U.S. Postal Markets and Delivery Liberalization: A Simulation Approach

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1 Introduction

The likely outcomes of liberalizing, or adapting regulations to already liberalized postal markets, are important concerns for many incumbent postal operators. Entry into liberalized postal markets can be analyzed as a simultaneous game with Nash equilibria with the incumbent as price leader if entry occurs. This approach can be extended to encompass multi-product markets, to accept alternative economic objectives, to accommodate various kinds of regulatory controls and to cases where the incumbent is not the price leader.

It is rarely possible to conduct scientific experiments with an actual economic system. Simulation offers a practical alternative by substituting a model intended to mimic the system. However, the rules for setting up controlled experiments, taking observations, and analyzing results all remain about the same. Our simulator mimics the behavior over time of Postal Operators (POs) and Entrant Competitors (ECs) in inter-related postal markets. Our research method sets up these markets as games and solves them numerically using the method of fictitious play as described in a companion paper (Cigno and Pearsall 2016).

We explore critical choices applicable to all posts but focus on the current U.S. postal regulatory regime. The present characteristics of U.S. postal regulation include a vaguely defined Universal Service Obligation (USO), a large and well-protected reserved area, rules that tend to impose a price leadership role on the U.S. Postal Service (USPS), a system of product-specific caps and floors, and, federal ownership with Congressional oversight. The last leaves USPS without a well-defined economic objective. Several end-to-end U.S. postal markets are

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M. Crew et al. (eds.), *The Changing Postal and Delivery Sector*,
Topics in Regulatory Economics and Policy,
DOI 10.1007/978-3-319-46046-8_11

already liberalized.[1] However, for most categories of mail, USPS enjoys a monopoly with statutory barriers to entry to any direct competitors. In this paper we explore the economic consequences of liberalizing and partially de-regulating these national markets.

We conduct computer simulations of equilibrium for increased entry and relaxed regulation. The scenarios include variations in USPS's reserved area, less restrictive price controls, a floor on USPS's profits, and arrangements that both do and do not leave USPS as a price leader.

Most important, we treat entry into postal markets as endogenous. Potential entrants are assumed to enter and exit liberalized postal markets in response to profit opportunities. USPS remains in all markets to meet its present USO. Our simulations were conducted with demand and cost functions calibrated to FY 2015 USPS data and elasticity matrices derived from recent econometric research.

Two characteristic properties of many of the equilibria found by the simulator are limit-pricing by USPS and stochastic offerings of different combinations of postal products by potential entrants. At equilibrium limit-pricing leaves a potential entrant with the same profit on each product combination. Then, the potential entrant's probabilistic entries leave USPS unable to improve its objective by altering its prices. An entrant's prices for each product combination are chosen later to maximize the entrant's profit given USPS's prices. (We later include in the model the possibility that the entrant chooses its price without knowing the incumbent's price.) Our model does not make the assumption of standard limit pricing models that the entrant will not enter at the limit price. Unlike those models, our simultaneous game approach treats entry as endogenous with a probability that is not necessarily zero or one.

In Sect. 2 we provide our theoretical approach to understanding a liberalized single-product single-entrant postal market. Our model is unconventional, so in Sect. 3 we digress to explain how the conventional limit pricing approach mischaracterizes decision processes as sequential and requires the auxiliary assumption that no entry occurs at the limit price. In Sect. 4 we set out our data and simulation control settings for a benchmark outcome of postal liberalization in the U.S. under a relaxed regulatory regime. This Base Case is examined in detail in Sect. 5. In Sects. 6–10, we examine sets of simulations designed to exhibit the consequences of pursuing various general alternatives to the current U.S. regulatory system and controlled changes to the parameters of the Base Case. Our numerical results are displayed in five tables accompanying our analysis.

[1] Entrants, including UPS, FedEx and others, have competed with USPS in the delivery markets for Priority mail, Express mail and single-piece Package services since the mid-1970s. In FY 2015 this liberalization applied to only 2.4 % of U.S. domestic mail by volume and 21.7 % by revenue.

Our simulations indicate that USPS can survive liberalization with a smaller reserved area and that effective postal price regulation will be necessary following liberalization. However, effective regulation would require only a few elementary controls. Section 11 concludes by outlining the elements of a reformed regulatory system for USPS based upon our findings.

2 How Liberalized Postal Markets Work

The concepts underlying our simulator apply when an incumbent Postal Operator (PO) remains in a market that has been opened to Entrant Competitors (ECs). Typically, the pre-existing price regulation is relaxed but not eliminated and the PO usually assumes the role of price leader. Any regulation tends to make the prices of the PO sticky by imposing administrative rules or enforcing competition laws that delay the PO's pricing responses to an unregulated EC. Entry and exit by an EC, although we treat it as costless, is also sticky because entry and exit normally require substantial lead times. However, an EC's prices are not ordinarily subject to regulation and can be changed rapidly. Therefore, an EC's prices are not sticky and the EC is in a position to observe the PO's prices before it must set its own (although it does not observe the PO's prices prior to its decision to enter).

Following market opening, the PO may keep some of the advantages it gained as a monopoly. It may actually retain its monopoly over a reserved area of services. The *quid pro quo* for a reserved area is a Universal Service Obligation (USO). The PO is obligated to remain in markets that it might otherwise abandon. A PO may also have advantages that encourage it to remain in postal markets even when not required to do so. A reserved area without the USO may still leave the PO with economies of scope and scale that an EC cannot match. Market opening may also leave the PO in possession of material resources and legal protections that potential EC's cannot command.

Conversely, the role of price leader following a market opening may be a disadvantage since it prevents the PO from setting its prices based upon the product combinations and prices selected by ECs on entry. If a PO can react to an EC's prices in this way, it will act as a Bertrand oligopolist and employ a different set of prices for each combination of products it encounters from ECs.

In the single-good case the market has properties that define a non-cooperative non-zero-sum two-person game between the PO and EC (Pearsall and Trozzo 2008; Pearsall 2011, 2016; Cigno and Pearsall 2016). The PO's pure strategies are the different prices P_I (for "Incumbent") that it may set. P_I is set before the PO learns if the EC is *in* the market and remains unchanged. The EC has only two pure strategies, to be either *in* or *out* of the market. Entry and exit by the EC have no associated fixed costs. However, both require a lead time so the EC does not know P_I with certainty at the time that it chooses to be either *in* or *out*. Equally important, the PO cannot affect the EC's decision to be *in* or *out*. Therefore, the PO's price choice and the EC's decision to be *in* or *out* are made simultaneously.

The payoffs are determined by the player's objective functions. If the EC enters the market, it sets its price to maximize its profits based on P_I, which it observes after entry, producing a reaction function relating P_E to P_I. The PO has two objective functions: an objective function with the EC *in* the market (incorporating that reaction function), and, one with the EC *out*.[2] An incumbent government-owned PO's objective may be to maximize profit, welfare, cost, revenue or some combination of these. To describe the single-good case we treat the PO as maximizing profit.

The EC's strategies may be extended to include stochastic entry by introducing a probability of entry μ in the range [0, 1]. Stochastic entry by the EC becomes relevant if, at the price chosen by the PO, the EC would be indifferent to being *in* or *out* (recognizing that the EC would know P_I when it sets P_E). When the PO sets P_I this way it is engaged in limit-pricing. In the single-product case the EC's profit is limited to zero because the EC always has the option of not entering the market.

We assume that the standard neo-classical conditions regarding demand and cost are respected so that there must exist a Nash equilibrium consisting of a price P_I for the PO and a probability of entry μ for the EC that are simultaneously optimal against each other. The game is solved partly by induction. The EC's reaction function is imported into the PO's profit function with the EC *in*. Then equilibrium is defined by two conditions: P_I maximizes the PO's expected profit given μ, and μ maximizes the EC's profit over the range [0, 1]. Depending on demand and cost, the equilibrium can occur at a limit price that leaves the EC indifferent between being *in* or *out*. When this happens the EC's entries and exits are stochastic. The equilibrium prices P_I and P_E are usually unique.

Equilibrium takes one of three forms:

E1: PO monopoly.

E2: Duopoly with price leadership by the PO.

E3: Limit-pricing by the PO and stochastic entry by the EC.

The equilibria E1 and E2 describe outcomes of the game when it is optimal for the EC to employ a pure strategy. In E1 the EC finds that it is unprofitable to be *in* even when the PO sets a monopoly price. Consequently, $\mu = 0$ and the EC is always *out* and the market becomes a PO monopoly. In E2, $\mu = 1$ and the incumbent PO finds that it is unprofitable to try to drive the EC out of the market.

