OFFICE OF INSPECTOR GENERAL
UNITED STATES POSTAL SERVICE

# Co-opetition in Parcel Delivery:

# An Exploratory Analysis

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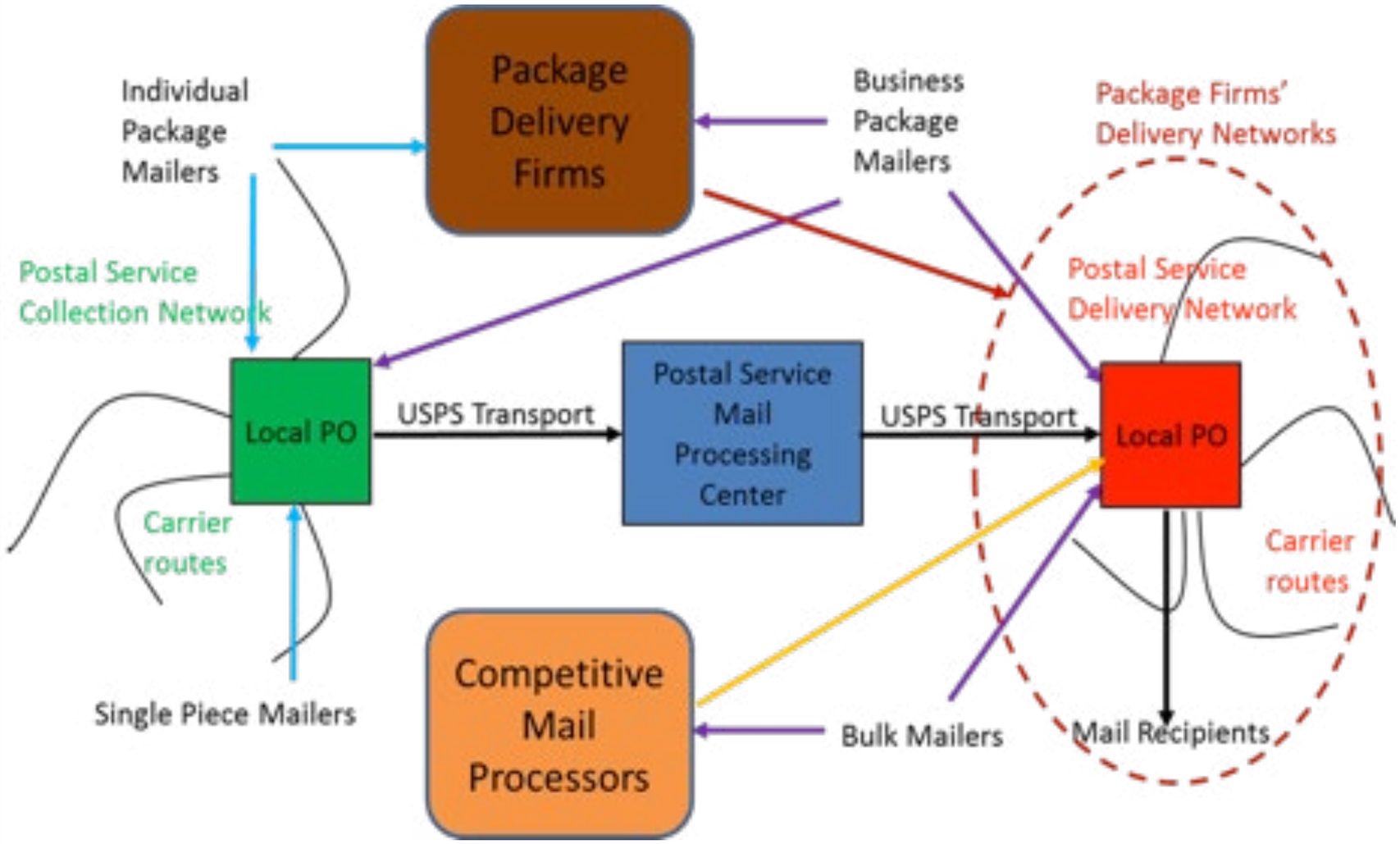

OFFICE OF INSPECTOR GENERAL
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# Executive Summary

The parcel market is currently undergoing dynamic change as e-commerce and changing consumer demand has led to an explosion in parcel volume. This new demand has led to a flood of new entrants. Not only has this increased demand for parcels benefitted the providers of parcel services through increased volume, it has also changed the relationship between the players in the market. In order to remain competitive, firms are beginning to collaborate with their once rivals — providing processing, transportation, or delivery for each other — something we refer to as co-opetition. For example, both UPS and FedEx use the U.S. Postal Service to provide last mile delivery for a significant portion of their ground parcels.[1]

In light of this evolving dynamic, the U.S. Postal Service Office of Inspector General (OIG) invited Dr. John C. Panzar, professor of economics, University of Auckland, to examine the economic efficiency of co-opetition and the relationship among the crowded field of players.[2] This paper provides Professor Panzar's analysis, and we present a few of his key findings below.

Professor Panzar finds a potential "win win win" situation when the Postal Service enters into a negotiated service agreement

1 According to an article by the Wall Street Journal, it is estimated that FedEx uses the Postal Service for delivery of approximately 30 percent of its ground parcels and UPS does the same for approximately 40 percent of its ground parcels. See Laura Stevens, "For FedEx and UPS, A Cheaper Route: The Post Office," Wall Street Journal, August 4, 2014, http://www.wsj.com/articles/u-s-mail-does-the-trick-for-fedex-ups-1407182247.

2 Professor of Economics, University of Auckland and Louis W. Menk Professor Emeritus, Northwestern University.

## Highlights

**The OIG collaborated with John C. Panzar, professor of economics at the University of Auckland, to examine the dynamics of co-opetition in the parcel market.**

**Professor Panzar shows that the presence of the Postal Service has important pro-consumer benefits.**

**Professor Panzar finds that co-opetition leads to a "win win win" situation; the Postal Service is better off through increased revenues, competitors are better off through lower delivery costs, and consumers potentially benefit from lower prices.**

**This occurs because the NSA results in a more efficient end-to-end parcel delivery service — one where the private parcel carrier is providing the upstream processing and the Postal Service is providing delivery.**

**Even with the presence of a large, strategic mailer, the Postal Service and the private parcel carrier should be able to negotiate an efficient NSA.**

***This result occurs because through co-opetition the Postal Service and the private parcel carrier create the more efficient end-to-end parcel delivery service.***

(NSA) with a large private parcel carrier.[3] The Postal Service benefits through earning additional revenues through the provision of last mile delivery, the private package carrier benefits from having a lower delivery cost, and all of this occurs without the customer having to pay a higher price. In fact, it is possible that co-opetition can lead to an overall price decrease for the customer.

This result occurs because through co-opetition the Postal Service and the private parcel carrier create the more efficient end-to-end parcel delivery service. The private firm provides the more efficient mail processing and transportation, and the Postal Service provides the more efficient delivery portion. If efficiency gains are high enough, co-opetition can lead to overall lower end-to-end (E2E) prices for parcel customers. How the profits are split between the Postal Service and the private parcel carrier depends on the relative bargaining power of the two.

Under the assumptions of Professor Panzar's model, the greatest efficiency is obtained when upstream parcel volume is handled by the private sector but delivered by the Postal Service. In fact, Professor Panzar shows that the presence of the Postal Service in the parcel market has the important pro-consumer consequence of reducing the market power enjoyed by a private parcel carrier. In cases where the Postal Service has a small E2E cost disadvantage relative to its private sector competitor, its potential entry serves to put an upper limit on the price this competitor can charge. And this is true even if the Postal Service were to get none of the E2E parcel volume. This is less true, of course, where the private parcel carrier can differentiate its product from that of the Postal Service, by offering such measures as better tracking or superior acceptance.

