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AN EMPIRICAL ANALYSIS OF THE GRAVEYARD SPIRAL

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1. INTRODUCTION

The graveyard spiral conjecture applies to posts that have a universal service obligation and uniform prices. It begins with the fact that these posts must cross-subsidize unprofitable delivery routes with profitable ones. This causes prices on profitable routes to be higher than need be. Under liberalization this increment in price allows cream skimming to take place by a less efficient entrant whose costs are higher than the incumbent, but who can set lower prices on the most profitable routes. Once profits on these routes are lost to the entrant, the incumbent is forced to raise prices because its average unit cost has increased and it needs additional revenue to maintain its level of profit (breakeven or otherwise). This could lead to a continuous cycle of higher average unit costs, lost profits and forced rate increases. Thus, it is conjectured that the current practice of cross-subsidy is unsustainable without a monopoly. In other words, liberalization may well lead to a graveyard spiral (Crew and Kleindorfer 2000, 2001).

This scenario has not played out in Sweden or New Zealand, the two countries that have liberalized and have actual competition. In this paper we present an empirical analysis to show that a graveyard spiral would not happen as long as a post has sufficient per capita volume at the outset of liberalization and management can maintain total factor productivity.

The sustainability of the cross-subsidy required by uniform prices is of interest because it raises the possibility of a *less* efficient entrant capturing the market. If the market were to be lost to a *more* efficient entrant, well *c'est la guerre*. The purpose of liberalization is to increase efficiency. We will show, however, that even if competitors are more efficient than incumbents, posts in general and the United States Postal Service (USPS) in particular, are unlikely to be ensnared in a graveyard spiral.

The sustainability of the cross-subsidy is also of interest in the case where an entrant adopts a less frequent delivery schedule than the incumbent and thereby reduces its cost structure *vis-à-vis* the incumbent (*e.g.*, Sweden Post's competitor, City Mail, delivers every third business day). Analytically this is very similar to the situation where the entrant is more efficient than the incumbent. It differs, however, in an

important respect. Less frequent delivery would mean that there would be less contestable mail for the entrant to vie for, since many senders require more frequent service. This in turn would leave more non-contestable mail to absorb any price increases that the incumbent may need. We will also show that this type of entry would not lead to a graveyard spiral.

In this paper we present both qualitative arguments and an empirical quantitative analysis to demonstrate that liberalization would not lead to a graveyard spiral, especially in the United States. We believe that our findings are applicable to most other posts of industrialized countries.

First, we show that costs would not rise rapidly in response to cream-skimming activity. Next, we use an actual delivery profit curve to show that the 230,000 U.S. Postal Service delivery routes do not appear amenable to substantial cream skimming. Thirdly, we develop a model to analyze the potential impact of cream skimming based on actual route data. The model treats parametrically the amount of contestable mail and the efficiency of the cream skimmer relative to USPS. As a preliminary matter we estimate the contestable volume in order to benchmark the model results. We analyze three cases with the model: (1) a cream skimmer that is *less* efficient than USPS; (2) a cream skimmer that is *more* efficient; and (3) a cream skimmer that delivers fewer days per week than USPS. Finally, we present our conclusions.

2. QUALITATIVE ARGUMENTS

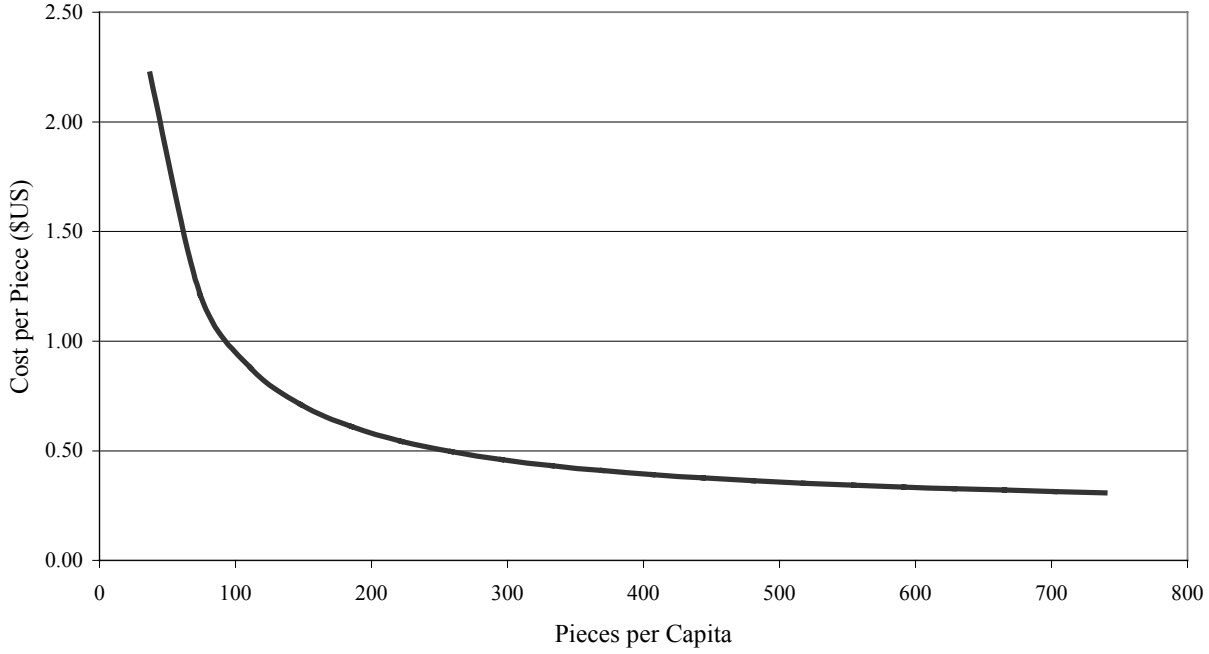
2.1 The Effect of Volume on Cost

Because of substantial fixed costs a post's average unit cost will increase if it loses volume to a competitor. Figure 1 displays unit costs, as a function of per capita volume. The curve is based on USPS cost elasticities and its shape has been validated for several other posts in industrialized countries (Cohen, et al. 2002). A post's actual position on the vertical axis depends primarily on its productive hourly wage as compared to USPS's.[1] It can be seen that costs rise relatively slowly as volume decreases from 700 pieces down to about 200 pieces per capita. For example, at 700