[2]The PO's objective with the EC *in* the market is $f_I(P_I, P_E)^{in}$, and, with the EC *out* is $f_I(P_I)^{out}$. $f_I(P_I, P_E)^{in}$ becomes $f_I(P_I,\ P_E\ (P_i))^{in}$ when we install the EC's reaction function $P_E(P_I) = ArgMax_{P_E}\{f_E(P_I, P_E)\}$ for P_E. The EC's profit function is $f_E(P_I, P_E)$ when the EC is *in* and zero when it is out. A Nash equilibrium consists of a pair of strategies for the two players that are simultaneously optimal against each other. The PO's strategy solves the problem:: $Max_{P_I}\{\mu f_I(P_I, P_E(P_I))^{in} + (1-\mu) f_I(P_I)^{out}\}$ given μ and the EC's strategy solves $Max_{\mu}\{\mu f_E(P_I, P_E(P_I)) | 0 \le \mu \le 1\}$ given P_I. Ordinarily, the EC's solution to this problem is to simply be *in* or *out*. The EC chooses $\mu = 1$ if $f_E(P_I, P_E(P_I)) > 0$ and chooses $\mu = 0$ if $f_E(P_I, P_E(P_I)) < 0$. However, it is necessary to formulate the EC's problem in a way that accommodates ties. Then, the EC's maximization problem may also be solved by a probabilistic mix such that $0 < \mu < 1$.

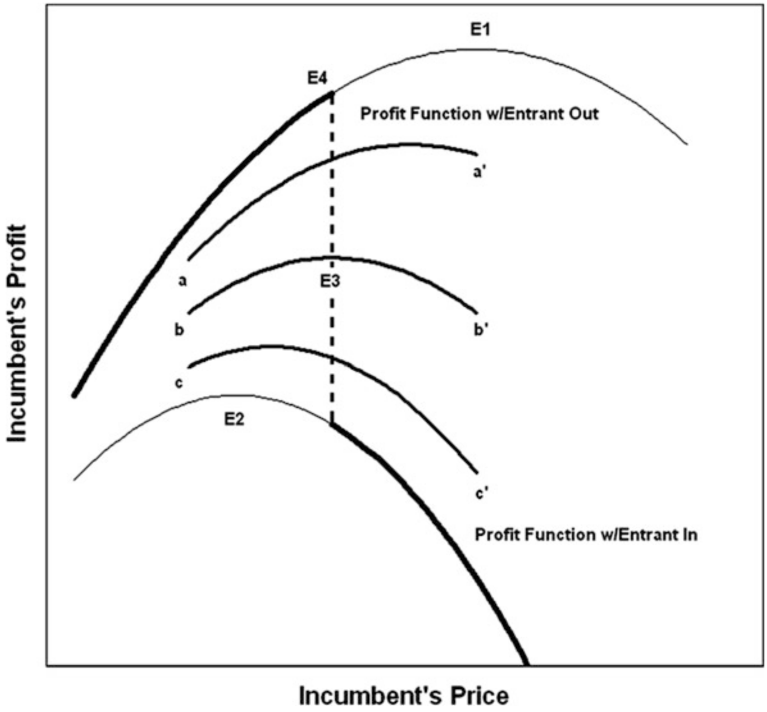

Fig. 1 Forms of Equilibrium

The EC is always *in* and the market becomes a duopoly with the PO acting as the price leader. E3 is a solution consisting of a limit price P_I, which leaves the EC with a zero profit whether *in* or *out*, and a mixed strategy such that $0 < \mu < 1$.[3]

Figure 1 depicts the three forms of equilibrium. The PO's expected profit function with the EC *in* is the parabola at the bottom of the figure. This function is drawn with the EC's reaction function inserted for the EC's price in the PO's profit function. The profit function with the EC *out* is the parabola at the top of the figure. This function is independent of the EC's price. E1 is located at the maximum of the PO's profit function with the EC *out*. It is the equilibrium if the EC always remains out of the market. E2 is at the maximum of the PO's profit function with the EC *in*

[3]To find μ, we differentiate the expected value of the PO's objective function, $E[f_I] = \mu f_I(P_I, P_E)^{in} + (1-\mu) f_I(P_I)^{out}$ with respect to P_I, set the result equal to zero, and solve for: $\mu = \frac{df_I^{out}}{dP_I} / \left[\frac{df_I^{out}}{dP_I} - \frac{df_I^{in}}{dP_I}\right]$, with the derivatives evaluated at equilibrium. The derivative with the EC *in* has two parts $\frac{df_I^{in}}{dP_I} = \frac{\partial f_I^{in}}{\partial P_I} + \frac{\partial f_I^{in}}{\partial P_E}\frac{dP_E(P_I)}{dP_I}$. The first part is the direct effect of the PO's price changes on the PO's profit. The second term is an indirect effect that occurs when the EC sees the change and responds by changing its own price.

and with the EC's price set according to its reaction function. E2 is the equilibrium if the EC is always *in*.

The vertical dashed line connecting the two profit functions is drawn at the PO price that leaves the EC with a zero economic profit. Below the dashed line, the EC takes a loss if it is *in*; above the dashed line the EC gets a positive economic profit if it is *in*. The EC's profits are calculated under the assumption that the EC knows P_I when it sets P_E.

Neither E1 nor E2 can be the equilibrium as Fig. 1 has been drawn. At E1 the EC's profit is positive so it will not remain permanently out of the market as required for the monopoly outcome E1. At E2 the EC takes a loss so it will not remain in the market as required for the duopoly equilibrium E2.

Equilibrium occurs at E3, an intermediate point on the dashed line corresponding to μ. E3 is a stochastic equilibrium because $0 < \mu < 1$. Curves such as a-a′, b-b′ and c-c′ describe the PO's expected profit as a function of P_I for different fixed values of μ. These curves are different weighted averages of the PO's two profit functions. Each of them reaches a maximum at a different price P_I. The equilibrium E3 occurs along the curve b-b' where the price P_I that maximizes the PO's expected profit coincides with the price that leaves the EC with no profit or loss. E3 does not occur where a-a′ or c-c′ reach their maximums because only a PO price corresponding to the vertical dashed line will leave μ unchanged as the game is played. PO prices to the right of the dashed line cause μ to increase because the EC responds to these prices by entering and remaining *in*. Prices to the left cause μ to decrease because the EC exits and remains *out*. The curve b-b′ is the only curve along which the PO can maximize its expected profit without disturbing μ. Therefore, E3 is the Nash equilibrium.

Our simulator extends concepts that apply to the case of a profit maximizing PO offering a single mail service and a single profit-maximizing EC also offering only a single service. It generalizes and applies this single-product model of a liberalized postal market to multiple markets for inter-related postal services. It also generalizes the model with respect to the PO's possible objectives, for various ways that a collection of postal markets might be liberalized, for multiple ECs, and for different kinds of price constraints that might be imposed by a regulator. The simulator is also capable of relaxing the assumption that the PO is the price leader.[4]

The simulator treats liberalized postal markets as a non-zero-sum, non-cooperative, multi-person game and finds the game's Nash equilibrium by our numerical method based on "fictitious play". ECs react to USPS's pricing by choosing combinations of products and prices that maximize their own profit. USPS is assumed to observe the frequencies of entrants' product choices and to set its own

[4]The only difference this makes in the single-product case is that the PO optimizes its choice of P_I against the EC's specific choice of P_E, and not against the EC's reaction function. To calculate μ for this game we just delete the second term of the derivative $\frac{df_I^{in}}{dP_I}$ in footnote 3. This will always result in a higher value for μ because the deleted term is positive.

prices to maximize the expected value of its economic objective subject to constraints imposed under an assumed regulatory regime. The simulator converges iteratively on USPS's prices and frequencies for entrants' product choices and their associated prices that constitute the game's Nash equilibrium.[5]

3 How Liberalized Postal Markets Do Not Work

Our model of liberalized postal markets is unconventional. A conventional model[6] of a single-product liberalized market would place the Nash equilibrium for limit-pricing at the point labeled E4 in Fig. 1. At E4 the PO sets a price that leaves the EC indifferent between being *in* or *out* and the EC always chooses to remain *out*.

The conventional model finds an equilibrium different from E3 by making different assumptions. First, the conventional model treats the strategy choices of P_I and μ for a single play of the game as sequential rather than simultaneous. The PO is assumed to choose P_I before the EC chooses to be *in* or *out* and the EC knows P_I before it must choose. Second, the EC is assumed to always remain *out* if it will be left with a zero profit from entering. This auxiliary assumption makes it unnecessary to consider any values of μ except zero and one.

The first assumption allows the PO to control the EC's choice to be *in* or *out* for a single play of the game. The PO is able to choose any point along the heavily outlined segments of its profit functions in Fig. 1. E4 is the point at which the PO's profit is maximized along these segments. The second assumption effectively erases all of the vertical dashed line except the point E4. When the PO sets the limit price that leaves the EC with no profit, the PO ends up at E4 and not at some lower point on the dashed line.

The conventional model and our model have different equilibria when the PO engages in limit pricing. These equilibria are mutually exclusive. If the

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[5]For multiple products the EC's pure strategies consist of product combinations indexed t drawn from a feasible set of such combinations T. μ_t is the probability of use assigned to the combination t. The PO's strategies are price vectors denoted P_I. A Nash equilibrium consists of a pair of strategies for the two players that are simultaneously optimal against each other. The EC's mixed strategy of entry and exit using various product combinations solves the problem: $Max_{\mu_t}\left\{\sum_{t \in T} \mu_t f_E^t\left(P_I, P_E^t(P_I)\right) | 0 \le \mu_t \le 1 \forall t \in T \text{ and } \sum_{t \in T} \mu_t = 1\right\}$ given the prices chosen by the PO. Ordinarily, the solution to this problem takes the form of a single combination. That is, the EC simply sets $\mu_t = 1$ for the pure strategy that yields the largest profit $f_E^t\left(P_I, P_E^t(P_I)\right)$. However, it is necessary to formulate the EC's problem in a way that accommodates ties. Then, the EC's maximization problem is also solved by probabilistic mixes of two or more equally-profitable product combinations. The PO's strategy is a vector of prices for its own products that solves the problem: $Max_{P_I}\left\{\sum_{t \in T} \mu_t f_I^t\left(P_I, P_E^t(P_I)\right) | P_I \in S\right\}$ given the probabilities that describe the EC's entries and exits. The set S embodies the restrictions imposed on the PO's prices by the regulator. In our simulator these restrictions are all linear inequalities.