Professor Panzar also analyzes the impact of the presence of a large mailer, with the capability of self-delivery. The Postal Service and the private parcel carrier now have to compete for the large mailer's volumes. He finds that it remains possible for the Postal Service and the private parcel carrier to negotiate an efficient NSA — one where the private parcel carrier provides the upstream processing and the Postal Service provides the delivery. He also finds that as a result of the competition, the large mailer's shipping costs go down and, as a result, total carrier profits decline. In addition, the presence of the large mailer affects the terms of the NSA. Since the private parcel carrier knows that the Postal Service can compete directly for the large mailer's delivery volumes, the Postal Service's NSA bargaining power may improve. This may mean it can obtain a larger share of the (lower) carrier profits. These gains come at the expense of the private shipper, not from mailers.

While this paper is based on theoretical models, as often the case in economics, the theory follows practice. The co-operative agreements that are analyzed in this paper have been in place for some time. The theoretical analysis provided in this paper provides some insights into the benefits of the Postal Service entering into co-opetition with its competitors — most importantly, that these arrangements are if anything, beneficial to customers through lower prices.

3 A negotiated service agreement is a contract between the Postal Service and a customer.

Executive Summary

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# Co-opetition[1] in Parcel Delivery: An Exploratory Analysis

prepared by

John C. Panzar
Professor of Economics, University of Auckland
Louis W. Menk Professor Emeritus, Northwestern University

for

United States Postal Service
Office of Inspector General

Risk Analysis and Research Center (RARC)

## 1. Introduction and Summary

The financial difficulties of the Postal Service following the Global Financial Crisis have prompted extensive discussions about its future. There have been many proposals regarding how its business plan should be changed. Perhaps the most numerous and persistent suggestions have been those that argue for an increased focus on the "first and last mile" of postal operations.[2] Conventional wisdom has long held that it is this part of the postal value chain in which economies of scale are concentrated.[3] This conclusion has received substantial support from

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1 According to Wikipedia: "Co-opetition is a neologism coined to describe cooperative competition." Apparently, the word has been re-coined several times, beginning in 1913. Brandenburger and Nalebuff (1996) seem to be largely responsible for its current usage in Economics and Game Theory.

2 I contributed to this body of literature in Panzar (2012).

3 See, for example, Owen and Willig (1983) and Panzar (1991).

***The basic conclusion of my analysis is easy to state: co-opetition improves the efficiencies of the postal sector.***

empirical studies over the past two decades.[4] Thus it is not surprising that there have recently been significant innovations designed to enhance the utilization of the ubiquitous delivery network of the Postal Service.[5]

The purpose of this white paper is to analyze the economic impact of one of these innovations: the use of the Postal Service's delivery network by rival package delivery firms. As is often the case in economics, "theory follows practice." The co-operative agreements I attempt to analyze have been in place for some time. My hope is that by formally analyzing them in the context of a very simplified economic model, it will be possible to gain insights into the likely impact of co-opetition on the postal sector: i.e., its effects on the Postal Service, its competitors and consumers. The basic conclusion of my analysis is easy to state: co-opetition improves the efficiencies of the postal sector. By doing so, it makes it possible to increase the profits of the Postal Service *and* its rivals, *without* increasing prices to consumers.

These efficiency advantages come about because co-opetition makes possible what amounts to a cost-reducing technological innovation for the postal sector. As we shall see, the basic model of E2E rivalry in parcel delivery features firms who have complementary strengths and weaknesses. The Postal Service has an advantage with respect to marginal delivery costs while its rivals enjoy lower per unit upstream costs. In an E2E rivalry, the market process balances these advantages and disadvantages as best it can. However, if the Postal Service is able

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4 The empirical literature has grown to be quite extensive. See, for example, Bradley *et. al.* (2007), Cazals *et. al.* (2005), Cazals *et. al.* (1997) and Cohen and Chu (1997).

5 For a recent discussion of these developments, see USPS OIG (2014).

to sell delivery-only services to its E2E rivals, it is possible to implement a more efficient E2E productive technology. In effect, co-opetition creates a new, more efficient E2E provider that is capable of transforming the industry through lower costs and, possibly, lower prices.

However, it is important to recognize that this efficient new production process is not the property of any single entity. This means that the new, more efficient E2E technology must continue to "compete" with the original firm offerings. That is, the possibility of continuing to use existing E2E providers makes it impossible for co-opetition to result in price increases. Most likely, the efficiency gains will be achieved without any changes in the market prices facing final consumers. If the efficiency gains are great enough, however, it is possible that the market prices paid by consumers will decrease.[6]

***If the efficiency gains are great enough, however, it is possible that the market prices paid by consumers will decrease.***

The remainder of this White Paper is organized as follows. Section 2 provides a review of a simple model of a two component postal letter network often used in the literature. The same two stages, upstream mail processing and downstream delivery, are used in the analysis of the parcel delivery market presented in Section 3. There, I introduce my assumptions about demand and cost conditions and present a detailed model of the interactions between the Postal Service and other firms in the parcel market. These are of two different types. The first group consists of competitive worksharing firms ("consolidators"). Similar to firms that pre-sort letters, these firms compete with the Postal Service in the mail processing component, but typically do not deliver packages. The second category of firms is large, "strategic" rivals that operate their

6 Put simply, whether or not consumer prices decline turns on the issue of whether the new, integrated technology constitutes a *major* or *minor* innovation relative the status quo.

own E2E networks. In the model, this group is represented by a single rival, "Firm *U*," which competes with the Postal Service as a price-setting (Bertrand) duopolist in the E2E parcel market and, possibly, in the delivery only, workshare market. The primary result of Section 3 is that, in equilibrium, the Postal Service dominates the delivery-only market because of its cost advantage there. However, the threat of competition from Firm *U* limits the prices it can charge consolidators.

Section 4 extends the basic model to illustrate how the Postal Service can, in principle, strategically utilize its delivery cost advantage to increase its profits and the efficiency of the postal sector *without* harming consumers or competitors. The analysis begins with the case in which the Postal Service can make a take-it-or-leave-it offer to Firm *U* for delivery-only service. Clearly, Firm *U* will choose to outsource its delivery function only if the rate offered by the Postal Service is no higher than the unit cost of using its own delivery network. However, it turns out that it is somewhat complicated to determine precisely what delivery price offering is most profitable for the Postal Service.[7] Intuitively, one would expect that the Postal Service would choose a delivery price as high as possible: i.e., just slightly below Firm *U*'s unit delivery cost. In that case, market outcomes and consumer prices would remain unchanged but Postal Service profits and parcel sector efficiency would increase. However, in general, one cannot rule out the possibility that the Postal Service would choose to set an even lower delivery price in order to expand Firm *U*'s E2E market. In that case, not only would efficiency and Postal Service profits increase, Firm *U* profits would go up and all consumer prices would go down!

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7 The details of this analysis are relegated to the Appendix.

***The efficiency gains are split between the Postal Service and Firm U based upon their relative bargaining power.***

Section 5 turns to the more realistic situation in which the relative bargaining power of the Postal Service and its E2E parcel competitor is more equally balanced. Thus, I analyze "co-opetition" negotiated service agreements (NSAs) between the Postal Service and its E2E competitor, Firm *U*. In this situation, the firms are assumed to negotiate a per unit delivery charge (paid by Firm *U* to the Postal Service) that maximizes total parcel market profits. These profit gains are split between the two firms using lump sum transfers determined by their relative bargaining power. Determining the optimal NSA delivery price is quite complicated in general,[8] but instructive special cases are discussed in the text. The most likely result of co-opetition is that Firm *U* is charged a delivery price slightly below it's per unit delivery costs while its volumes are delivered by the Postal Service. In this case, all market prices and quantities remain the same. The efficiency gains are split between the Postal Service and Firm *U* based upon their relative bargaining power. Again, however, if the integrated technology constitutes a major innovation, the negotiated transfer price will be below Firm *U*'s unit delivery cost and E2E prices will decline.