[1] Other factors influencing a post's position on the vertical axis include the amount of worksharing and the number of delivery days.

pieces per capita, costs would rise 4 percent in response to a 10 percent decrease in per capita volume. At the bottom end of the range, however, costs begin to rise much more steeply. A post with 100 pieces per capita would see its cost rise 8.3 percent with a 10 percent decrease in per capita volume. The curve presupposes that efficiency (total factor productivity) remains constant over the volume range. Thus, it would appear that medium to high volume posts (say above about 200 pieces per capita) can withstand the loss of volume more easily than low volume posts. The latter may well enter a graveyard spiral if entrants can capture a relatively small share of volume. This would happen even if they maintained constant efficiency levels.

Figure 1: Model Estimates of Unit Cost
Benchmarked by U.S. Costs and Volumes



2.2 Delivery Profits

Delivery profits are the surplus of revenue on a route after the upstream attributable costs of the delivered mail and the total cost of the route are subtracted.[2]

[2] "Delivery profits" are not profits in the ordinary sense. As the term is used here they are contribution to institutional (overhead) costs.

The graveyard spiral depends on the degree of delivery profit heterogeneity. Consider two possible profit curves shown in Figure 2. Curve A provides ample room for cream skimming. Once profits are lost (on say, the most profitable 25 percent of the routes), the incumbent must raise prices to regain its lost profits. This in turn creates a similar cream-skimming opportunity, and so on. On the other hand, curve B represents a perfectly homogeneous profit curve (*i.e.*, each route makes the same profit). There is no cream to skim with curve B and a death spiral caused by cream skimming is impossible. The more the actual profit curve for a post resembles A, the more likely a death spiral and the more it looks like B, the less likely.

Figure 2: Hypothetical Profit Curves
Routes Ordered by Profit

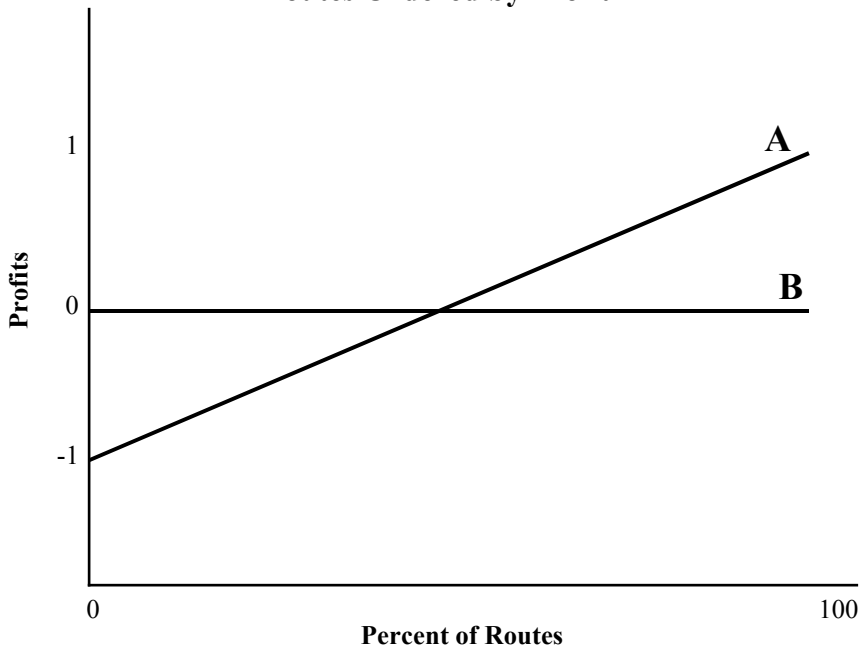


Table 1 displays USPS delivery profits by semi-decile. It can be seen that about 55 percent of the routes are profitable, generating $5.6 billion in profits. This is offset by $2.6 billion in losses from the unprofitable routes yielding net delivery profits of $3.0 billion. However, profits are highly skewed. Ten percent of the routes generate nearly half the gross profits. Losses are similarly skewed with 10 percent of the routes generating about half the losses.

Table 1: Annual Route Profits (Losses) by Semi-Decile (1999, $ Millions)

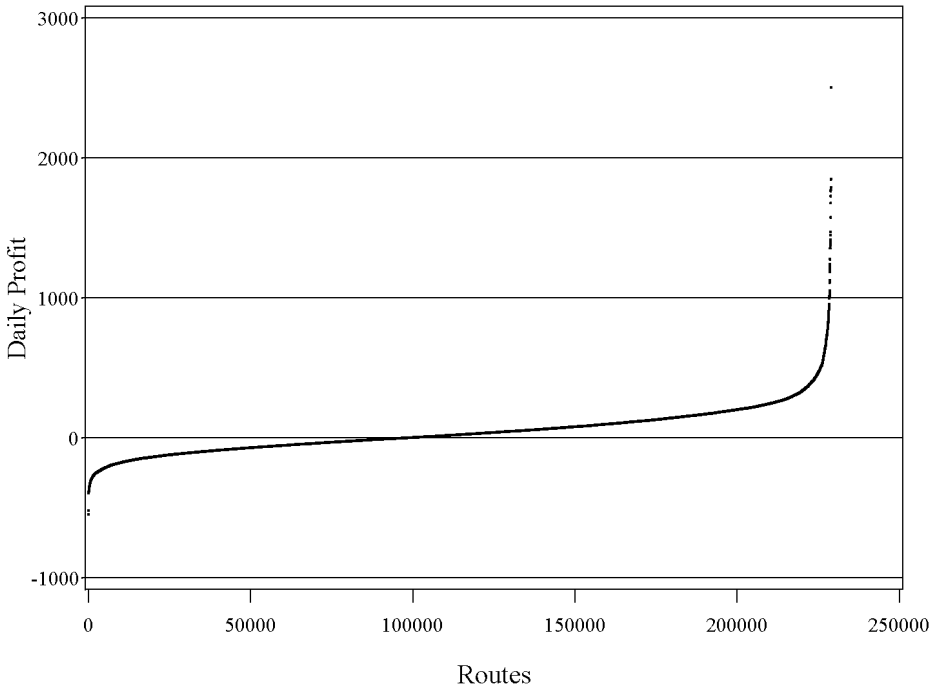
Profits		Losses	
1	$1,690	12	(4)
2	888	13	(56)
3	701	14	(112)
4	575	15	(172)
5	471	16	(236)
6	382	17	(307)
7	303	18	(391)
8	232	19	(505)
9	168	20	(764)
10	108		
11	50		
Total Profits	5,572	Total Losses	(2,551)
Net Profits	3,021		