[6]A conventional model of a liberalized market is the contestable market model of Baumol et al. (1988).

conventional model is correct then E3 cannot be an equilibrium because the EC will never enter. The conventional model moves the limit pricing outcome to E4. If our model is correct then E4 is not an equilibrium because the PO would try to move along the profit function with the entrant *out* to reach the maximum E1. With our model the PO will raise its price above the limit price if it believes that the EC will not enter.

In order to identify the most appropriate model it is necessary to recognize that both the PO's choice of P_I and the EC's choice to be *in* or *out* are decisions that cannot be made instantly effective and thus each has to be made before the other's choice is known. At present, USPS must declare its prices to the U.S. regulator more than 60 days before putting them into effect and must leave the prices in place for at least six months. Although this appears to be advance notice, it is hard to see how an EC could enter or leave a U.S. national postal market any more quickly. We can also expect that the EC will not reveal its decision to be *in* or *out* if it can avoid it since the information may be exploited by the PO. Therefore, the most reasonable assumption is that both the PO and the ECs make their choices simultaneously without knowing what the other player will do.

A PO should know this and would not engage in a futile effort to affect an EC's entry decision *ex-post* by trying to move along the outlined segments of the profit functions in Fig. 1. Instead, a rational PO would form an estimate of μ from whatever information is at hand and maximize its expected profit based upon the estimate. This leads the PO to move along a curve such as aa′, bb′ or cc′ in Fig. 1. Likewise, the EC decides to be *in* or *out* of the market without knowing for certain the PO price that it will face. Thus the PO's choice of P_I and the EC's decision to be *in* or *out* are best depicted as simultaneous decisions, not sequential as is done by the conventional model.

4 Data Inputs and Controls

We simulate the markets for six aggregated categories of domestic mail. These categories correspond to the broadly-defined classes used in current USPS reporting to the Postal Regulatory Commission (PRC). The labels used in our tables are:

1Cls	First-Class Mail
PrOth	Priority Mail and Expedited Packages
2Per	Periodicals
3Std	Standard Mail
4Pkg	Market-Dominant Packages
PclSR	Parcel Select and Return Services

Potential entrants in postal markets offer services that roughly correspond to these six categories. However, we have generally assumed that these services would be somewhat imperfect substitutes for those offered by USPS. At present there are such entrants only in the markets PrOth and PclSR.

The simulator extrapolates from demand models for USPS mail service in existing markets to construct models of postal markets after entry for each possible entrant product combination. The extrapolations are made as described in Cigno and Pearsall (2016) using elasticity tables drawn from recent econometric studies. The demand model is calibrated to USPS volumes, revenues and market shares for FY 2015. USPS's FY 2015 market shares by volume for those markets with entrants were PrOth: 0.494 and PclSR: 0.299.

The simulator employs a highly simplified version of the cost driver model used by USPS for cost attribution. For entrants we assumed generally lower institutional costs than USPS. Weights for the driver calculations are ratios of unit volume-variable costs for each class to the unit volume-variable cost for an average piece of First-Class mail. In effect, the cost driver is the equivalent volume of First-Class mail.

The calibrated demand and cost models were applied to simulate postal markets under existing entry limitations with FY 2015 average revenues per piece installed as USPS's prices. The resulting simulated equilibrium approximated USPS volumes, market shares, revenues and costs in FY 2015. Net costs for an entrant were calculated to leave a zero profit. Consequently, our simulated profits for entrants are profit changes measured from their (unknown) combined profit level in FY 2015.

The demand and cost models are linearized at a point corresponding to an assumed basis solution as described in Cigno and Pearsall (2016). For the basis solution all markets are entered by potential competitors and USPS and its competitors all charge the same prices for similar services. The simulation uses a combination of observed and assumed values for USPS market shares as follows:

$$\text{1Cls: } 0.900,\ \text{PrOth: } 0.494,\ \text{2Per: } 0.800,\ \text{3Std: } 0.700,\ \text{4Pkg: } 0.700,\ \text{PclSR: } 0.299$$

The marginal diversion rate is the rate at which USPS and an entrant divert mail from each other as demand shifts in response to an unmatched price change. The marginal diversion rates are applied to derive the demand functions for the different product combinations that the entrant may use when entering. The marginal diversion rates for most of our simulations are:

$$\text{1Cls: } 0.900,\ \text{PrOth: } 0.775,\ \text{2Per: } 0.900,\ \text{3Std: } 0.900,\ \text{4Pkg: } 0.900,\ \text{PclSR: } 0.780$$

The diversion rates for PrOth and PclSR were derived as part of our calibration of the model. The others are assumed values reflecting the belief that the postal services offered by an entrant in these markets would be close substitutes for the services presently offered by USPS.

The parameter settings for a simulation define USPS's economic objective, predetermined market conditions and the controls imposed by the regulator on USPS's choice of prices. The parameter settings also determine several technical features of a simulation. The settings for the Base Case are:

Incumbent Objective: Welfare defined as the sum of the consumers' surplus on just USPS mail services plus USPS's profit subject to a floor on the incumbent's profit.
Incumbent Profit Floor: Imposed at zero (breakeven)
Reserved/Entered Areas: 1Cls is reserved for USPS. PrOth and PclSR are always entered by an entrant. 2Per, 3Std and 4Pkg are open to entry.
Price Caps and Floors: USPS is subject to price floors on all products set at marginal cost plus average product-specific cost.[7] There are no individual price caps.
Global Price Cap. There is no global price cap. The price index is calculated with weights based upon FY 2015 volumes.
Frequency Model: Entry frequencies are estimates using an exponentially weighted average of previously selected product combinations. The estimates truncate the start of the sample and censor frequencies below 0.010.
Iterations: The iteration limit is 200. Simulated results are averages computed for a sample composed of the last 100 iterations.[8]

The Base Case simulates the operation of postal markets when prices are set by a welfare-maximizing postal regulator. Therefore, it is unnecessary to impose any price caps on USPS. The simulator maximizes just the welfare components associated with USPS's own products and profits because these are the only components that are likely to be considered by a postal regulator.[9]

5 Base Case Equilibrium

A summary of the results for equilibrium in the Base Case is displayed in Table 1. The simulator converges upon a solution that exhibits limit-pricing by USPS and stochastic selection of product combinations by a single potential entrant. The "Incumbent" prices shown in Table 1 confront the "Entrant" with three product combinations for which the entrant takes the same added annual loss of about $760 million. The identities of the services in each combination are shown at the bottom left-hand side of Table 1. The entrant alternates its choice among these three combinations at frequencies that leave us with a Nash equilibrium. For the individual products these frequencies translate into the simulated entry frequencies shown in the table. The entrant does not enter the prohibited market for 1Cls.

[7]The added product-specific costs are computed using the basis solution volumes and are very small.

[8]Our experiments with the simulator indicate that convergence is rapid and that there is little to be gained by iterating longer to obtain a larger sample.

[9]The components that are omitted are the consumers' surplus effects for all other products (principally for the products of entrants) and the producers' surplus effects for all other producers (principally the profits of entrants).

Table 1 Base case equilibrium

Set ID:	Base case		4/15/2016 18:6	Simulated ($000)
Demand	Branching AIDS model		Consumers' surplus	73,484,144
Objective	Welfare max. w/zero profit		Producers' surplus	−741,184
Reserved	lCls Res., PrOth and PclSR Ent.		Social welfare	72,742,959
Price controls	No caps		Welfare benchmark	88,838,076
	Simulated prices ($)		Expected volumes (000)	
Product	Incumbent	Entrant	Incumbent	Entrant
1Cls	0.5318		55,827,631	0
PrOth	5.4106	5.5243	1,898,013	1,670,420
2Per	0.5605	0.5389	4,318,167	550,175
3Std	0.1831	0.1730	55,370,296	41,993,055
4Pkg	3.0020	2.8936	304,893	223,807
PclSR	1.7703	1.9066	3,103,015	3,986,619
	Price constraint	Simulated entry	Market	Price
Product	Multiplier	Frequency	Condition	Control
lCls	0	0.0000	Reserved	Floor
PrOth	0	1.0000	Always entered	Floor
2Per	0	0.5248	Open to entry	Floor
3Std	0	0.9604	Open to entry	Floor
4Pkg	0	1.0000	Open to entry	Floor
PclSR	0	1.0000	Always entered	Floor
Incumbent	Incumbent	Objective	Global price cap	None
Objective	Value ($000) ($000)	Weight	Price cap index	0.4309
Welfare	29,613,030	0.5954	Last cap multiplier	0
Profit	0	0.4046	Inc. profit floor	0
Adj'd cost	58,921,316	0.0000	Single Ent. profit	−760,513
Revenue	58,921,316	0.0000	No. of entrants	1.0000
	Product	Simulated	Profit from combination ($000)	
Index	Combination	Frequency	Incumbent	Entrant
54	011011	0.0396	1,316,164	−772,619
58	010111	0.4752	59,604	−761,385
62	011111	0.4851	−129,357	−759,041

Otherwise, the entrant is always present in the markets for PrOth, 4Pkg and PclSR, and is a frequent visitor in the markets for 2Per (0.525) and 3Std (0.960).