Section 6 presents an exploratory analysis of the impact of the emergence of large volume parcel mailers as "strategic players" with the capability to force the Postal Service and its parcel delivery rivals to directly compete for their volumes. In the base case, such firms behave as price-takers and form part of the overall E2E market. I then introduce the possibility that the Postal Service and Firm *U* can compete to offer discounted rates to a representative large mailer, Firm *A*. In the context of the example analyzed, it remains possible for the Postal Service and Firm *U* to negotiate and efficient NSA: i.e., Firm *U* handles the upstream processing of Firm

8 Again, the analysis of the general case is relegated to the Appendix.

***The ability of the Postal Service to compete directly for the delivery volumes of large mailers may improve its NSA bargaining position, allowing it to obtain a larger share of the (lower) total carrier profits.***

*A*'s volumes and the Postal Service delivers them. The ability of large parcel mailers to induce rival carriers to directly compete for their business with discounted rates has two effects. First, as one would expect, the result of this competition is to reduce customer shipping costs and carrier profits. However, the ability of the Postal Service to compete directly for the delivery volumes of large mailers may *improve* its NSA bargaining position, allowing it to obtain a larger share of the (lower) total carrier profits. These gains come at the expense of Firm *U*, not Firm *A* or other consumers.

## 2. Review: A Two-Stage Postal Letter Network

The setting analyzed is quite simple. Figure 1 depicts a simplified version of a (unidirectional) postal letter network. Single piece mailers utilize the "upstream" network of the Postal Service, which *processes* (i.e., collects, transports and sorts) their mail and advances it to the Postal Service's destination Local Post Office for delivery to mail recipients.[9] In this stylized version of the current system, large, "bulk" mailers have the option to bypass the upstream network of the Postal Service by lodging their mail at a local delivery office, for which they are rewarded with a worksharing discount. Alternatively, bulk mailers can lodge their volumes directly with competitive mail processing firms at a bulk mail rate that reflects said worksharing discount.

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9 Of course, the actual postal network is bi-directional and most (i.e., 66%) local post offices combine the collection and delivery functions. See USPS OIG (2011).

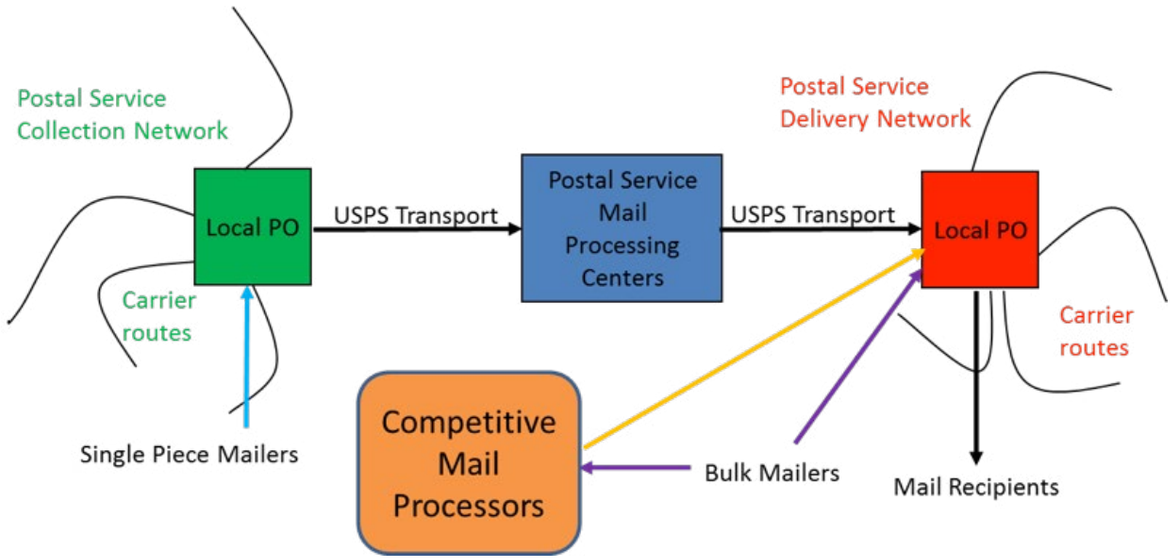


Figure 1: USPS Letter Network with Worksharing

The Postal Service operates its *monopoly* local collection and delivery networks and is also the dominant firm in the mail processing market, competing with a fringe of (perfectly) competitive operators. Thus, the Postal Service collects "single piece," retail mail from the public and small businesses. It then sorts and transports these volumes to its local delivery locations. Firms in the competitive mail processing sector collect mail from their customers, sort it and transport it to the Postal Service's delivery sortation facility. (This could be the local delivery office or a mail processing center that performs walk-sequence sorting for a number of delivery units.) In addition to the mail originating with the Postal Service, large mailers may lodge their volumes directly with mail processors. The basic model does not allow for small mailers to "bypass" the Postal Service by patronizing competitive collection offices, it also assumes that there is no bypass of the Postal

***For simplicity and ease of exposition, I combine all parts of the Postal Service parcel delivery value chain in to just two components, "upstream" and "downstream."***

Service's letter delivery function. It is straightforward to allow for the presence of a "competitive fringe" in one or both markets without materially affecting the analysis.

This model is similar to others I have used[10] to analyze vertically integrated postal networks. The focus of the analysis has typically been to study the efficiency implications of various worksharing discount policies in the presence of the Postal Service's delivery monopoly. In the next section, I develop a similar two-component model to analyze the effects of alternative delivery pricing strategies for the Postal Service.

## 3. A Two-Stage Model of the Parcel Delivery Market

Again, for simplicity and ease of exposition, I combine all parts of the Postal Service parcel delivery value chain in to just two components, "upstream" and "downstream." The upstream component includes collection, transportation, inward and outward sortation and other types of "mail processing" activities other than delivery. The sole downstream component is "delivery."

Figure 2 adds a stylized package delivery market to the postal letter network depicted in Figure 1. On the demand side of the market, I have added individual and business mailers of packages. On the supply side, I have added an industry of (one or more) independent package delivery firms, each of which operates its own E2E delivery network. Since the Postal Service

10 See, for example, Panzar (2008), (2010), (2011) and USPS OIG (2010). These theoretical models usually limit attention to two vertical stages: a delivery stage and a composite, "mail processing" stage in which collection, inward and outward sortation and transportation are all lumped together. I follow standard practice by assuming that mail processing can be performed by the Postal Service at an essentially constant cost per unit, while the delivery function exhibits significantly increasing returns to scale.

also delivers packages over its network, the diagram allows both business and individual package mailers the option of using either the Postal Service or the package delivery firms to send their packages. Also, as in the case of letters, large mailers are assumed to be able to "workshare" by lodging their packages with the Postal Service at the destination local PO. I also allow for the *possibility* that large package mailers and parcel delivery firms may choose to workshare. That is, large package mailers and/or consolidators perform upstream network functions and utilize the network of a parcel delivery firm only for delivery.