Note: Profitable and unprofitable semi-deciles do not sum to total profits and total losses because semi-decile 12 contains both profitable and unprofitable routes.

Figure 3 displays USPS's routes ordered by profit. It can be seen that except for the extremes the curve is remarkably flat.[3] In fact, it resembles the horizontal curve B in Figure 2 much more than it resembles curve A. Thus, in the U.S. there is little cream to skim (beyond the top 10 percent of routes). After the first iteration of cream skimming, smaller and smaller price increases would be needed to maintain profitability.

[3] The distribution of these route profits is close to a normal distribution. All else being equal, a higher dispersion in the distribution of a post's route profits makes the post more vulnerable to cream skimming by competitors. Using the hypothetical curves in Figure 2 as an example, curve A corresponds to a uniform distribution and has a high dispersion, whereas curve B has no dispersion.

Figure 3: Actual Profit Curve
USPS Routes Ordered By Profit (1999)



The profit curve for *Poste Italiane* has a shape quite similar to the U.S. profit curve.[4] If two such disparate posts have such similarly shaped profit curves, it is a reasonable conjecture that the post in most industrial countries has a profit curve with a similar shape.

3. QUANTITATIVE ANALYSIS

3.1 Contestable Mail

Without a collection system and upstream infrastructure, delivery cream skimmers cannot compete for single-piece mail. In this section we estimate the proportion of bulk mail that is contestable by cream skimmers in the U.S. market.

The worksharing discounts in the U.S. are based on avoided cost. If a mailer's cost (or that of its third party consolidator) is less than the Postal Service's, it will do the work. If its cost is greater, it will allow the Postal Service to do the work. Thus, in the U.S. there already is a competitive upstream system.

[4] In fact, it is even more homogenous than the U.S. curve. *See* Cohen, et al. (2002).

Table 2 displays the worksharing volumes for Fiscal Year (FY) 2002 by presort level and Table 3 displays the dropship level for advertising carrier route mail. Mail is contestable if it is carrier route presorted and dropshipped at the Sectional Center Facility (SCF)[5] or Destination Delivery Unit (DDU)[6] level. The remaining mail in the competing upstream system has costs that exceed USPS's to reach that level of presort and dropshipment, otherwise it would have been captured by an upstream competitor. Purely on an upstream cost basis this mail would not be available to a delivery cream skimmer.

Table 2: Presortation Levels of Mail (2002)

	Volume (billions)	Percent of Total Mail
First-Class		
Single Piece	51.9	25.6
Presort (without barcodes)	3.7	1.8
Barcoded Mail		
Basic	6.1	3.0
3-Digit	23.7	11.7
5-Digit	15.8	7.8
Carrier Route	1.1	0.5
Publications		
Basic	0.7	0.4
3-Digit	1.6	0.8
5-Digit	2.9	1.4
Carrier Route	4.4	2.2
Advertising Mail		
Basic	7.9	3.9
3/5-Digit	42.4	20.9
Carrier Route	36.9	18.2
Other Mail	3.5	1.7
TOTAL	**202.8**	**100.0**

Source: USPS 2002 RPW & Billing Determinants

[5] An SCF serves as the distribution and processing center for post offices in a specific geographic area, which is designated by the first three digits of the zip code.

[6] A DDU is the postal facility from which the carriers depart to deliver mail on their routes. It is designated by the five-digit zip code.

Table 3: Distribution of Advertising Carrier Presorted (ECR) Mail by Drop Entry Point (2002)

	Volume (billions)	Percent Distribution of Volume
Non-Dropshipped	2.8	7.6
BMC Entry	3.8	10.2
SCF Entry	20.0	54.3
DDU Entry	10.3	27.9
TOTAL	**36.9**	**100.0**

Source: USPS 2002 RPW & Billing Determinants

Bulk Mail Center (BMC) - 21 nationwide
Sectional Center Facility - 500 nationwide
Delivery Distribution Unit - 24,000 nationwide

The amount of First-Class carrier route mail should be adjusted upward to get a more accurate estimate of contestable volume because the discount for carrier route is available only for selected zip codes (where carrier sequencing is done at the delivery unit). There is no incentive offered for other zip codes. Consequently, for our estimate we assume that half of the 5-digit plus all of the carrier route First-Class can be sorted to the carrier route level at a cost less than the Postal Service's.

In addition, First-Class has no dropship incentives so we make the conservative assumption that all actual and imputed carrier route First-Class Mail is dropshipped. Publications' dropship incentives are not based on actual cost (since no discount is awarded for the editorial content). Consequently, we assume that the share of carrier route publications that would be dropshipped at the DDU or SCF is the same as for advertising carrier presorted (ECR) mail.