Neither USPS nor the ECs have an incentive to change the strategies displayed in Table 1. Together the strategies establish the players' prices and the EC's probabilities for offering the three combinations of services. Other combinations are not used either because they violate the assumed regulatory restrictions or because they result in lower profits for the ECs.

USPS's position as the price leader places it at a disadvantage in postal markets where it faces competition. This fact is mostly evident from the "Incumbent" and "Entrant" prices and expected volumes in Table 1. The USPS prices are Ramsey prices given the entrants' probabilities of entry and reaction functions. The entrants' prices maximize an entrant's profit given USPS's prices. USPS gets underpriced in every market where an entrant is present except PclSR. Here the ECs enjoy so much market power (the base case market share for USPS is only 0.299) that they are able to set a price above that of USPS.

The expected volumes in Table 1 are the weighted averages of the volumes for the different product combinations. Opening the markets for 2Per, 3Std and 4Pkg results in substantial losses of market share by USPS in these markets. On the other hand, USPS gains market share in PrOth and PclSR.

Liberalization is unlikely to produce any new entrants in postal markets. The expected profit for the competitors to USPS already present in the markets for PrOth and PclSR drops by about $760 million. More entrants would simply increase this loss.

Price floors were set on all USPS services; however, none of the floors are binding. All of the associated price constraint multipliers are zero.

The assigned objective of the Base Case is to maximize welfare on USPS's products subject to a zero-profit floor. This floor is an effective constraint on USPS pricing. It results in a Lagrangian that positively weights both welfare and profit. These weights are normalized to sum to one and are shown in Table 1. They are welfare: 0.595 and profit: 0.405.

There is no global price cap. A global price cap index computed using USPS FY 2015 volumes as weights is 0.431. The index for USPS prices in FY 2015 is 0.514 so liberalization has the effect of lowering the general level of USPS prices.

The upper right-hand corner of Table 1 shows the calculation of social welfare for the Base Case. Here, social welfare is calculated as the sum of the expected consumers' surpluses for all products offered by both USPS and entrants and the profits of both USPS and all entrants.[10] The welfare benchmark is the maximum social welfare compatible with the data and controls for the Base Case. It is the sum of consumers' and producers' surpluses when USPS prices are set at marginal cost, when entrants' prices are set according to the reaction functions to maximize the entrants' profit, and when the entrants' product combination is selected to maximize social welfare subject to the restrictions on reserved/entered areas. For the base case this product combination is just PrOth and PclSR. The Base Case equilibrium does moderately well against the benchmark, $72.7 million versus $88.8 million, but clearly leaves room for some improvement.

[10]Note that the USPS objective "welfare" shown at the lower left of Table 1 encompasses only the consumers' surplus for products offered by USPS and USPS's profit.

6 The Dark Side of Postal Liberalization

Table 2 displays the results of a series of simulations designed to model incremental openings of postal markets. The table consists of a six-case progression from full opening of all markets (Case 1) to closing all markets (Case 6). The Base Case is Case 2. The other cases are Case 3: 1Cls and 2Per reserved, Case 4: all markets reserved except PrOth and PclSR which are entered, and Case 5: all markets reserved except PrOth and PclSR which are open but not necessarily entered. Otherwise, the data and controls for all of the cases are the same as for the Base Case.

The objective for all of the cases is welfare maximization subject to a zero-profit condition. This choice of objective gives us a set of cases that abstract from the disciplining effects of entry on USPS's prices.

When postal markets are opened there are several conflicting effects on social welfare. On the positive side there are likely to be two somewhat differentiated postal products offered to consumers in postal markets that previously had only the service offered by USPS. On the negative side USPS loses significant economies of scope and scale. The new equilibrium is likely to have multiple suppliers of highly substitutable services. This is inefficient when postal delivery is an activity with declining average costs as in our simulator.

Table 2 shows that it is the latter effect that predominates. The social welfare levels that are achievable without the additional product offerings of potential entrants are higher than the levels that are achievable when entry is permitted. This is the dark side of postal liberalization. Entry leads to less efficient production of an array of highly substitutable products by multiple producers. The added cost from the loss of scale economies by dividing production among several suppliers is more than the consumer's surplus gained from the added selection of products and lower prices.

The lowest level of social welfare in Table 2 occurs in Case 1 with all markets open. In this case, USPS is unable to make a positive profit. The simulator maximizes USPS's profit which turns out to be a loss of $10.3 billion. In all of the other cases the zero-profit condition remains feasible. Reserving 1Cls (Case 2) improves welfare by $6.2 billion. Adding 2Per to the reserved area (Case 3) increases welfare by another $2.0 billion. Adding 3Std and 4Pkg to the reserved area (Case 4) adds another $11.6 billion. Another $3.2 billion is added if we do not assume that entrants will always be present in PrOth and PclSR (Case 5). This improvement occurs because entrants choose not to enter PrOth. Finally, a small retrenchment of around $0.4 billion takes place if entrants are excluded from all postal markets (Case 6).

Perhaps the most important lesson to be drawn is that the economics of the U.S. postal sector create a high bar for successful liberalization. Case 4 is the case that most closely resembles the current situation. If we liberalize all but 1Cls (Case 2) the change creates a large potential welfare loss. In order for the liberalization envisioned in our Base Case to succeed, USPS would have to find production

Table 2 Liberalization simulations

Identification	Case 1		Case 2		Case 3		Case 4		Case 5		Case 6	
Demand	Branching AIDS model		Branching AIDS mode		Branching AIDS model		Branching AIDS model		Branching AIDS mode		Branching AIDS model	
Objective	Welfare max. w/zero profit		Welfare max. w/zero profit		Welfare max. w/zero profit		Welfare max. w/zero profit		Welfare max. w/zero profit		Welfare max. w/zero profit	
Reserved	None, PrOth and PclSR Ent.		lCIs Res., PrOth and PclSR Ent.		1CIs and 2Per Res.		All reserved Ex entered		All reserved Ex open		All reserved	
Price controls	No caps		No caps		No caps		No caps		No caps		No caps	
	Simulated prices ($}		Simulated prices ($)		Simulated prices ($)		Simulated prices ($)		Simulated prices ($)		Simulated prices ($)	
Product	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant
1CIs	0.3710	0.3009	0.5318		0.4996		0.3211		0.3283		0.3068	
PrOth	5.8282	5.6341	5.4106	5.5243	5.2763	5.4443	4.6243	5.1349	4.8774		4.6864	
2Per	1.0089	0.7552	0.5605	0.5389	0.9268		1.4465		1.2494		1.3470	
3Std	0.2025	0.1818	0.1831	0.1730	0.1844	0.1739	0.2410		0.2326		0.2303	
4Pkg	3.9561	3.3111	3.0020	2.8936	3.0097	2.9028	4.9636		4.7014		4.1618	
PclSR	1.9595	1.9813	1.7703	1.9066	1.7768	1.9136	1.6552	1.8709	1.6818	1.8814	1.8569	
	Expected volumes (000)		Expected volumes (000)		Expected volumes (000)		Expected volumes (000)		Expected volumes (000)		Expected volumes (000)	
Product	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant
1cls	37,653,077	33,422,455	55,327,631	0	56,406,789	0	67,333,755	0	68,146,824	0	69,094,053	0
PrOth	1,332,320	1,829,739	1,898,013	1,670,420	1,919,004	1,561,297	2,314,717	1,143,581	3,544,867	0	3,609,004	0
2Per	2,847,920	2,309,865	4,318,167	550,175	4,654,512	0	5,586,087	0	5,708,139	0	5,750,163	0
3Std	38,707,338	54,273,696	55,370,296	41,998,055	55,478,689	44,323,780	83,210,545	0	83,787,271	0	84,935,023	0
4Pkg	214,354	283,801	304,893	223,807	307,728	225,319	483,483	0	488,218	0	501,484	0
PclSR	2,181,696	4,590,473	3,103,015	3,986,619	3,131,208	4,044,707	3,782,427	3,671,443	4,610,722	2,876,188	7,365,960	0
	Price limit	Entry	Price limit	Entry	Price limit	Entry	Price limit	Entry	Price limit	Entry	Price limit	Entry
Product	Multiplier	Frequency	Multiplier	Frequency	Multiplier	Frequency	Multiplier	Frequency	Multiplier	Frequency	Multiplier	Frequency
1CIs	0	1.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000
PrOth	0	1.0000	0	1.0000	0	1.0000	0	1.0000	0	0.0000	0	0.0000
2Per	0	1.0000	0	0.5248	0	0.0000	0	0.0000	0	0.0000	0	0.0000
3Std	0	1.0000	0	0.9604	0	1.0000	0	0.0000	0	0.0000	0	0.0000
4Pkg	0	1.0000	0	1.0000	0	1.0000	0	0.0000	0	0.0000	0	0.0000
PclSR	0	1.0000	0	1.0000	0	1.0000	0	1.0000	0	0.7723	0	0.0000