***Figure 2 emphasizes the important fact that the letter and parcel services of the Postal Service are provided over a shared network.***

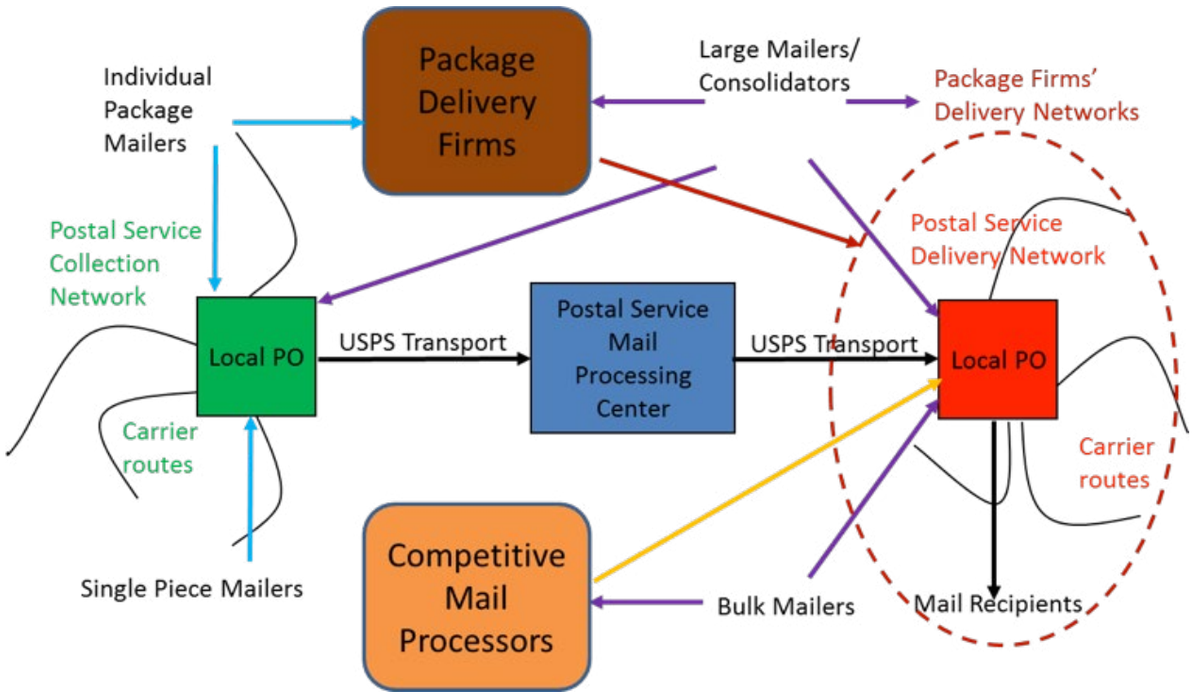


Figure 2: USPS Network with Parcel Competition

Although the cost is a seriously "busy" diagram, Figure 2 emphasizes the important fact that the letter and parcel services of the Postal Service are provided over a *shared network*. This gives rise to a substantial amount of costs that are common to both services. My purpose in this

section is to develop a simple model focusing on equilibrium in the parcel market. However, it is important to remember that the two services are inextricably connected on the cost side of the market. For simplicity, the model developed below typically assumes constant marginal costs for the two vertical cost components of the Postal Service's letter and parcel operations. These costs can be directly assigned to *either* the letter or parcel operations. However, the bulk of the *fixed costs* associated with the delivery function are most realistically viewed as *common* to the two services.

***The bulk of the fixed costs associated with the delivery function are most realistically viewed as common to the two services.***

## 3.1 The Market Demand System

In this framework, I assume that the Postal Service provides two tariffed parcel products: retail, E2E service, which it sells a price $p$ and a workshared, delivery access service which it sells at a price of $a$. Two other types of firms also participate in the parcel delivery sector. For simplicity, I model only a single *strategic* parcel delivery rival of the Postal Service. "Firm *U*" is an E2E provider that sells a retail product at a price $p_u$. Firm *U* may also offer a discounted delivery access service at a price $a_u$. In addition, there is an upstream competitive sector of (very many) worksharing firms, or consolidators, which collect parcels from business parcel mailers and turns them over to the Postal Service or Firm *U* for delivery. The E2E products of the Postal Service and its Firm *U* may be *differentiated* in the minds of consumers. That is, they may be *imperfect substitutes* with market demand curves given by $X(p,p_u)$ and $X^u(p,p_u)$, respectively. In contrast, I assume for simplicity that consumers view that the E2E service assembled by competitive consolidators are essentially identical to *either* those of the Postal Service or Firm *U*. Thus, while consolidators may differentiate their products somewhat, they all treat the delivery access services

of Firm *U* and the Postal Service as perfect substitutes in their E2E production processes.[11]

Competitive firms worksharing with the Postal Service supply a quantity $W(m)$ of upstream service, where the competitors' margin, $m = p - a$, is the difference between the Postal Service's retail price and its delivery price. The function, $W(p-a)$, also represents the demand curve for the workshared product of the Postal Service. Thus, the *derived* (net) demand curve facing the Postal Service for its E2E product is given by $D(p,p_u,a) = X(p,p_u) - W(p-a)$. Similarly, competitive firms worksharing with Firm *U* supply a quantity $W_u(m_u)$ of Firm *U* – type upstream services. Again, these competitors' margin is given by $m_u = p_u - a_u$. The derived demand for Firm *U*'s E2E product is given by $D^u(p,p_u,a_u) = X^u(p,p_u) - W_u(p_u - a_u)$.

## 3.2 Costs

The E2E firms, the Postal Service and its strategic rival (Firm *U*), are assumed to have constant marginal costs for mail processing and delivery.[12] These are denoted, respectively, by $t$ and $r$ for the Postal Service and $t_u$ and $r_u$ for its rival. Sometimes it will prove convenient to let $c = t + r$ and $c_u = t_u + r_u$, respectively, denote the E2E *marginal costs* of the Postal Service and

11 In reality, consolidators may differentiate their upstream services in a variety of dimensions: e.g., pick-up flexibility, web tracking capabilities, etc. In theory, this could give rise to a very large number of differentiated upstream services. This situation could be analyzed using a more complicated model of E2E *monopolistic competition*. For simplicity, I assume that consolidators upstream service characteristics are designed to be of only two types: one that is identical to that of the Postal Service and another that is identical to that of Firm *U*. This assumption limiting upstream product differentiation is not crucial. The results of the paper spring from the assumption that the delivery access services of Firm *U* and the Postal Service are essentially perfect substitutes.

12 Both the Postal Service and Firm *U* may have fixed costs associated with their networks. These will have no impact on short to medium term pricing decisions as long as neither is on the margin of leaving the parcel market.

Firm *U*. For realism, I assume that the Postal Service has a cost advantage over its rival in terms of marginal delivery costs (i.e., $r < r_u$), while Firm *U* has an advantage in mail processing, so that $t > t_u$.[13] The marginal cost curves of the competitive worksharing firms are characterized by their rising supply curves, $W(m)$ and $W_u(m_u)$.[14]

### 3.3 Market Equilibrium

As noted above, I assume that consolidators behave as (passive) competitive price-takers. These firms make their market supply decisions, $W(m)$ and $W_u(m_u)$, taking as given the margin between the "retail" and "wholesale" prices quoted by the Postal Service and Firm *U*: i.e., $m = p - a$ and $m_u = p_u - a_u$. In contrast, I assume that that Postal Service and Firm *U* are strategic rivals in both the "retail" E2E parcel delivery market and the "wholesale" delivery-only market. Each firm is acutely aware that the volume of parcels it receives from customers is affected by the price charged by its rival. I model this market interaction using the concept of a Bertrand-Nash equilibrium. That is, I assume that each firm chooses its price to maximize its profits *taking as given* the price charged by its rival. Then, in Bertrand-Nash market equilibrium, neither firm has an incentive to *unilaterally* alter its price.