We conclude that 21 percent of total mail or 29 percent of FY 2002 bulk mail[7] is contestable in the U.S. market by delivery cream skimmers. This is the percentage of mail that would be sorted to the carrier route (with barcodes for carrier sequencing) and dropshipped to the SCF or DDU level with cost based incentives in all classes. For

[7] The term "bulk mail" refers to non-single-piece mail, which comprises about 74 percent of total mail.

FY 1999, 18 percent of the mail is contestable using these definitions. In the subsequent empirical analysis presented here, data are used from FY 1999.[8]

Our model treats contestable volume parametrically. We present our estimate as a reasonable benchmark to use in interpreting the model results. We do, however, use total delivered bulk mail as an upper bound for contestable volume in the model.

3.2 Model Description

The model involves four iterative steps:

1. The model examines individual routes to identify the ones where an entrant can profitably deliver the contestable volume.

2. The incumbent's profit from these routes is reduced by the contribution to overhead from the lost contestable volume.

3. The incumbent's prices are raised to recover the profit lost to cream skimming and the subsequent effect of demand price elasticities.

4. The rise in incumbent's prices creates additional cream-skimming opportunities for the entrant. The model returns to step 1 until equilibrium is achieved.

The model uses FY 1999 cost and revenue data. The price charged in 1999 by USPS for mail presorted to the carrier route level in saturation quantities arranged in the carrier walk sequence and entered at the delivery unit or SCF was 12.6 cents.[9] We use 12.6 cents as the imputed price charged by the Postal Service for delivery. This price has no upstream costs associated with it. It represents a conservative upper bound.

For a given amount of contestable volume, the model examines each delivery route, and based on the contestable volume it determines if the entrant can deliver the contestable mail at a profit (*i.e.*, the potential revenue from the contestable volume on

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[8] Cohen et al. 2000, using the same definition and volume data from FY 1997, estimated the contestable mail to be 15.5 percent of total mail. The following two changes in mail volume explain the increase in contestable mail from 15.5 percent in FY 1997 to 21 percent in FY 2002: (a) the proportion of advertising carrier route (ECR) mail that is dropshipped at SCF and DDU has increased from 68 percent in FY 1997 to about 82 percent in FY 2002; and (b) for FY 2002, we moved about 4.5 billion pieces from advertising 3/5-digit back to carrier route (ECR) to correct for the migration of carrier route mail to 3/5 digit that occurred when rates were adjusted in 1998 to support the letter automation program.

[9] It had a markup over cost of 156 percent, the highest for any category of mail. Less heavily workshared mail was charged a higher price based on costs which were incurred to prepare it to the same level plus a markup that in all cases was less than 156 percent.

the route is greater than the entrant's fixed and variable cost of delivering that volume on that route).[10]

This test involves calculating the unit cost of delivering the contestable volume and determining if it is below 12.6 cents. The sum of the fixed route costs and the variable delivery costs of the contestable mail is divided by the contestable volume to determine the entrant's average cost per piece on the route. If the average cost is less than 12.6 cents, the model assumes that the entrant captures all contestable mail on the route. As a result, the incumbent loses the contribution formerly made by the contestable volume.[11] Because the fixed costs remain unchanged, the volume loss also results in a higher average unit cost for the incumbent.

The total lost contribution is then made up by increasing prices on the incumbent's remaining delivered volume taking into account the effect of price elasticities. This increases the 12.6-cent price threshold. The model repeats the above steps until no more routes are captured by the entrant (*i.e.*, an equilibrium is reached). A formal description of the model including data sources is presented in the Appendix.

3.3 Results for Inefficient Entry

The degree to which an entrant's cost level exceeds that of the incumbent represents the degree of inefficiency posed by entry. We model the consequences of inefficient entry with the most conservative assumption (*i.e.*, the entrant's cost level is the same as the incumbent's). Table 4 displays the model results for an entrant whose cost level is the same as USPS's, assuming 36 billion pieces of mail are contestable in FY 1999 (as defined in Section 3.1).

[10] The model assumes that the same percentage of each subclass is contestable for every route.

[11] A "captured" route may still be profitable for the incumbent provided sufficient non-contestable volume remains.

Table 4: Iterative Steps of the Model
Assuming Benchmark Contestable Volume and USPS Efficiency

