postal System $j \; (j = 1,2,3,...,m)$

$$\frac{C_{ij}}{C_j} = \frac{a_{ij} Q_j + b_{ij} P_j}{a_j Q_j + b_j P_j} = \frac{AC_{ij}}{AC_j} = \frac{a_{ij} + b_{ij}(1/ppc_j)}{a_j + b_j(1/ppc_j)} \text{ for } (i = 1,2,3,...,n)$$

Relationship of Cost Functions for two Postal Systems 1 & 2

Suppose that postal system 2 has unit attributable costs and per capita institutional (i.e., fixed) costs for all of its activities that are proportional to the corresponding postal system 1 costs by the same factor λ. That is

$$a_{i2} = \lambda * a_{i1} \text{ and } b_{i2} = \lambda * b_{i1} \text{ for } (i = 1,2,3,...,n)$$

Then

$$a_2 = \lambda \sum_{i=1}^{n} a_{i1} = \lambda * a_1 =$$ Unit attributable cost of postal system 2

And

$$b_2 = \lambda \sum_{i=1}^{n} b_{i1} = \lambda * b_1 =$$ Institutional cost per capita of postal system 2

Substituting the assumed values of the coefficients into the <u>cost functions</u> for postal system 2, we have

$C_{i2} = \lambda(a_{i1} Q_2 + b_{i1} P_2) = \lambda C_{i1} =$ Postal systems 1 and 2 have proportional cost equations for activity $i(i = 1,2,3,...,n)$

and

$C_2 = \lambda(a_1 Q_2 + b_1 P_2) = \lambda C_1 =$ The total cost equations for postal systems 1 and 2 are proportional.

Similarly, substituting the assumed values of the coefficients in the <u>average cost functions</u> for postal system 2, we get

$AC_{i2} = \lambda[a_{i1} + b_{i1}(1/ppc_2)] = \lambda AC_{i1}$ = Postal systems 1 and 2 have proportional average unit cost curves for activity $i(i = 1,2,3,...,n)$

$\frac{d(AC_{i2})}{d(ppc_2)} = -\lambda[b_{i1}(1/ppc_2{}^2)] = \lambda\frac{d(AC_{i1})}{d(ppc_1)} =$ For postal systems 1 and 2 the slopes of their average unit cost curves for function $i(i = 1,2,3,...,n)$ are proportional

and

$AC_2 = \lambda[a_1 + b_1(1/ppc_2)] = \lambda AC_1 =$ The average unit cost curves for postal systems 1 and 2 are proportional

$\frac{d(AC_2)}{d(ppc_2)} = -\lambda[b_1(1/ppc_2{}^2)] = \lambda\frac{d(AC_1)}{d(ppc_1)} =$ For postal systems 1 and 2 the slopes of their average unit cost curves are proportional.

***Proposition 1**: If postal system 2 has unit attributable costs and per capita institutional (i.e., fixed) costs for all of its activities that are proportional to the corresponding costs of postal system 1 by the same factor λ, then the two postal systems have different total cost and average cost curves. However, the shape of the corresponding curves is similar for the two postal systems.*
More specifically, the average cost curves for the two postal systems 1 and 2 are proportional, not parallel. Each point on the average cost curve for postal system 2 is the same as the corresponding point on the average cost curve for postal system 1 multiplied by the constant λ.

Now substituting the proportional values of the coefficients in the cost elasticity or variability equations for postal system 2, we obtain

$$E_{i2} = \frac{\lambda a_{i1}Q_2}{\lambda(a_{i1}Q_2 + b_{i1}P_2)} = \frac{\lambda a_{i1}}{\lambda[a_{i1} + b_{i1}(1/ppc_2)]} = \frac{a_{i1}Q_2}{a_{i1}Q_2 + b_{i1}P_2} = \frac{a_{i1}}{a_{i1} + b_{i1}(1/ppc_2)} = E_{i1} =$$

= Cost elasticity with respect to volume or variability curve of activity $i(i = 1,2,3,...,n)$ is the same for both postal systems 1 and 2

$$E_2 = \frac{\lambda a_1Q_2}{\lambda(a_1Q_2 + b_1P_2)} = \frac{\lambda a_1}{\lambda[a_1 + b_1(1/ppc_2)]} = \frac{a_1Q_2}{a_1Q_2 + b_1P_2} = \frac{a_1}{a_1 + b_1(1/ppc_2)} = E_1 =$$

= Overall cost elasticity with respect to volume or variability curve is the same for both postal systems 1 and 2.