13 Because of the possibility of product differentiation, it is not necessary to assume that Firm *U* has an overall marginal cost advantage (i.e., $c_u < c$) in order to explain Firm *U*'s domination of the E2E package delivery market. However, in examples in which the products of the Postal Service and Firm *U* are assumed to be perfect substitutes, it will be assumed that $c_u = r_u + t_u < r + t = c$.

14 The supply curves can also be viewed as representing the marginal cost curves of the two consolidator *industries*. More technically, let $C(W)$ and $C_u(W_u)$, respectively, denote the total costs of *all* the competitive upstream firms whose products compete with the Postal Service and Firm *U*, respectively. Next, let $MC(W)$ and $MC_u(W_u)$ denote the associated industry marginal cost curves. Then, $MC^{-1}(m) = W(m)$ and $MC_u^{-1}(m_u) = W_u(m_u)$ or, equivalently, $m = MC(W(m))$ and $m_u = MC_u(W_u(m_u))$.

First, consider the equilibrium in the wholesale market. Because of the assumption that delivery is a homogeneous service, I make use of the standard result of the heterogeneous cost Bertrand model: i.e., the low cost firm captures the market at a price (very, very) slightly below the unit cost of the high cost firm. In the present model, this means that the equilibrium delivery access price for Firm $U$ is $a_u^e = r_u$ and that of the Postal Service is $a_u^e = r_u - \varepsilon$ where $\varepsilon$ is an arbitrarily small positive number. Following standard practice, I will proceed by assuming that the equilibrium worksharing price is equal to the unit delivery cost of Firm $U$: i.e., $a^e = r_u$.[15]

Proceeding to the characterization of equilibrium in the E2E market, the (variable) profits of Firm $U$ are given by the product of its E2E volume and the difference between its price and its E2E unit costs. That is,

(1) $\pi^u (p,p_u) = (p_u - t_u - r_u)[X^u (p,p_u) - W_u (p_u - r_u)] = (p_u - t_u - r_u)D^u(p,p_u,r_u)$.

Note that equation (1) reflects the fact that, in equilibrium, Firm $U$ serves only a portion, $D^u$, of the potential E2E demand for its product, $X^u$. The remainder is processed by "type – $U$" worksharers and handed off to the Postal Service for delivery. The contribution (gross of any incremental fixed costs) made by the parcel business of the Postal Service to its institutional costs is given by the sum of its net earnings from its E2E and workshared products: i.e.,

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15 To be precise, one should allow for the possibility that the profit-maximizing worksharing price of that the Postal Service would choose if it were a *monopolist* in the delivery market, $a^*$, is actually lower than the unit cost of its rival. Then, the Bertrand outcome would be assumed to be the lower of the two: i.e., $a^e = \min \{r_u, a^*\}$. Intuitively, the assumption that $a^e = r_u$ is equivalent to the assumption that the existence of Firm $U$ places any limits on the Postal Service's pricing power in the delivery market. This *limit pricing* issues recurs in the discussions of some of the examples of Sections 4 and 5.

(2) $\pi(p, p_u, r_u) = (p - t - r)D(p, p_u, r_u) + (r_u - r)[W(p - r_u) + W_u(p_u - r_u)]$.

The equilibrium in the E2E market is found by solving the First Order Necessary Conditions (FONCs) for profit maximization for both firms *simultaneously*. Differentiating the profit function of Firm *U* with respect to $p_u$ yields the optimality condition:

(3) $$\frac{\partial \pi^u}{\partial p_u} = (p_u - t_u - r_u)\frac{\partial D^u}{\partial p_u} + D^u(p, p_u, r_u) = 0.$$

Similarly, differentiating the profit function of the Postal Service with respect to *p* yields the optimality condition:

(4) $$\frac{\partial \pi}{\partial p} = (p - t - r)\frac{\partial D}{\partial p} + D(p, p_u) + (r_u - r)W'(p - r_u) = 0.$$

Equations (3) and (4) constitute an equilibrium system of two equations and two unknowns that can typically be solved for the equilibrium values of the remaining two endogenous variables: $p^e$ and $p_u^e$ .

Figure 3 provides a somewhat simplified depiction of parcel market equilibrium. In addition to eliminating the letter mail flows, the diagram consolidates all parcel customers into a single group and illustrates their choice between patronizing consolidators, the Postal Service or Firm *U*. The diagram also shows that relevant prices and/or unit costs alongside the product flow arrows. Although Firm *U* does not capture any of the delivery-only market, the fact that it contests that market limits the price the Postal Service can charge to consolidators. This fact is reflected by the dotted arrow between consolidators and Firm *U*'s delivery network.

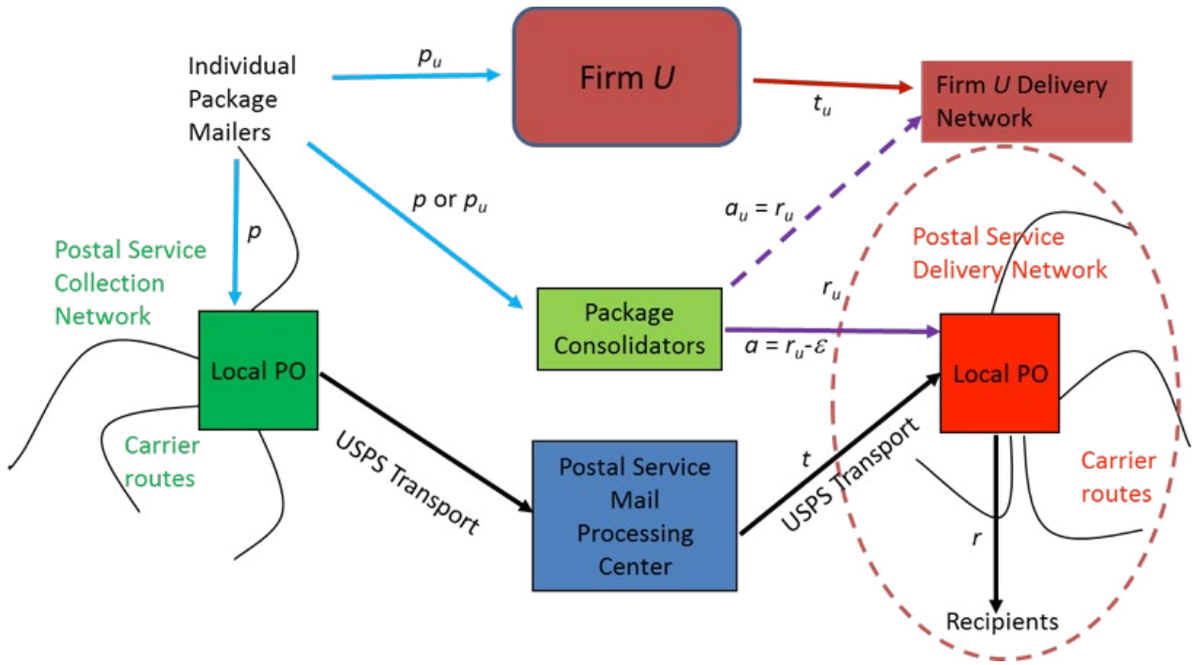


Figure 3

## 4. Let's Make a Deal!

The rival duopolists whose interaction is described in the previous section have complementary strengths and weaknesses. It was assumed that the Postal Service has lower marginal costs of delivery, while Firm *U* has lower upstream marginal costs. And, although the Postal Service may offer worksharing discounts, I assume that those calculated on an avoided cost basis are not sufficiently attractive to obtain the business of Firm *U*. However, given the assumed comparative advantage of the Postal Service in the delivery function (i.e., $r < r_u$), one would expect that it will be possible to make a mutually attractive agreement.