(continued)

Table 2 (continued)

Identification	Case 1		Case 2		Case 3		Case 4		Case 5		Case 6	
Inc. objective	Value ($000)	Last weight	Value ($000)	Last weight	Value ($000)	Last weight	Value ($000)	Last weight	Value ($000)	Last weight	Value ($000)	Last weight
Welfare	−3,825,022	0.0010	29,613,030	0.5954	29,803,036	0.6091	75,702,261	0.8461	80,129,267	0.8524	88,884,764	0.8689
Profit	−10,321,968	0.9990	0	0.4046	0	0.3909	0	0.1539	0	0.1476	0	0.1311
Adj'd cost	47,889,483	0.0000	58,921,316	0.0000	59,339,394	0.0000	69,310,726	0.0000	76,359,126	0.0000	81,180,293	0.0000
Revenue	37,567,515	0.0000	58,921,316	0.0000	59,339,394	0.0000	69,310,726	0.0000	76,359,126	0.0000	81,180,293	0.0000
Ent. prof it/Inc. floor	4,732,749	0	−760,513	0	−881,319	0	−2,361,568	0	3600	0	0	0
Price index/multiplier	0.4027	0	0.4309	0	0.4309	0	0.4052	0	0.3984	0	0.3902	0
Welfare/benchmark	66,563,998	88,838,076	72,742,959	88,838,076	74,743,874	88,838,076	86,102,803	88,838,076	89,322,358	92,082,833	88,884,764	91,536,233

efficiencies, service improvements and other economies outside the scope of our model of about $13.4 billion.

Access pricing may put this target within reach. Most of the economies of scope and scale in postal operations occur in the delivery function. Access pricing provides a means for USPS to partially recover these economies. We did not consider access pricing and workshared services in the model used to simulate postal markets for this paper. However, the large welfare losses shown from liberalization show the importance of exploring access pricing as an option for avoiding them.

7 The Reserved Area

The simulations shown in Table 3 were conducted for the purpose of defining a reserved area that would allow USPS to break even while opening as many postal markets as possible to potential entrants. We changed the simulator's controls to run with profit maximization as the USPS objective and with no caps on USPS prices either individually or globally.

Case 1 simulates equilibrium without any reserved area. The result is that entrants enter every postal market with probability one and USPS's maximum possible profit is a loss of $10.3 billion. Full market opening leaves USPS unable to break even by a large margin.

Case 2 corresponds to the Base Case with a reserved area of only 1Cls, while Case3 adds 2Per. In Case 2 USPS's maximum profit is $4.9 billion and in Case 3 the maximum profit rises modestly to $5.5 billion. In Case 2 USPS could not make a $5.5 billion health fund contribution currently required by U.S. law while in Case 3 this contribution would become feasible—barely.

Case 4 represents the *status quo* with market opening limited to only those markets, PrOth and PclSR, already open. USPS's possible profit in this scenario soars to $27.1 billion. Thus the reserved area that is presently assigned to USPS is far larger than necessary to ensure that USPS can break even.

Cases 5 and 6 have the same reserved area as Cases 2 and 3. USPS is still assumed to maximize profit. However, these cases were run using a somewhat different model of postal markets in which entrants make their pricing decisions and product selections simultaneously. With these changes in the model, USPS is not obliged to be the price leader in postal markets. These cases become interesting if, following liberalization, the US postal regulator is able to compel potential entrants to submit their prices to the regulator at the same time as USPS. We consider this unlikely; in practice potential entrants would probably not be subjected to any price regulation. The change makes it less profitable for potential competitors to enter postal markets but otherwise appears to have little effect on our results. Surprisingly, it decreases rather than increases USPS's potential profits. Nevertheless, social welfare improves modestly when USPS is not obliged to be the price leader in markets where entry is permitted.

Table 3 Reserved area simulations

Identification	Case 1		Case 2		Case 3		Case 4		Case 5		Case 6	
Demand	Branching AIDS model		Branching AIDS model		Branching AIDS model		Branching AIDS model		Branching AIDS mode		Branching AIDS model	
Objective	Profit max.		Profit max.		Profit max.		Profit max.		Profit max.		Profit max.	
Reserved	None		1Cls		1Cls, 2Per		1Cls, 2Per, 3Std, 4Pkg		1Cls		1Cls, 2Per	
Price controls	None		None		None		None		Simultaneous pricing		Simultaneous pricing	
	Simulated prices ($)		Simulated prices {$)		Simulated prices {$)		Simulated prices ($)		Simulated prices ($)		Simulated prices ($)	
Product	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant
1Cls	0.3711	0.3009	0.7697		0.7203		0.6095		0.7618		0.7189	
PrOth	5.8289	5.6344	6.0816	5.7985	5.8523	5.6532	4.8648	5.1339	5.8023	5.6928	5.6628	5.5897
2Per	1.0092	0.7553	0.5995	0.5392	1.3497		2.7221		0.6016	0.5388	1.2514	
3Std	0.2025	0.1818	0.2071	0.1844	0.2132	0.1878	0.4980		0.1919	0.1775	0.1956	0.1797
4Pkg	3.9573	3.3117	4.1320	3.4160	4.2237	3.4704	14.2776		3.4697	3.1210	3.5244	3.1574
PclSR	1.9597	1.9814	1.9604	1.9813	1.9863	2.0007	2.0602	2.0379	1.8707	1.9478	1.8839	1.9609
	Expected volumes (000)		Expected volumes (000)		Expected volumes (000)		Expected volumes (000)		Expected volumes (000)		Expected volumes (000)	
Product	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant
1Cls	37,634,269	33,434,502	39,192,455	0	39,229,458	0	39,194,767	0	39,344,825	0	39,385,213	0
PrOth	1,331,655	1,830,054	1,331,928	2,042,817	1,334,617	1,844,270	1,335,489	1,147,280	1,597,153	1,898,476	1,545,312	1,757,498
2Per	2,846,498	2,310,666	2,928,358	826,752	3,237,092	0	3,222,925	0	3,089,022	642,615	3,250,420	0
3Std	38,688,004	54,290,126	38,654,485	57,731,794	38,583,988	62,162,253	48,008,798	0	51,028,937	48,950,755	52,263,415	51,849,815
4Pkg	214,247	283,883	214,157	299,486	214,017	307,669	278,948	0	273,841	256,885	275,992	262,372
PclSR	2,180,606	4,591,212	2,179,796	4,608,726	2,177,674	4,769,261	2,182,293	5,038,662	2,639,703	4,330,573	2,681,173	4,438,953
	Price limit	Entry	Price limit	Entry	Price limit	Entry	Price limit	Entry	Price limit	Entry	Price limit	Entry
Product	Multiplier	Frequency	Multiplier	Frequency	Multiplier	Frequency	Multiplier	Frequency	Multiplier	Frequency	Multiplier	Frequency
1Cls	0	1.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000
PrOth	0	1.0000	0	1.0000	0	1.0000	0	1.0000	0	1.0000	0	1.0000
2Per	0	1.0000	0	0.8020	0	0.0000	0	0.0000	0	0.6139	0	0.0000
3Std	0	1.0000	0	1.0000	0	1.0000	0	0.0000	0	1.0000	0	1.0000
4Pkg	0	1.0000	0	1.0000	0	1.0000	0	0.0000	0	1.0000	0	1.0000
PclSR	0	1.0000	0	1.0000	0	1.0000	0	1.0000	0	1.0000	0	1.0000

(continued)

Table 3 (continued)

Identification	Case 1		Case 2		Case 3		Case 4		Case 5		Case 6	
Inc. objective	Value ($000)	Last weight	Value ($000)	Last weight	Value ($000)	Last weight	Value ($000)	Last weight	Value ($000)	Last weight	Value ($000)	Last weight
Welfare	−3,831,507	0.0000	19,253,517	0.0000	19,942,888	0.0000	52,295,943	0.0000	18,875,739	0.0000	18,377,149	0.0000
Profit	−10,321,965	1.0000	4,945,648	1.0000	5,527,632	1.0000	27,096,335	1.0000	4,636,872	1.0000	5,150,473	1.0000
Adj'd cost	47,877,202	0.0000	48,241,286	0.0000	48,365,341	0.0000	49,847,369	0.0000	52,142,580	0.0000	52,226,370	0.0000
Revenue	37,555,237	0.0000	53,186,934	0.0000	53,892,973	0.0000	76,943,704	0.0000	56,779,452	0.0000	57,376,843	0.0000
Ent. profit/Inc. floor	4,739,086	None	2,322,076	None	2,378,724	None	−908,957	None	710,413	None	690,027	None
Price index/multiplier	0.4028	0	0.5569	0	0.5665	0	0.8130	0	0.5390	0	0.5469	0
Welfare/benchmark	65,550,682	88,838,076	63,502,975	88,838,076	66,513,748	88,838,076	67,211,607	88,838,076	64,890,701	88,838,076	67,160,963	88,838,076

Finally, we note that none of the reserved area simulations is attractive as a model for regulatory reform. In all of the simulations, price regulation is suspended resulting in very high USPS prices in the reserved areas and social welfare levels that range from $63.5 to $67.2 billion. The social welfare level for the Base Case ($72.7 billion) represents a much better performance primarily because maximizing profit is not the assumed objective of USPS.