Finally, substituting the proportional values of the coefficients in the equation of activity proportions or shares of total cost for postal system 2, we have

$$\frac{C_{i2}}{C_2} = \frac{\lambda(a_{i1}Q_2 + b_{i1}P_2)}{\lambda(a_1Q_2 + b_1P_2)} = \frac{\lambda[a_{i1} + b_{i1}(1/ppc_2)]}{\lambda[a_1 + b_1(1/ppc_2)]} = \frac{a_{i1}Q_2 + b_{i1}P_2}{a_1Q_2 + b_1P_2} = \frac{a_{i1} + b_{i1}(1/ppc_2)}{a_1 + b_1(1/ppc_2)} = \frac{C_{i1}}{C_1} =$$

Postal systems 1 and 2 have identical cost share curves for each activity $i(i = 1,2,3,...,n)$.

<u>Proposition 2</u>: If postal system 2 has unit attributable costs and per capita institutional (i.e., fixed) costs for all of its activities that are proportional to the corresponding costs of postal system 1 by the same factor λ, then the two postal systems have identical cost elasticity and cost share curves.

<u>Proposition 3</u>: As long as the two postal systems have the same <u>linear</u> form of cost function $C_j = a_jQ_j + b_jP_j$ the opposite of Proposition 2 is true. That is, if postal systems 1 and 2 have identical cost share and cost elasticity curves, then postal system 2 has unit attributable costs and per capita institutional (i.e., fixed) costs for all of its activities that are proportional to the corresponding costs of postal system 1 by the same factor λ.

Proof for Proposition 3

Suppose that postal system 2 has: (1) unit attributable costs for all of its activities that are proportional to the corresponding postal system 1 costs by different factors $\delta_i(i = 1,2,3,...,n)$; (2) per capita institutional (i.e., fixed) costs for all of its activities that are proportional to the corresponding postal system 1 costs by different factors $\eta_i(i = 1,2,3,...,n)$; (3) a unit attributable cost that is proportional to the unit attributable cost of system 1 by the factor k; and (4) a per capita institutional (i.e., fixed) cost that is proportional to the per capita institutional cost of system 1 by the factor μ. That is $a_{i2} = \delta_i * a_{i1}$ and $b_{i2} = \eta_i * b_{i1}$ for any activity $i(i = 1,2,3,...,n)$

Also

$a_2 = \kappa * a_1$ and $b_2 = \mu * b_1$

Now suppose that the two postal systems have identical cost share curves. That is

$\frac{a_{i1}Q + b_{i1}P}{a_1Q + b_1P} = \frac{a_{i2}Q + b_{i2}P}{a_2Q + b_2P}$ for any values of Q and P; and for any activity $i(i=1,2,3,...,n)$

Substituting the assumed values of the coefficients in cost share equation of postal system 2, we have

$$\frac{a_{i1}Q + b_{i1}P}{a_1Q + b_1P} = \frac{\delta_i a_{i1}Q + \eta_i b_{i1}P}{\kappa a_1Q + \mu b_1P}$$ for any values of Q and P; and for any activity $i(i = 1,2,3,...,n)$

By cross multiplying terms and simplifying results in the above equation, we get

$$(\kappa - \delta_i)(a_{i1}a_1Q^2) + (\mu - \delta_i)(a_{i1}b_1QP) + (\kappa - \eta_i)(a_1b_{i1}QP) + (\mu - \eta_i)(b_{i1}b_1P^2) = 0$$

for any values of Q and P; and for any activity $i(i = 1,2,3,...,n)$

Since all the terms in the above expression are by definition greater than zero, the left hand side can only be zero if and only if

$(\kappa - \delta_i) = (\mu - \delta_i) = (\kappa - \eta_i) = (\mu - \eta_i) = 0$ for any activity $i(i = 1,2,3,..., n)$

For the above equalities to hold, it requires that all proportionality factors are equal to the same factor λ. That is

$\delta_i = \eta_i = \kappa = \mu = common\ \ proportion\ \lambda$ for any activity $i(i = 1,2,3,..., n)$

Furthermore, the requirement of a common proportion λ implies, through Proposition 2, that the cost elasticity curves are also identical for the two postal systems.

Finally, given the form of the cost model in this appendix, the above three propositions are true for any two postal systems.