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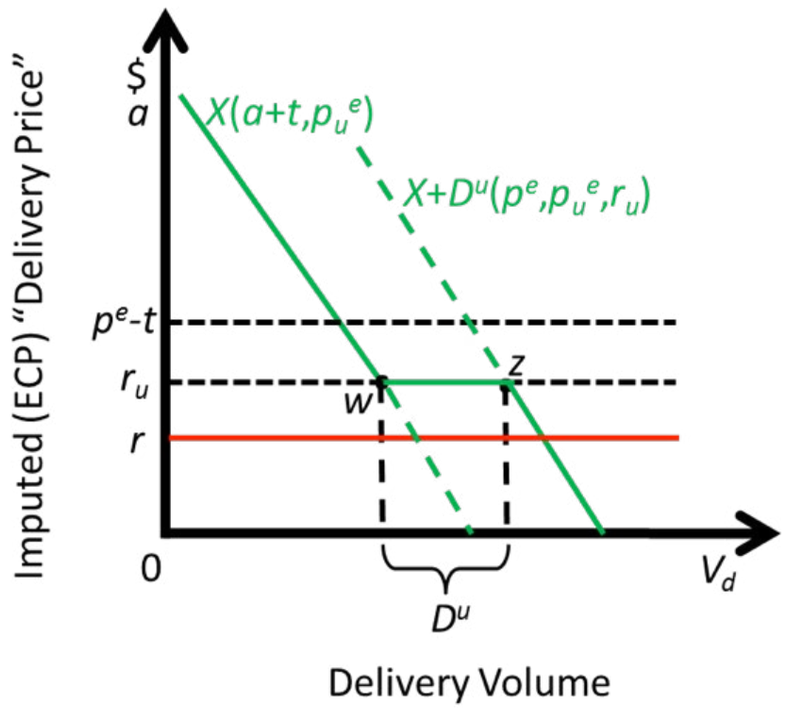


Figure 4

Figure 4 reveals the source of the potential "gains from trade." The base case analysis of the previous section ignores a major portion of the potential demand for the delivery services of the Postal Service. As a result of the "top down" focus of worksharing discounts, the upstream services of competitive suppliers are efficiently incorporated into the postal sector supply chain. However, this pricing approach makes it very difficult to efficiently integrate the networks of the Postal Service and alternative parcel delivery firms. Figure 4 illustrates the impact such an integration might have on the aggregate demand for the delivery services of the Postal Service. As in the theoretical analysis, the demand for Postal Service delivery is derived from the E2E parcel demand curve for the Postal Service and its workshare partners. For ease of presentation,

I convert this E2E demand to delivery demand under the assumption that the Postal Service and set equal delivery access prices and that each firm captures the volumes of those consolidators engaged in worksharing its particular product variety.[16] However, if the delivery price falls below $r_u$, it is no longer profitable for Firm *U* to follow this matching strategy.

As one can see from the diagram, the derived demand for access would increase dramatically as soon as the imputed delivery access price drops below $r_u$, the per unit delivery cost of Firm *U*. Figure 4 depicts two aggregate derived demand curves for delivery services. The curve on the left plots the sum of single-piece and workshared Postal Service parcel demand as a function of the delivery access price *a*. The curve on the right adds the package delivery demand $D^u$ for values of *a* that are *below* $r_u$, the in-house unit delivery cost of the package firms. Any delivery price below that level will make outsourcing optimal for them. Thus, the *relevant* aggregate demand curve has a discontinuity at the price $a = r_u$. At a delivery price slightly above $r_u$, the market outcome is at point *w*. At a delivery price slightly below $r_u$, the quantity demanded jumps to point *z*. The solid line with the horizontal segment at $a = r_u$ combines the relevant portions of the two demand curves.[17] Postal Service marginal delivery costs are indicated by a horizontal line at $r < r_u$.

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16 That is, delivery volumes for the Postal Service are given by $X = D + W$ for $a = a_u \geq r_u$.

17 Taken literally, the analysis results in *all* of Firm *U*'s volumes being transferred to the Postal Service for delivery whenever the quoted delivery price is even slightly below $r_u$. This is because it is implicitly assumed that Postal Service delivery is a perfect substitute for Firm *U* delivery for *all* of Firm *U*'s parcels. In reality, only some of Firm *U*'s parcels may be suitable for delivery by the Postal Service. The rest may not be capable of being transferred to the Postal Service because of transportation schedules, delivery time windows, etc. This consideration can easily be introduced into the analysis by assuming that only some specified share, $s \in (0,1)$, of Firm *U* volumes are suitable for Postal Service delivery. (All that is necessary is to replace $D^u$ by $sD^u$ in the appropriate Figures and formulae.)

***Clearly, a mutually profitable relationship can be established between the Postal Service and Firm U.***

An alternative way to interpret Figure 4 is to view it as depicting the demand curve facing a "Delivery Only" Postal Service (DOPS): i.e., a delivery firm whose upstream processing functions had been "divested" and turned over to separate entities. In that case, the "kink" in the delivery demand curve has a quite intuitive interpretation. It reflects that situation in which the stand-alone delivery price has dropped to such a level that the DOPS serves not only the "legacy" parcel volumes of its divested upstream units and workshare partners, but also becomes an attractive outsourcing option for the delivery operations of its former rival, Firm *U*.

Clearly, a mutually profitable relationship can be established between the Postal Service and Firm *U*. First, consider the possibility that the Postal Service can design a "take-it-or-leave-it" (TIOLI) delivery tariff, $d_u$, *only* available to Firm *U*.[18] In order to be profitable for the Postal Service, it clearly must be the case that $d_u \geq r$. Otherwise, the Postal Service would lose money on each parcel of Firm *U* that it delivered. Similarly, Firm *U* would not utilize the tariff unless it was at or below $r_u$, the level of its marginal delivery cost. Clearly, one profitable strategy would be for the Postal Service to charge a delivery tariff $d_u$ (very, very) slightly below $r_u$. Confronted with such a TIOLI offer, Firm *U* would agree to take it (and save a tiny amount of money). Note that this would *not* alter the duopoly equilibrium in the E2E market, because the unit cost facing Firm *U* is essentially unchanged. However, the contribution earned by the Postal Service from the parcel market would clearly increase, perhaps dramatically. The equilibrium prices, quantities,

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18 While tariffs are supposedly available to "all comers," in practice it is usually possible to design the volume thresholds and/or lodgment requirements in such a way that the tariff does not appeal to "ordinary" worksharing consolidators.

***By switching Firm U's parcel delivery volumes to the more efficient delivery function of the Postal Service, the efficiency of the postal sector would increase.***

revenues and costs received in its E2E retail market and its competitive worksharing market would remain unchanged, but it would earn an additional contribution of

(5) $\Delta\pi=(d_u - r)\, D^u$.

By switching Firm *U*'s parcel delivery volumes to the more efficient delivery function of the Postal Service, the efficiency of the postal sector would increase. The Postal Service increases the contribution earned from the parcel market and both Firm *U*'s profits and the prices paid by consumers remain unchanged.

Indeed, it is possible that the Postal Service may find it profitable to offer Firm *U* a delivery only price that is *substantially* below that firm's marginal delivery cost. Exactly what TIOLI price would maximize Postal Service profits depends in a complicated way on the firms' own-price and cross-price demand elasticities and the comparative cost advantages of the two firms.[19] However, it is instructive to analyze the limiting cases in which the two parcel services are (i) *perfect substitutes* in demand; or (ii) have *independent* demands. As we shall see, in both cases, the Postal Service would tend to set $d_u = r_u$, unless $r << r_u$.