8 The Case for Postal Price Regulation

Opening postal markets to entrants still leaves USPS with a considerable amount of power in the liberalized markets. Price regulation of some kind is needed to prevent abuses that can occur if USPS fully exploits this residual market power. If USPS acts as a profit maximizer, then the abuses take the form of higher prices, leaving USPS with excessive profits. If USPS acts to maximize cost or revenue following liberalization, then the abuses are likely to partly take the form of cross subsidies enabling USPS to set prices to take excessive shares of postal markets from entrants. Cross subsidies will also be the result of price regulation when a regulator imposes individual price caps that lie below the price floors that we have assumed. Case 2 from Table 3 shows what happens if USPS acts to maximize its profit following liberalization of all markets except 1Cls. Without any kind of price regulation USPS is able to raise its prices not only in 1Cls but in all postal markets to produce an excess profit of $4.9 billion compared to the Base Case. Another noteworthy feature of this case is that none of USPS's prices fall below the price floors. This is characteristic of our simulations when we assume that the economic objective of USPS is to maximize profit.

This changes if USPS's objective is to maximize cost or revenue subject to a profit constraint. The results in Table 4 show why price floors are needed to avoid cross subsidies when USPS does not behave as a profit maximizer. Case 1 reproduces the Base Case, however, the weights for the global price cap have been changed to the Base Case volumes for USPS. In Case 2 the assumed objective is cost maximization subject to a zero-profit floor. With this change the price floors for PrOth and PclSR become necessary to prevent USPS from pricing these categories below marginal cost. With the price floors preventing cross subsidies, cost maximization results in a substantially higher level of overall welfare than the Base Case.[11] This is the net result of sharply lower prices for PrOth and PclSR by both USPS and entrants, mostly lower prices for all other services except 1Cls, no change in USPS's profit and a loss of about $2.5 billion by entrants. The result in Case 3 where revenue maximization is the objective is somewhat similar. The price floors prevent USPS from underpricing PrOth and PclSR and welfare improves, but

[11] Recall that in the Base Case only the USPS components of social welfare are maximized subject to a break-even constraint.

Table 4 Relaxed regulation simulations

Identification	Case 1		Case 2		Case 3		Case 4		Case 5		Case 6	
Demand	Branching AIDS model		Branching AIDS model		Branching AIDS model		Branching AIDS model		Branching AIDS model		Branching AIDS mode	
Objective	Welfare max. w/zero Profit		Cost max. w/zero profit		Revenue max. w/zero profit		Welfare max. w/zero profit		Cost Max. w/zero profit		Revenue max. w/zero profit	
Reserved	1CIs Res., PrOth and PclSR Ent.		1CIs Res., PrOth and PclSR Ent.		1CIs Res., PrOth and PclSR Ent.		1CIs Res., PrOth and PclSR Ent.		1CIs Res., PrOth and PclSR Ent.		1CIs Res., PrOth and PclSR Ent.	
Price controls	No caps		No caps		No caps		No caps, simultaneous pricing		No caps, simultaneous pricing		No caps, simultaneous pricing	
	Simulated prices ($)		Simulated prices ($)		Simulated prices ($)		Simulated prices ($)		Simulated prices ($)		Simulated prices ($)	
Product	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant
1CIs	0.5318		0.5839		0.6635		0.5334		0.5976		0.6633	
PrOth	5.4106	5.5243	4.5368	5.1954	4.5368	5.2013	5.2125	5.4491	4.5368	5.1964	4.5368	5.2018
2Per	0.5605	0.5389	0.5629	0.5395	0.5742	0.5420	0.5559	0.5383	0.5528	0.5399	0.5725	0.5405
3Std	0.1831	0.1730	0.1819	0.1729	0.1815	0.1732	0.1830	0.1729	0.1805	0.1729	0.1793	0.1733
4Pkg	3.0020	2.8936	2.5411	2.7083	3.3789	3.0906	2.5240	2.6825	1.8995	2.4040	2.5861	2.7327
PclSR	1.7703	1.9066	1.5078	1.8084	1.5078	1.8085	1.7041	1.8823	1.5078	1.8097	1.5078	1.8097
	Expected volumes (000)		Expected volumes (000)		Expected volumes (000)		Expected volumes (000)		Expected volumes (000)		Expected volumes (000)	
Product	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant
1CIs	55,827,631	0	51,690,576	0	45,543,127	0	55,642,617	0	50,685,447	0	45,857,194	0
PrOth	1,898,013	1,670,420	2,739,656	1,225,210	2,765,799	1,236,485	2,087,538	1,569,407	2,747,220	1,226,883	2,764,838	1,233,964
2Per	4,318,167	550,175	4,468,573	340,978	3,840,562	543,490	4,417,834	491,960	4,429,085	325,868	3,987,650	434,490
3Std	55,370,296	41,998,055	90,297,665	5,962,826	79,242,187	19,679,693	68,344,134	27,834,874	91,943,029	4,742,420	87,404,931	12,297,746
4Pkg	304,893	223,807	354,440	196,088	285,003	250,707	348,785	193,409	411,842	154,805	354,701	199,785
PclSR	3,103,015	3,986,619	4,447,173	3,174,943	4,448,690	3,177,014	3,446,938	3,784,568	4,462,021	3,182,367	4,464,291	3,185,828
	Price limit	Entry	Price limit	Entry	Price limit	Entry	Price limit	Entry	Price limit	Entry	Price limit	Entry
Product	Multiplier	Frequency	Multiplier	Frequency	Multiplier	Frequency	Multiplier	Frequency	Multiplier	Frequency	Multiplier	Frequency
1Cls	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000
PrOth	0	1.0000	−1,951,651	1.0000	−1,481,781	1.0000	0	1.0000	−2,859,029	1.0000	−3,268,411	1.0000
2Per	0	0.5248	0	0.3366	0	0.5347	0	0.4752	0	0.3168	0	0.4158
3Std	0	0.9604	0	0.1386	0	0.4653	0	0.6535	0	0.1188	0	0.2871

(continued)

Table 4 (continued)

Identification	Case 1		Case 2		Case 3		Case 4		Case 5		Case 6	
4Pkg	0	1.0000	0	1.0000	0	1.0000	0	1.0000	0	1.0000	0	1.0000
PclSR	0	1.0000	−3,444,626	1.0000	−2,929,086	1.0000	0	1.0000	−5,444,836	1.0000	−6,639,539	1.0000
Inc. objective	Value ($000)	Last weight	Value ($000	Last weight	Value ($000)	Last weight	Value ($000	Last weight	Value ($000	Last weight	Value ($000)	Last weight
Welfare	29,613,030	0.5954	55,186,905	0.0000	43,784,725	0.0000	36,519,178	0.5877	53,495,250	0.0000	46,765,643	0.0000
Profit	0	0.4046	0	0.3361	1,306,144	0.0001	0	0.4123	0	0.3597	1,269,539	0.0001
Adj'd Cost	58,921,316	0.0000	69,140,971	0.6639	65,965,386	0.0000	62,262,988	0.0000	69,361,107	0.6403	67,327,735	0.0000
Revenue	58,921,316	0.0000	69,140,971	0.0000	67,271,530	0.9999	62,262,988	0.0000	69,361,107	0.0000	68,597,273	0.9999
Ent. profit/Inc. floor	−760,513	0	−2,506,515	0	−2,303,368	0	−1,288,481	0	−2,601,290	0	−2,462,583	0
Price index/multiplier	0.4877	0	0.4900	0	0.5313	0	0.4823	0	0.4922	0	0.5266	0
Welfare/benchmark	72,742,959	88,838,076	78,533,386	83,838,076	72,997,117	88,838,076	75,025,827	88,838,076	78,487,942	88,838,076	74,894,894	88,338,076

only slightly. In Case 3 the profit floor is ineffective and USPS's profit rises to $1.3 billion without additional controls.

Cases 4, 5 and 6 repeat the simulations under the assumption that USPS is not the price leader in liberalized markets. The results follow the same pattern observed with USPS as price leader. However, in Cases 4 and 6 welfare is about $2.0 billion higher than in the comparable Cases 1 and 3. Welfare in Cases 2 and 5 scarcely differs. On the whole it appears best not to impose the role of price leader on USPS if there is a way to avoid it.

9 A Global Price Cap

Table 5 displays the results of several simulations with a global price cap. Currently, USPS price controls consist of individual floors and/or caps on all but PrOth and PclSR. In the simulations in Table 5 the floors remain but the individual price caps are replaced by a single global price cap.

Case 1 is the Base Case. In Case 2 we reproduce a basic theoretical result known to apply to the efficient regulation of monopolies. A profit-maximizing monopolist can be induced to self-select Ramsey prices by imposing an appropriately designed global price cap. The secret to the design of the global cap is that the regulator must select the demand volumes corresponding to Ramsey prices as the weights for the global price index. When the regulator sets the global cap at the welfare-maximizing level of average revenue per piece, the constrained monopolist will respond by choosing the Ramsey prices. This can greatly simplify the design of regulatory systems aimed at efficient price regulation.