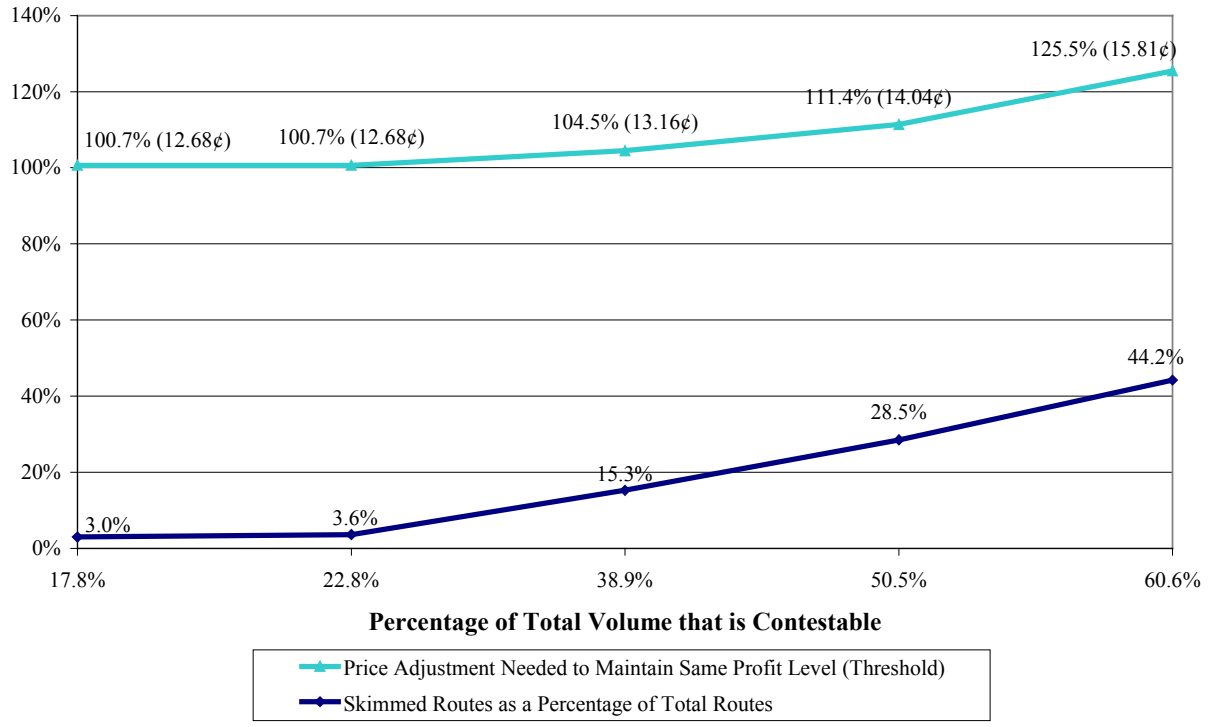
Iteration	Stage	Markup	Routes Skimmed	Volume Skimmed (thousand)	Volume Lost (thousand)	Volume Remaining (million)	Incumbent Contribution ($ million)
1	pre skim	1.00000				158,301	3,021
1	post skim	1.00000	6,742	3,271,799	3,271,799	155,029	2,773
1	pre elast	1.00572				155,029	3,021
1	post elast 1	1.00572			321,752	154,707	2,989
1	post elast 2	1.00646			40,910	154,666	3,017
1	post elast 3	1.00655			5,210	154,661	3,021
1	post elast 4	1.00656			664	154,660	3,021
1	post elast 5	1.00656			84	154,660	3,021
1	post elast 6	1.00656			12	154,660	3,021
1	post elast 7	1.00656			-	154,660	3,021
2	pre skim	1.00656				154,660	3,021
2	post skim	1.00656	107	47,424	47,424	154,613	3,017
2	pre elast	1.00665				154,613	3,021
2	post elast 1	1.00665			4,743	154,608	3,021
2	post elast 2	1.00666			603	154,607	3,021
2	post elast 3	1.00666			76	154,607	3,021
2	post elast 4	1.00666			9	154,607	3,021
2	post elast 5	1.00666			3	154,607	3,021
2	post elast 6	1.00666			-	154,607	3,021
3	pre skim	1.00666				154,607	3,021
3	post skim	1.00666			-	154,607	3,021
3	pre elast	1.00666				154,607	3,021
3	post elast 1	1.00666			-	154,607	3,021

This set of parameters results in equilibrium after two iterations at which point no routes are available to be skimmed. Prior to equilibrium being established, the incumbent loses about 3.3 billion pieces to the entrant and an additional 374 thousand pieces due to price elasticities. Compensating for these losses requires a price increase of a little more than one-half percent. As the table shows, the price increase required to make up the contribution lost in the first iteration is not great enough to make very many additional routes attractive to the entrant. This is in part because all of the low hanging fruit is captured in the first iteration, and the entrant now has to compete on routes where the costs are very close to the average.

Next we evaluate the sensitivity of this result to variations in the amount of contestable mail. Figure 4 shows the results of the new equilibrium under various estimates of contestable mail. The model calculates the impact of cream skimming on

the incumbent using five different estimates of contestable volume (shown on the horizontal axis). The results for 17.8 percent of total volume being contestable correspond to the benchmark for contestable volume in FY 1999. The highest percentage, 60.6 percent, corresponds to all delivered bulk mail being contestable. The bottom curve displays the percent of the 230,000 routes captured by the entrant. The top curve represents the new price as a percentage of the original prices that must be charged to make up the lost contribution to the entrant.

Figure 4: Effect of Creamskimming of Contestable Mail Assuming Entrant Cost Level is the Same as USPS

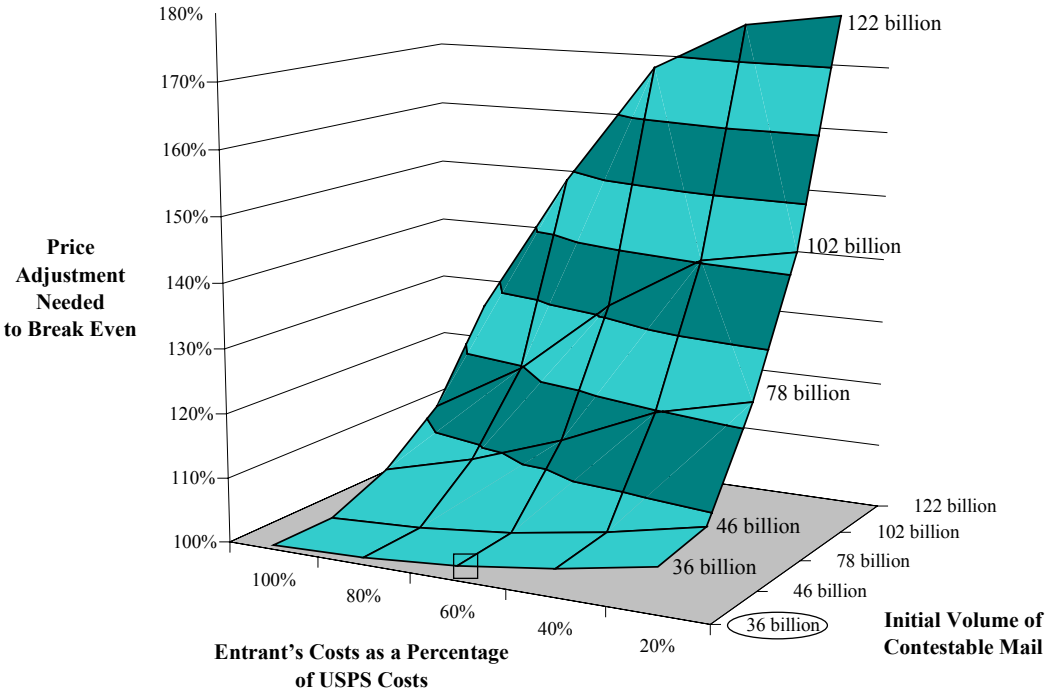


The percentage of routes on which cream skimming occurs increases faster than the price increases. But this does not affect the financial stability of the post. The increase in price required for the benchmark amount of contestable mail is less than 1 percent. When all delivered bulk mail is treated as contestable, a 25.5 percent increase in price is required before equilibrium is reached. Because of the limited impact on price, it is apparent that a graveyard spiral will not occur.