## 4.1 Case (i): Perfect Substitutes

In the base case situation, market demand is equal to $D_m(p_m)$, where $p_m = \min\{p, p_u\}$. As in the standard homogeneous product Bertrand pricing model, the firm with the cost advantage captures the entire market by setting an equilibrium price (very, very) slightly below the unit cost of the high cost

19 The Appendix 1 presents a formal analysis.

***A cost-reducing innovation is classified as a major invention if the monopoly price charged by a firm using the low cost method would be strictly less than the per unit cost resulting from use of the high cost method.***

firm. Here, the more efficient firm ($U$) captures the entire market by charging a price (slightly below) the unit cost of the Postal Service: i.e., $p_u = t + r$.[20] Firm $U$ would accept any TIOLI offer of the Postal Service below its own unit delivery cost; i.e., $d_u \leq r_u$. As discussed above, if $d_u$ were set (very, very) slightly below $r_u$, Firm $U$ would not choose to change the initial E2E price. Firm $U$'s profits would increase by the amount of its delivery costs savings, i.e., $(r_u - d_u)D_m(p_u)$. Similarly, the contribution earned from the parcel market by the Postal Service would increase by $(d_u - r)D_m(p_u)$. In order to determine whether or not the Postal Service might wish to offer a TIOLI price significantly *below* $r_u$, it is necessary to analyze how Firm $U$ would respond to such a discrete price decrease.

In principle, the issue is quite simple. The delivery only tariff offering of the Postal Service provides Firm $U$ with a "new" E2E technology with a unit cost of $t_u + d_u$. The determination of the optimal $d_u$ for the Postal Service to charge is directly related to whether this new E2E technology would be classified as a "major invention" or "minor invention" *relative* to the Postal Service's E2E technology with unit cost $t + r$.[21] Put simply, a cost-reducing innovation is classified as a *major invention* if the monopoly price charged by a firm using the low cost method

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20 Market demand is equal to $D_m(p_m)$, where $p_m = \min\{p, p_u\}$. As in the standard homogeneous product Bertrand pricing model, the firm with the cost advantage captures and sets an equilibrium price (very, very) slightly below the unit cost of the high cost firm. To limit the number of cases discussed, I assume that the total E2E unit cost of the Postal Service, $t + r$, is *less* than the monopoly price that would be charged by a hypothetical monopolist with E2E unit cost as low as $t_u + r$. That is, the presence of the Postal Service places a constraint on the market power of even the most efficient possible entity in the parcel market.

21 This distinction is standard in the innovation literature. See, for example, Viscusi, Harrington and Vernon (2005), pp. 868-71.

***The presence of the Postal Service places a constraint on the market power of even the most efficient possible entity in the parcel market.***

would be strictly *less* than the per unit cost resulting from use of the high cost method. Otherwise, the cost-reducing innovation is classified as a *minor invention*. Clearly, the Postal Service would never offer a delivery only price below its marginal delivery cost (i.e., $d_u \geq r$). This makes it easy to state the following *sufficient condition*: if the integrated E2E technology (with unit cost $r + t_u$) constitutes a *minor invention* relative to the Postal Service E2E technology (with unit cost $r + t$), then the Postal Service's profit maximizing TIOLI delivery only price is (very, very) slightly below the unit delivery cost of Firm *U*: i.e., $d_u^* = r_u$.

To limit the number of cases discussed, I assume that the total E2E unit cost of the Postal Service, $t + r$, is *less* than the monopoly price that would be charged by a hypothetical monopolist with E2E unit cost as low as $t_u + r$. That is, the presence of the Postal Service places a constraint on the market power of even the most efficient possible entity in the parcel market.

## 4.2 Case (ii) Independent Demands and Monopoly Pricing

The next limiting case to consider is that in which the demand curves for the E2E products are *independent* of the price charged by the rival: i.e., $D = D(p)$ and $D^u = D^u(p_u)$. Here, the base case situation involves Firm *U* charging the E2E monopoly price associated with its E2E marginal costs, $c_u$. That is,

(6) $\quad p_u^*(c_u) \equiv \text{argmax}_{pu}(p_u - c_u)D^u(p_u).$

When operating independently, Firm *U*'s E2E unit cost is given by $c_u = t_u + r_u$ and it would charge the monopoly price $p_u^*(t_u + r_u)$. Now suppose Firm *U* purchased delivery-only services

from the Postal Service at the price $d_u \leq r_u$. Its effective E2E marginal cost would be $t_u + d_u$. It would choose to charge the associated monopoly price $p_u^*(t_u + d_u)$. As in the previous case, the Postal Service *indirectly* determines Firm *U*'s price through its delivery price offering. This relationship can be analyzed to characterize the Postal Service's profit-maximizing TIOLI delivery price.

The incremental profits of the Postal Service consist of the added contribution earned on the delivery volumes it carries for Firm *U*. For $d_u \leq r_u$, these are given by

$$\Delta\pi = (d_u - r)\, D^u\, [p_u^*(t_u + d_u)]. \tag{7}$$

One could proceed by differentiating equation (7) to characterize the optimal $d_u$ using the resulting FONCs. However, it is more useful to recognize that the solution in this case also turns upon a *major invention* versus *minor invention* issue. Here, it is somewhat more difficult to precisely define the "relevant market" in which to apply the major/minor dichotomy. The appropriate market is that of *the market for delivery services derived from Firm U's hypothesized upstream monopoly market*. That is, would a *hypothetical delivery monopolist* (e.g., a DOPS or the "delivery only division" of Firm *U*) view it to be a *major invention* or a *minor invention* if it were suddenly able to provide delivery services at a unit cost of *r* rather than $r_u$. If such a hypothetical delivery monopolist would view the change as a *minor invention*, then, again, the optimal TIOLI delivery-only price would be $d_u^* = r_u$.

## 4.3 Concluding Remarks on TIOLI Delivery Pricing

As the next section explains, it is somewhat naïve to assume that the Postal Service can

credibly offer a TIOLI delivery tariff to Firm *U*. However, analysis of this simplest case starkly reveals some of the potential benefits of co-opetition. First, it shows that substantial benefits can accrue to the Postal Service without adversely affecting consumers, worksharing firms or Firm *U*. This is because when, as will usually be the case, the Postal Service captures the delivery function from Firm *U* by setting $d_u$ (very, very) slightly below $r_u$, equilibrium in the parcels market remains completely unchanged. Second, this strong conclusion can hold in quite complicated models beyond the limiting cases considered here.

## 5. An Analysis of NSA-type Delivery "Co-opetition" Agreements

In a situation in which there are two dominant firms, it is naïve to limit consideration to simple TIOLI delivery prices. First, the TIOLI setting, *by assumption*, gives the Postal Service *all* of the bargaining power. This may be an appropriate assumption to use in modelling the relatively atomistic upstream workshare market. However, the vertically integrated, E2E delivery market certainly possesses "large players" capable of negotiating "toe to toe" with the Postal Service, e.g., Firm *U* of the previous section. Second, it is natural to assume that, when engaged in one-on-one bargaining, firms would be able to negotiate more complicated (and mutually advantageous) contracts. A *Nash Bargaining* analysis of the interaction is appropriate in such circumstances. In this section, I extend the basic model of parcel market competition to analyze the effects of introducing negotiated service agreements (NSAs) between the Postal Service and Firm *U*.