In Case 2 we show that the global cap works if USPS maximizes its profit in liberalized postal markets where it is no longer a monopolist. The simulated equilibria in Cases 1 and 2 are virtually identical.[12] They both result in Ramsey prices and corresponding volumes, profits, welfare *et cetera*. However, in Case 2 the prices are chosen by USPS to maximize its profit subject to a global price cap constructed with index weights corresponding to the Base Case volumes and with the cap set at the Base Case average revenue per piece (0.4877).

In Case 3 and Case 4 we test the global price cap under the assumptions that USPS maximizes cost and revenue, respectively, subject to a zero-profit floor. The simulated equilibria for these two cases are very similar to each other but vary somewhat from the equilibrium in Cases 1 and 2. In Cases 3 and 4 USPS raises the price for 1Cls slightly (from 0.532 to 0.555) in order to lower its prices for PrOth (from 5.410 to about 4.960) and PclPR (from 1.770 to about 1.625). These changes allow it to raise its cost (or revenue) from $58.9 to $63.1 billion while maintaining a

[12]The remaining small differences between the two cases can be almost completely eliminated by extending the length of the simulations beyond 200 iterations and using a sample size larger than 100.

Table 5 Global price cap simulations

Identification	Case 1		Case 2		1 Case 3		I Case 4		I Case 5		I Case 6	
Demand	Branching AIDS model		Branching AIDS model		Branching AIDS model		Branching AIDS model		Branching AIDS model		Branching AIDS model	
Objective	Welfare max. w/zero Profit		Profit max.		Cost max. w/zero profit		Revenue max. w/zero profit		Profit max.		Profit max., zero profit pricing	
Reserved	1Cls Res., PrOth and PclSR Ent.		1Cls Res., PrOth and PclSR Ent.		1Cls Res., PrOth and PclSR Ent.		lCls Res., PrOth and PclSR Ent.		lCls Res., PrOth and PclSR Ent.		1Cls Res., PrOth and PclSR Ent.	
Price controls	No caps		Global cap		Global cap		Global cap		Global cap w/FY 2015 Wgts		Global Cap w/Fy 2015 Wgts	
	Simulated prices ($)		Simulated prices {$)		Simulated prices ($)		Simulated prices ($)		Simulated prices ($)		Simulated prices ($)	
Product	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant
1Cls	0.5318		0.5317		0.5550		0.5551		0.5334		0.5212	
PrOth	5.4106	5.5243	5.4101	5.5238	4.9726	5.3575	4.9591	5.3573	5.5263	5.5684	5.4952	5.5574
2Per	0.5605	0.5389	0.5626	0.5392	0.5590	0.5391	0.5628	0.5391	0.5521	0.5388	0.5563	0.5388
3Std	0.1831	0.1730	0.1830	0.1731	0.1827	0.1729	0.1829	0.1729	0.1827	0.1730	0.1833	0.1730
4Pkg	3.0020	2.8936	3.0025	2.8930	3.0660	2.9325	3.0669	2.9325	2.3270	2.5834	2.2353	2.5438
PclSR	1.7703	1.9066	1.7704	1.9065	1.6250	1.8513	1.6211	1.8512	1.8547	1.9401	1.8496	1.9382
	Expected volumes (000)		Expected volumes (000)		Expected volumes (000)		Expected volumes (000)		Expected volumes (000)		Expected volumes (000)	
Product	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant
1Cls	55,827,631	0	55,824,496	0	53,989,805	0	53,962,416	0	55,770,539	0	56,627,338	0
PrOth	1,898,013	1,670,420	1,897,915	1,670,933	2,319,506	1,453,329	2,331,346	1,445,860	1,790,871	1,729,809	1,814,639	1,711,455
2Per	4,313,167	550,175	4,320,580	540,985	4,245,220	602,856	4,247,724	600,591	4,711,434	154,578	4,800,209	130,966
3Std	55,370,296	41,998,055	55,347,391	42,041,968	65,802,946	31,335,146	66,026,971	31,058,584	61,252,347	35,713,470	62,857,464	33,610,004
4Pkg	304,893	223,807	304,873	223,829	303,812	228,659	303,894	228,751	362,514	180,080	370,193	174,034
PclSR	3,103,015	3,986,619	3,102,805	3,986,667	3,837,489	3,542,643	3,857,908	3,530,653	2,695,721	4,261,226	2,722,416	4,245,360
	Price Limit	Entry	Price Limit	Entry	Price Limit	Entry	Price Limit	Entry	Price Limit	Entry	Price Limit	Entry
Product	Multiplier	Frequency	Multiplier	Frequency	Multiplier	Frequency	Multiplier	Frequency	Multiplier	Frequency	Multiplier	Frequency
1Cls	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000
PrOth	0	1.0000	0	1.0000	0	1.0000	0	1.0000	0	1.0000	0	1.0000
2Per	0	0.5248	0	0.5248	0	0.5842	0	0.5743	0	0.1584	0	0.1188
3Std	0	0.9604	0	0.9802	0	0.7327	0	0.7228	0	0.8218	0	0.7822

(continued)

Table 5 (continued)

Identification	Case 1		Case 2		1 Case 3		I Case 4		I Case 5		I Case 6	
4Pkg	0	1.0000	0	1.0000	0	1.0000	0	1.0000	0	1.0000	0	1.0000
PclSR	0	1.0000	0	1.0000	0	1.0000	0	1.0000	0	1.0000	0	1.0000
Inc. objective	Value ($000)	Last weight	Value ($000)	Last weight	Value ($000)	Last weight	Value ($000)	Last weight	Value ($000)	La st weight	Value ($000)	Last weight
Welfare	29,613,030	0.5954	30,039,338	0.0000	36,415,088	0.0000	35,434,813	0.0000	35,326,850	0.0000	37,042,565	0.0000
Profit	0	0.4046	10,099	1.0000	0	0.8009	0	0.7511	376,672	1.0000	0	1.0000
Adj'd cost	58,921,316	0.0000	58,949,119	0.0000	63,079,233	0.1991	63,084,257	0.0000	58,951,210	0.0000	59,505,421	0.0000
Revenue	58,921,316	0.0000	58,959,218	0.0000	63,079,233	0.0000	63,084,257	0.2489	59,327,882	0.0000	59,505,421	0.0000
Ent. profit/lnc. floor	−760,513	0	−751,674	None	−1,684,488	0	−1,685,002	0	−463,224	None	−533,396	None
Price index/multiplier	0.4877	0	0.4877	71,937,193	0.4877	45,828,282	0.4877	56,869,788	0.4309	80,548,481	0.4256	84,718,860
Welfare/benchmark	72,742,959	88,838,076	72,608,756	88,838,076	73,449,311	88,838,076	73,463,366	88,838,076	75,431,213	83,838,076	76,311,654	88,838,076

zero profit. The changes also cause entrants' profits to fall by about $1.0 billion. In effect, USPS attempts to exploit its reserved area monopoly (1Cls) to provide the profit cushion needed for incursions into the markets PrOth and PclSR where entrants are always present. However, these incursions are so limited that the price floors for these categories are ineffective.

In general, it appears that the practical advantages of a global price cap are not badly compromised if USPS pursues some economic objective other than profit maximization so long as USPS remains subject to a zero-profit floor. The social welfare that results from Cases 3 and 4, around $73.4 billion, actually exceeds the Base Case level of $72.7 billion.

Global price caps are usually proposed in a different form from the price cap used in Cases 2-4. In practice, the demand volumes for Ramsey prices in liberalized markets are likely to be unknown to a postal regulator. This makes the selection of the weights for the global price index and the choice of a cap value problematic. Under the circumstances, a regulator applying a global price cap would probably attempt to construct the index and set the cap using an observable set of recent volumes. We have done this using FY 2015 USPS volumes in Cases 5 and 6.

In Case 5 USPS is assumed to maximize its profit under a global price cap that prevents USPS from exceeding the index value of the Base Case as shown in Table 2. Recall that this index value (0.431) was computed using FY 2015 volumes for weights. Except for 4Pkg, prices do not change very much from those of the Base Case. Profits for both USPS and an entrant increase by over $0.3 billion. Social welfare improves by about $2.7 billion.

In Case 6 we decrease the price cap value just enough to eliminate the positive USPS profit that occurred in Case 5. This slightly reduces USPS's prices for 1Cls, PrOth and 4Pkg and leaves the prices of the other categories little changed. An entrant's profits would fall slightly as the entrant's prices responded. Finally, social welfare increases by $0.9 billion.

The lessons to be drawn from Cases 5 and 6 are, first, that the advantages of a global price cap as an instrument of regulatory control do not depend too much on the selection of weights for the index. And second, a good rule for setting the cap value is to set the cap to eliminate excess profit.