3.4 Results for Efficient Entry

We examine the possible effects of efficient entry by parametrically reducing the entrant's cost of delivering contestable mail on each route. To model efficient entry we use a percentage of incumbent's costs for the entrant. Figure 5 presents the new equilibrium prices.[12]

Figure 5: Price Adjustment Needed to Break Even after Creamskimming and Volume Lost to Effect of Price Elasticities



The front axis (with a range of 100% to 20%) displays the cost of the entrant as compared to the incumbent. The right-hand axis displays the volume of contestable mail. The circled value is the benchmark estimate of contestable volume. The vertical (or left-hand axis) contains the increase in price necessary to retain profit level (breakeven or otherwise). Each alternating shade in the figure corresponds to a 10-percent range of price increases.

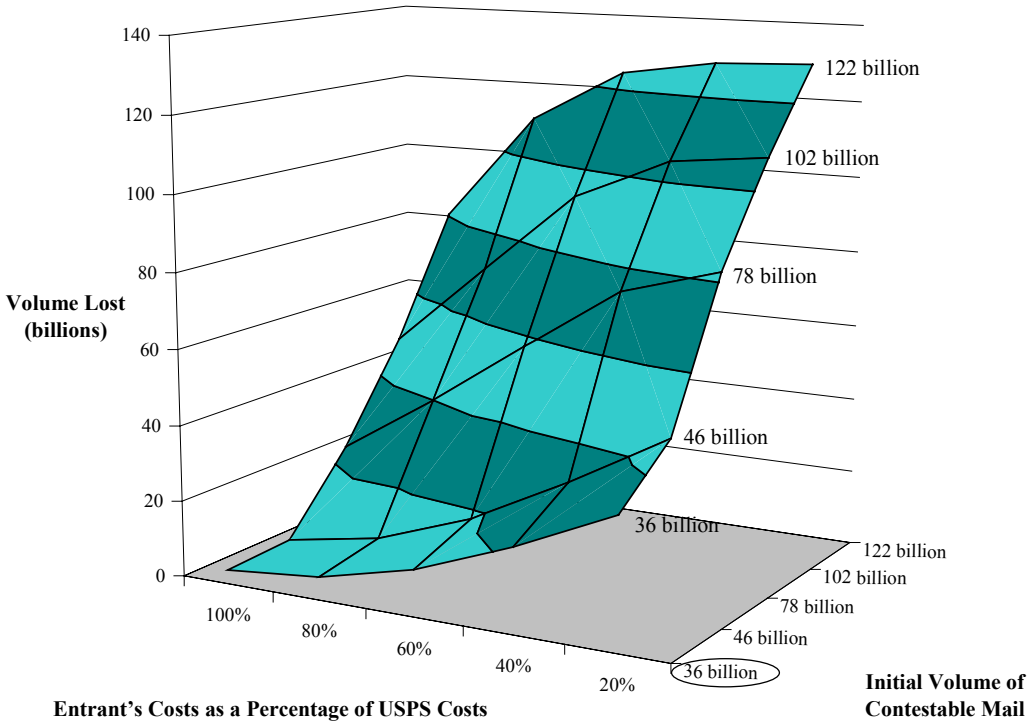
For example, using the entrant's cost level of 60 percent of USPS, and the benchmark contestable volume, the incumbent's prices would have to rise 2.3 percent

[12] The entrant may have lower costs than the incumbent by operating more efficiently, paying a lower wage, or by reducing the quality of service (*e.g.*, reducing frequency of delivery).

to maintain breakeven.[13] The worst case for the incumbent corresponds to 122 billion pieces of contestable mail and the entrant's costs being only 20 percent of USPS costs. That point (at the top right of the graph) shows a 78 percent increase in price would be required to breakeven.

Figure 6 has the same axes except for the vertical (left) which displays the amount of contestable volume actually lost. For the first case above (60 percent of USPS costs, benchmark contestable volume), the entrant captures 11 billion pieces, or 5.5 percent of total volume.[14] In the worst case for the incumbent, the entrant captures virtually all delivered bulk mail.

Figure 6: Volume Lost to Creamskimming and Effect of Price Elasticities



3.5 Results for Less Frequent Delivery

The model can also be used to evaluate the impact of an entrant that delivers fewer than six days per week. This case can be considered a special form of efficient

[13] In the figure, a square has been placed around this point to identify it.

[14] Roughly one billion more pieces are lost due to the effects of elasticity and the required rate increases.

entry. While such an entrant may have costs well below the level of the incumbent – as discussed before – a reduced level of service would be attractive to fewer mailers and therefore contestable volume would be low. Even in the unlikely event that 78 billion pieces (just over one-half of all delivered bulk mail) could be contested by a less frequently delivering entrant with 20 percent of the incumbent's costs, the incumbent would need to increase prices on the remaining mail by about 23 percent before equilibrium is restored. This suggests that entry by competitors offering less frequent delivery is not likely to cause a graveyard spiral.

3.6 Conclusions

In all cases we find that there is little impact on the incumbent beyond the first iteration of cream skimming. This is due to the shape of USPS's profit curve (*See* Figure 3). Thus, we see no possibility of a graveyard spiral.