10 Two Inefficient Practices

We simulate two common practices that can be inefficient in the more competitive environment created by a postal liberalization. These are, first, imposing a lump sum tax on USPS, and second, capping only the prices of services in the reserved area. The first three cases in Table 6 show the results of imposing a required minimum profit level on USPS. So long as USPS is solely owned by the U.S. government this is nominally equivalent to a lump sum tax equal to the required additional profit. Case 1 is the Base Case with USPS breaking even. Case 2 is identical except that the profit floor has been raised to $1.0 billion. Social welfare

Table 6 Inefficient practices simulations

Identification	Case 1		Case 2		Case 3		Case 4		Case 5		Case 6	
Demand	Branching AIDS model		Branching AIDS model		Branching AIDS model		Branching AIDS model		Branching AIDS model		Branching AIDS model	
Objective	Welfare max. w/zero profit		Welfare max. w/l.0M profit		Welfare max.w/1.0M subsidy		Profit max.		Cost or rev. max., w/zero profit		Profit max.	
Reserved	1Cls		1Cls		1Cls		1CIs Res., PrOth and PclSR Ent.		1CIs Res., PrOth and PclSR Ent.		1Cls Res., PrOth and PclSR Ent.	
Price controls	None		None		None		1Cls capped		1CIs capped		1Cls capped for zero profit	
	Simulated prices ($)		Simulated prices ($)		Simulated prices ($}		Simulated prices ($}		Simulated prices ($)		Simulated prices ($)	
Product	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant
1CIs	0.5318		0.5586		0.5049		0.5318		0.5318		0.5021	
PrOth	5.4106	5.5243	5.4872	5.5552	5.3320	5.4914	5.9373	5.7043	5.3009	5.4688	5.9180	5.6917
2Per	0.5605	0.5389	0.5631	0.5390	0.5533	0.5388	0.8242	0.6590	0.7341	0.6178	0.8570	0.6762
3Std	0.1831	0.1730	0.1850	0.1739	0.1831	0.1730	0.2043	0.1828	0.1832	0.1733	0.2039	0.1826
4Pkg	3.0020	2.8936	3.1291	2.9522	2.8706	2.8326	4.0268	3.3527	3.8298	3.2724	4.0144	3.3452
PclSR	1.7703	1.9066	1.7917	1.9150	1.7481	1.8979	1.9594	1.9808	1.7410	1.8964	1.9594	1.9809
	Expected volumeA (000)		Expected volumes (000)		Expected volumes (000)		Expected volumes (000)		Expected volumes (000)		Expected volumes (000)	
Product	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant	Incumbent	Entrant
1CIs	55,827,631	0	53,947,475	0	57,774,171	0	55,353,536	0	55,110,684	0	57,352,478	0
PrOth	1,898,013	1,670,420	1,833,945	1,713,186	1,964,389	1,627,626	1,331,248	1,922,408	1,359,531	1,603,006	1,331,248	1,906,203
2Per	4,318,167	550,175	4,154,342	583,551	4,463,330	551,467	2,850,246	1,739,025	3,165,851	1,497,676	2,850,246	1,839,561
3Std	55,370,296	41,998,055	53,163,768	44,338,818	58,586,817	37,935,464	38,672,321	55,620,373	55,423,445	43,387,695	33,672,321	55,388,822
4Pkg	304,893	223,807	294,644	232,307	315,538	215,008	214,193	290,169	234,825	277,705	214,193	289,071
PclSR	3,103,015	3,986,619	2,998,749	4,056,225	3,211,338	3,913,765	2,180,333	4,595,383	3,262,470	3,899,331	2,180,333	4,594,802
	Price limit	Entry	Price limit	Entry	Price limit	Entry	Price limit	Entry	Price limit	Entry	Price limit	Entry
Product	Multiplier	Frequency	Multiplier	Frequency	Multiplier	Frequency	Multiplier	Frequency	Multiplier	Frequency	Multiplier	Frequency
1CIs	0	0.0000	0	0.0000	0	0.0000	32,340,862	0.0000	21,814,939	0.0000	36,338,746	0.0000
PrOth	0	1.0000	0	1.0000	0	1.0000	0	1.0000	0	1.0000	0	1.0000
2Per	0	0.5248	0	0.5644	0	0.5347	0	1.0000	0	1.0000	0	1.0000
3Std	0	0.9604	0	1.0000	0	0.8812	0	1.0000	0	1.0000	0	1.0000
4Pkg	0	1.0000	0	1.0000	0	1.0000	0	1.0000	0	1.0000	0	1.0000

(continued)

Table 6 (continued)

Identification	Case 1		Case 2		Case 3		Case 4		Case 5		Case 6	
PclSR	0	1.0000	0	1.0000	0	1.0000	0	1.0000	0	1.0000	0	1.0000
Inc. objective	Value ($000)	Last weight	Value ($000)	Last weight	Value ($000)	Last weight	Value ($000)	La st weight	Value ($000)	Last weight	Value ($000)	Last weight
Welfare	29,613,030	0.5954	28,158,767	0.5467	32,938,113	0.6433	26,063,556	0.0000	27,988,444	0.0000	26,664,790	0.0000
Profit	0	0.4046	1,000,000	0.4533	−1,000,000	0.3567	1,020,782	1.0000	0	0.7755	0	1.0000
Adj'd cost	58,921,316	0.0000	57,672,600	0.0000	60,374,174	0.0000	51,704,768	0.0000	58,755,638	0.2245	52,136,924	0.0000
Revenue	58,921,316	0.0000	58,672,600	0.0000	59,374,174	0.0000	52,725,549	0.0000	58,755,638	0.0000	52,136,924	0.0000
Ent. profit/Inc. floor	−760,513	0	−478,965	1,000,000	−966,623	−1,000,000	2,061,720	None	−607,821	0	2,052,290	None
Price index/multiplier	0.4309	0	0.4446	0	0.4178	0	0.5226	0	0.4936	0	0.5095	0
Welfare/benchmark	72,742,959	88,838,076	71,687,989	88,838,076	73,876,485	88,838,076	69,631,131	88,838,076	70,221,248	88,838,076	70,227,649	88,838,076

declines by slightly less than $1.1 billion. This means that consumers' surplus has fallen by about $2.1 billion. In Case 3 USPS is allowed to run a loss of $1.0 billion. Then, welfare increases by $1.1 billion and consumers' surplus rises by about $2.1 billion.

The welfare loss from a lump sum tax occurs because USPS must convert the tax into a general increase in postal prices. The lump sum tax then becomes a specific tax on postal services. Most taxes are inefficient because the tax erodes the tax base. A specific tax does this by decreasing demand. Our results show that a tax on USPS following liberalization is especially inefficient. The net effect of the tax is to reduce social welfare by more than one dollar for each dollar collected. An ideal tax would cause no loss in social welfare and a reasonably efficient tax would cost far less than one dollar in welfare.

The last three cases in Appendix Table 6 show the results of imposing an individual price cap on only the services in the reserved area (1Cls). In Cases 4 and 5 the cap is set at the price of 1Cls from the Base Case (0.5318). In Case 4 USPS is assumed to maximize profit, in Case 5 USPS is assumed to maximize cost (or revenue, both result in the same equilibrium). The price cap on 1Cls is effective in both cases. In Case 4 social welfare drops to $69.6 billion from the Base Case $72.7 billion. In Case 5 the drop is to $70.2 billion. In Case 6 the price cap on 1Cls has been lowered until USPS breaks even when it maximizes profit. The price cap remains effective and welfare drops to only $70.2 billion. Recall from Sect. 8 that a global price cap that allows USPS to earn a zero profit can be imposed by the regulator to leave social welfare at $72.7 or higher. Cases 4, 5 and 6 indicate that it is impossible to achieve this level of welfare by capping only 1Cls while still allowing USPS to break even. The basic problem with the price cap on just 1Cls is that it must distort postal markets in order to be effective. These distortions cause appreciable welfare losses.

11 Conclusions

This paper employs an unconventional model of liberalized U.S. postal markets to simulate equilibrium under various schemes for liberalizing and de-regulating them. Entrants enter and exit with different combinations of postal services in response to the profit opportunities available in the markets. This behavior and USPS's pricing responses constitute a game that we solve by the method of fictitious play. We simulate the players' choices of strategies as the game is repeatedly played and analyze the results as we would a statistical sample.

The results of our simulations require more investigation before they can serve as a sufficiently reliable guide to the redesign of the U.S. regulatory system. In particular, our simulator should be enlarged and extended to explore delivery access. We also have not considered changes to USPS's USO. However, if confirmed by further research, our simulations show that regulation following liberalization can be achieved over a wide range of conditions with a modest reserved area and a small tool box of simple-but-effective regulatory controls.

USPS can be financially viable following liberalization with a reserved area consisting only of 1Cls. This liberalization would require regulatory controls in order to avoid welfare losses when USPS sets its own prices. It would be desirable (but may be impossible) to avoid making USPS the price leader in the liberalized markets. We have found that it is inefficient for the U.S. postal sector to be exploited as a source for public revenues and that price caps limited to individual postal products tend to create inefficiencies.

Our simulations indicate that an effective regulatory system needs three controls: individual price floors set at or slightly above marginal cost to prevent cross subsidies; a global price cap set on an index of all USPS prices with weights determined by the postal regulator; and, a profit floor set near zero to require USPS to also consider profits when setting prices to maximize any economic objective other than profit. If USPS can be relied upon to maximize its profit following liberalization, then both the individual price floors and the profit floor become unnecessary and only the global price cap is required.

Acknowledgments The views expressed in this paper are those of the authors. The authors wish to thank Michael Crew for his encouragement and assistance with the research reported in this paper. We have also benefited from the comments of Thomas-Olivier Leautier of the Toulouse School of Economics.

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