The results are most sensitive to the volume of contestable mail and much less sensitive to the efficiency level of the entrant or the Postal Service's imputed price for delivery.

Contestable volume is limited by the upstream cost of the Postal Service. The volume of mail that costs less than the Postal Service's cost to sort to carrier route and dropship to local areas is designated the contestable benchmark volume.

The worst scenario for the incumbent (entrant's cost is 20 percent of the Postal Service and all delivered bulk mail is contestable) does not result in a graveyard spiral. It does, however, require an average price increase of about 78 percent on the remaining delivered mail. This would mean a 66-cent First-Class stamp. In this scenario, however, the total cost to society of delivering mail is reduced.

Competition from a less efficient entrant would have minimal consequences for the Postal Service. At the benchmark amount of contestable mail, it would require less than a one-percent price increase by USPS.

A. APPENDIX: CREAM-SKIMMING MODEL

A.1 Model Overview

1. The model examines individual routes to identify the ones where an entrant can profitably deliver the contestable volume.

2. The incumbent's profit from these routes is reduced by the contribution to overhead from the lost contestable volume.

3. The incumbent's prices are raised to recover the profit lost to cream skimming and the subsequent effect of demand price elasticities.

4. The rise in incumbent's prices creates additional cream-skimming opportunities for the entrant. The model returns to step 1 until equilibrium is achieved.

A.2 Notation and Definitions

i Denotes a USPS mail subclass

M = Number of USPS mail subclasses

j Denotes a USPS delivery route

N = Number of USPS delivery routes

q_{ij} = Volume of subclass i delivered on route j

Q_j = $\sum_{i=1}^{M} q_{ij}$ = Volume of mail delivered on route j

QDM = $\sum_{j=1}^{N} Q_j = \sum_{j=1}^{N}\sum_{i=1}^{M} q_{ij}$ = Volume of USPS delivered mail

TQ = Volume of all USPS mail

QND = $TQ - QDM$ = Volume of USPS non-delivered mail

pqc_i = Percentage of subclass i volume considered contestable (*See* Section A.3)

qc_{ij} = $pqc_i * q_{ij}$ = Contestable mail in subclass i delivered on route j

QC_j = $\sum_{i=1}^{M} qc_{ij}$ = Volume of contestable mail delivered on route j
(QC_j is a subset of Q_j.)

TQC = $\sum_{j=1}^{N} QC_j = \sum_{j=1}^{N}\sum_{i=1}^{M} qc_{ij}$ = All contestable mail volume

e_i = Price elasticity of demand for subclass i

r_i = Price of mail subclass i

R_j = $\sum_{i=1}^{M} r_i q_{ij}$ = Revenue from mail delivered on route j

RDM = $\sum_{j=1}^{N} R_j = \sum_{j=1}^{N}\sum_{i=1}^{M} r_i q_{ij}$ = USPS revenue from delivered mail

TR = Total USPS revenue

RND = $TR - RDM$ = USPS revenue from non-delivered mail

mc_i = Unit delivery cost[15] of subclass i

vc_{ij} = $mc_i * q_{ij}$ = Variable delivery cost of volume of subclass i delivered on route j

VC_j = $\sum_{i=1}^{M} vc_{ij}$ = Volume variable cost of route j

VC = $\sum_{j=1}^{N} VC_j$ = Total USPS variable delivery cost

FC_j = Fixed cost of route j

FC = $\sum_{j=1}^{N} FC_j$ = Total USPS fixed costs assigned to delivery

umc_i = Upstream unit cost of subclass i

uvc_{ij} = $umc_i * q_{ij}$ = Upstream variable cost of volume of subclass i delivered on route j

UVC_j = $\sum_{i=1}^{M} uvc_{ij}$ = Upstream variable cost of mail delivered on route j

UVC = $\sum_{j=1}^{N} UVC_j$ = Total USPS upstream variable cost of delivered mail

C_j = $VC_j + FC_j + UVC_j$ = Total cost of route j

CDM = $\sum_{j=1}^{N} C_j = VC + FC + UVC$ = USPS cost of delivered mail

CND = USPS costs of non-delivered mail (i.e., upstream variable cost of non-delivered mail)

TFC = Total USPS fixed costs

FCR = $TFC - FC$ = Residual USPS fixed costs (i.e., fixed costs not assigned to delivery)

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[15] All costs used in the model include the costs of direct and supervisory labor as well as vehicle and space-related costs.

TC = $CDM + CND + FCR$ = Total USPS cost

P_j = $R_j - C_j$ = Profits from mail delivered on route j

PDM = $\sum_{j=1}^{N} P_j$ = $RDM - CDM$ = USPS profits from delivered mail

PND = $RND - CND$ = USPS profits from non-delivered mail

TP = $PDM + PND - FCR$ = Total USPS profits

vcc_{ij} = $mc_i * qc_{ij}$ = Variable cost of contestable mail in subclass i delivered on route j

VCC_j = $\sum_{i=1}^{M} vcc_{ij}$ = Variable cost of contestable mail on route j
(Does not include the upstream variable cost of contestable mail)

PC = 12.6 cents = USPS price for delivery only

ACE_j = $\frac{VCC_j + FC_j}{QC_j}$ = Entrant's average cost for delivering mail on route assuming the same efficiency and service level as USPS

λ = Entrant's cost efficiency factor (*See* Section A.3)

MU = Markup required to restore original delivery profit after mail skimming from USPS routes and volume losses due to price elasticity effect

A.3 Parameters

The model makes use of two parameters: pqc_i, the percentage of subclass i volume considered contestable, and λ, the entrant's cost efficiency factor in comparison to USPS. λ is a simple factor ranging from 20 percent to 100 percent. Table A-1 displays the values of pqc_i used to develop each level of contestable mail.

Table A-1: Percentage of Subclass Considered Contestable

Subclass	FY 1999 Delivered Volume (000)	Percentage of Subclass Included in Each Measure of Contestable Volume				
		36 billion	46 billion	78 billion	102 billion	122 billion
First-Class letters & parcels	31,734,789					
First-Class presort letters & parcels	36,615,502	14.6%	14.6%	43.9%	73.2%	100.0%
First-Class post cards	2,465,684					
First-Class presort cards	1,894,908	17.4%	17.4%	52.3%	87.2%	100.0%
Priority Mail	823,637					
Express Mail	36,994					
Periodicals	10,102,819	36.1%	36.1%	82.6%	100.0%	100.0%
Standard Regular	32,215,827		50.0%	50.0%	75.0%	100.0%
Standard Regular Carrier Route	30,841,276	82.0%	50.0%	100.0%	100.0%	100.0%
Standard Nonprofit	8,575,402		50.0%	50.0%	75.0%	100.0%
Standard Nonprofit Carrier Route	1,635,844	82.0%	50.0%	100.0%	100.0%	100.0%
Parcel Post	282,484			25.0%	50.0%	100.0%
Other Mail	1,075,418					
Delivered Volume	**158,300,584**	**22.7%**	**29.0%**	**49.5%**	**64.3%**	**77.2%**
Non-Delivered Volume	**43,342,930**					
TOTAL VOLUME	**201,643,514**	**17.8%**	**22.8%**	**38.9%**	**50.5%**	**60.6%**

A.4 Formulas

Calculation of new volume q_{ij} of a subclass $i(i = 1,2,3,...,M)$ delivered on route $j(j = 1,2,3,...,N)$ after a change in its price r_i

$$q_{ijA} = q_{ijB}\left(\frac{r_{iA}}{r_{iB}}\right)^{e_i}$$

Where A and B subscripts denote “After” and “Before” the change in price.

Calculation of new contestable volume qc_{ij} of a subclass $i(i = 1,2,3,...,M)$ delivered on route $j(j = 1,2,3,...,N)$ after a change in its price r_i

$$qc_{ijA} = qc_{ijB}\left(\frac{r_{iA}}{r_{iB}}\right)^{e_i}$$

Where A and B subscripts denote “After” and “Before” the change in price.

A.5 Model Algorithm

The computational method or algorithm of the model involves a number of iterations. In each iteration $k(k = 1,2,3,...,O)$ a test is performed on each route $j(j = 1,2,3,...,N)$ to determine whether the entrant captures the contestable mail (QC_j) on the route.

Iteration 1:

For all routes that satisfy the inequality

$$ACE_j * \lambda < 12.6$$

set QC_j = 0 and calculate MU as follows:

$$MU_1 = \frac{RDM_0 - CDM_0 + CDM_1}{RDM_1}$$

where RDM_0 = Initial USPS revenue from delivered mail;
RDM_1 = USPS revenue from delivered mail after the first skimming of routes and volume losses due to price elasticity effect;
CDM_0 = Initial USPS cost of delivered mail; and
CDM_1 = USPS cost of delivered mail after the first skimming of routes and volume losses due to price elasticity effect.

Iteration k:

For all routes that satisfy the inequality

$$ACE_j * \lambda < 12.6 * MU_{k-1}$$

set QC_j = 0 and calculate MU as follows:

$$MU_k = \frac{RDM_0 - CDM_0 + CDM_k}{RDM_k}$$

Where RDM_0 = Initial USPS revenue from delivered mail;
RDM_k = USPS revenue from delivered mail after the kth skimming of routes and volume losses due to price elasticity effect;
CDM_0 = Initial USPS cost of delivered mail; and
CDM_k = USPS cost of delivered mail after the kth skimming of routes and volume losses due to price elasticity effect.

Iteration O (last iteration):

None of the routes satisfies the inequality

$$ACE_j * \lambda < 12.6 * MU_{o-1}$$

and a new equilibrium is achieved.

A.6 Data

U.S. delivery data are from the City Carrier Cost System and the Rural National Mail Count System.[16] City carriers make up 72 percent of the routes and rural carriers make up the remainder.[17]

The City Carrier System contains a stratified sample of 8,281 routes and the 1999 Rural National Mail Count System provides data on 39,737 rural routes. These sources provide the subclass volumes delivered on each route. City carrier time is derived from the USPS Cost Segments and Components Report for FY 1999 and the average time is calculated and used for all city carrier routes.[18] Rural carrier time is included in the rural mail count system.

Variable and Fixed Costs

We divide out-of-office delivery costs into their components using the method developed by USPS.[19] Load time is included in the variable costs. For simplicity the variable portion of access and travel to and from the beginning of the route are ignored. The remaining time is fixed and includes the time between stops (route time and the fixed portion of access) and the fixed portion of travel time.

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16 *See* PRC Docket No. R2000-1.

17 Approximately 30 percent of rural routes serve non-rural urban suburbs.

18 In 85 of the 8,281 sampled city routes, the calculated variable delivery costs exceed the average total delivery costs. For these routes we increase the total costs to match the higher variable costs. This reduces route profits by $56 million.

19 *See* PRC Docket No. R2000-1.

USPS Price for Contestable Mail

Table A-2: Saturation SCF & DDU Revenue per Piece (FY 1999)

	Revenue	Pieces	Revenue / Pc.
Letters (SCF)	233,716,150	2,112,746,245	0.111
Letters (DDU)	52,236,050	492,950,136	0.106
Nonletters (SCF-pc rated)	275,773,861	2,317,389,513	0.119
Nonletters (DDU-pc rated)	400,659,835	3,514,558,178	0.114
Nonletters (SCF-lb rated)	84,882,816	502,195,302	0.169
Nonletters (DDU-lb rated)	316,714,334	1,880,099,721	0.168
Total	1,363,983,046	10,819,939,095	**0.126**

Source: USPS FY 1999 Billing Determinants

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