The nature of the interaction modelled is as follows. As in the duopoly case, the Firm *U* and the Postal Service compete as duopolists in the E2E market for package delivery. However, prior

to the "opening" of this market, the firms are allowed to negotiate a contract specifying terms under which Firm *U* may utilize the more efficient delivery network of the Postal Service.[22] Such contracts can, in general, be quite complex. However, in the simplified setting of the present paper, it is sufficient to focus on the case in which the firms reach an agreement on two variables: (i) the per unit charge, *d*, that Firm *U* pays to the Postal Service for each of *U*'s packages delivered over its network; and (ii) the fixed charge, or "license fee," *L*, that Firm *U* agrees to pay to the Postal Service each period regardless of the volume of packages it lodges for delivery by the Postal Service. After agreement is reached on *d* and *L*, the firms compete as duopolists in the E2E package delivery market. Equilibrium then results as in the duopoly model of Section 3 except that, now, Firm *U*'s E2E unit cost is $t_u + d$, rather than $t_u + r_u$, the unit delivery charge incurred when it delivers its packages itself. Thus, the firms co-operate at the contract stage in order to achieve the most efficient E2E service possible: i.e., one in which Firm *U* provides the upstream service component and the Postal Service provides the delivery component. However, the arrangement differs from that of a simple vertical merger, because the firms realize that the combined operation may still face E2E competition from the Postal Service. The bargain reached takes into account the outcome of possible duopoly competition.[23]

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22 For simplicity, I do not consider allowing the firms to negotiate terms under which the Postal Service might utilize the more efficient upstream facilities of Firm *U*.

23 Under a complete merger of the two firms, the new entity would shut down the E2E package service of the Postal Service, leaving the new firm a monopolist in the market with the lowest possible E2E unit cost of $t_u + r$. This would maximize total industry profits but is unlikely to be approved by the antitrust authorities. Therefore, I do not consider the situation in which the Postal Service refrains from competing in the E2E package delivery market when it is profitable for it to do so.

***Exactly what per unit price would maximize joint profits depends in a complicated way on the firms' own-price and cross-price demand elasticities and the comparative cost advantages of the two firms.***

There is an extensive body of economic theory devoted to the analysis of the plausible outcomes resulting from such interactions.[24] However, in the context of the simple model analyzed here, three intuitively appealing results emerge. First, the variable charge $d$ will be chosen so as to maximize the *joint* (total) profits of Firm $U$ and the Postal Service. Second, the fixed charge $L$ determines the division of the profit increase between the two firms. Third, the size of $L$ is determined by the relative bargaining strengths of the two firms and the level of profits each would earn in the absence of any agreement. Exactly what per unit price would maximize joint profits depends in a complicated way on the firms' own-price and cross-price demand elasticities and the comparative cost advantages of the two firms. However, it is again instructive to analyze the limiting cases in which the two parcel services are (i) *perfect substitutes* in demand or (ii) have *independent* demands.

## 5.1 Case 1: Perfect Substitutes

The perfect substitute limiting case has two important subcases depending upon whether or not the Postal Service's E2E technology places a constraint on the pricing of Firm $U$. That is, after the NSA is in place, does Firm $U$ charge the monopoly price associated with the integrated unit cost of $c_c = r + t_u$, or is its pricing power limited by the threat of E2E competition from the Postal Service. The astute reader may suspect that the distinction between the monopoly pricing and limit pricing cases again turns on whether the integrated E2E technology constitutes a major or minor invention relative to the E2E technology of the Postal Service. In the former case,

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24 See, for example, Binmore, Rubenstein and Wolinsky (1986) and Horn and Wolinsky (1988).

co-opetition leads to the two firms sharing monopoly profits, in a proportion determined by their bargaining power. If the integrated technology represents only a minor advance, the equilibrium market price is unchanged. In either case, there are significant efficiency gains from co-opetition. However, there may be significant differences in how the gains are distributed between producers and consumers.

***If the integrated technology represents only a minor advance, the equilibrium market price is unchanged.***

### 5.1.1 Case 1a: Limit Pricing by Firm *U*

If the Postal Service has a relatively small E2E unit cost disadvantage it might well be the case that the monopoly price associated with an integrated parcel technology turns out to be greater than the E2E marginal cost of the Postal Service, $t + r$. In that case, the joint profit-maximizing equilibrium outcome would be the standard Bertrand result: Firm *U* monopolizes the E2E parcel market by charging the *limit price* of (very slightly below) $p^e = r + t$. However, in this case the level of the per unit delivery charge $d^*$ is not precisely determined. Since the quantity sold is determined by the limit price, there is no distortion involved in setting $d^* > r$. It becomes a matter of indifference whether the Postal Service receives its negotiated share of the combination profits through the lump payment *L* or via a mark-up above marginal cost on each unit sold.

Figure 5 can be used to illustrate the gains that result when the integrated E2E technology is only a *minor* improvement over the E2E technology of the Postal Service.

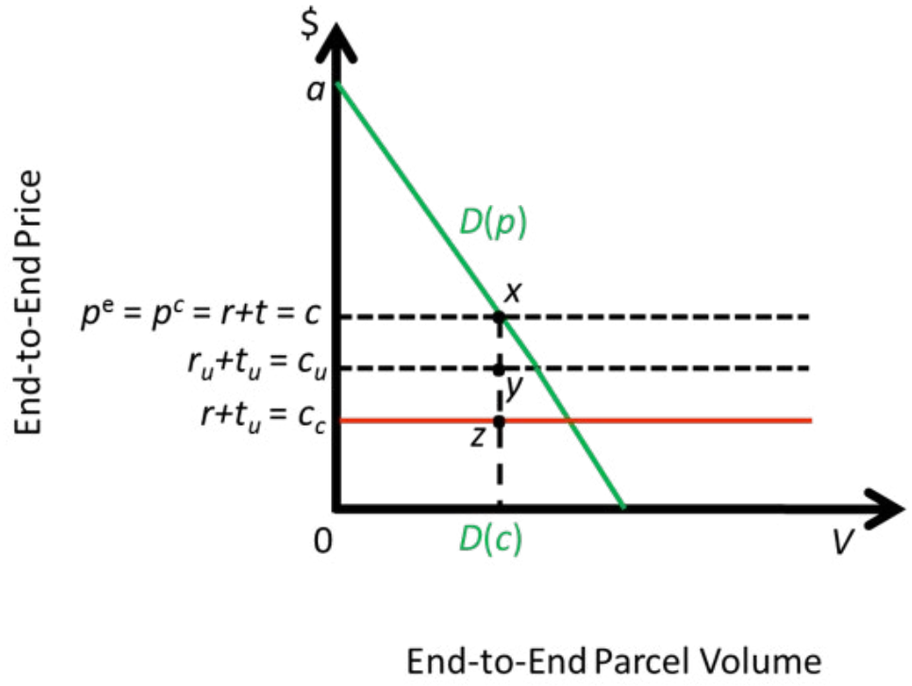


Figure 5

Consumer welfare is unaffected because the equilibrium price does not change following the introduction of the co-opetition NSA (i.e., $p^c = p^e$). Consumers' surplus remains equal to area $axc$. Before the NSA, the quantity $D(c)$ is produced entirely by Firm $U$ at an E2E cost of $c_u D(c)$. Following the NSA, each stage of the value chain is carried out by the most efficient provider, at a total E2E cost of $c_c D(c)$. Thus, the efficiency gains resulting from the NSA are given by the area of the rectangle $c_u yzc_c = (c_u - c_c)D(c)$.

### 5.1.2 Case 1b: Monopoly pricing by Firm *U*

Firm *U* uses the delivery function of the Postal Service to monopolize the E2E package delivery market. This outcome occurs when the *monopoly price* associated with the integrated E2E unit cost, $t_u + r$, is less than $t + r$, the E2E unit cost of the Postal Service. In that case, the Postal Service sets the per unit delivery charge equal to its marginal delivery cost: i.e., $d^* = r$. It profits from this arrangement through the fixed charge *L*.

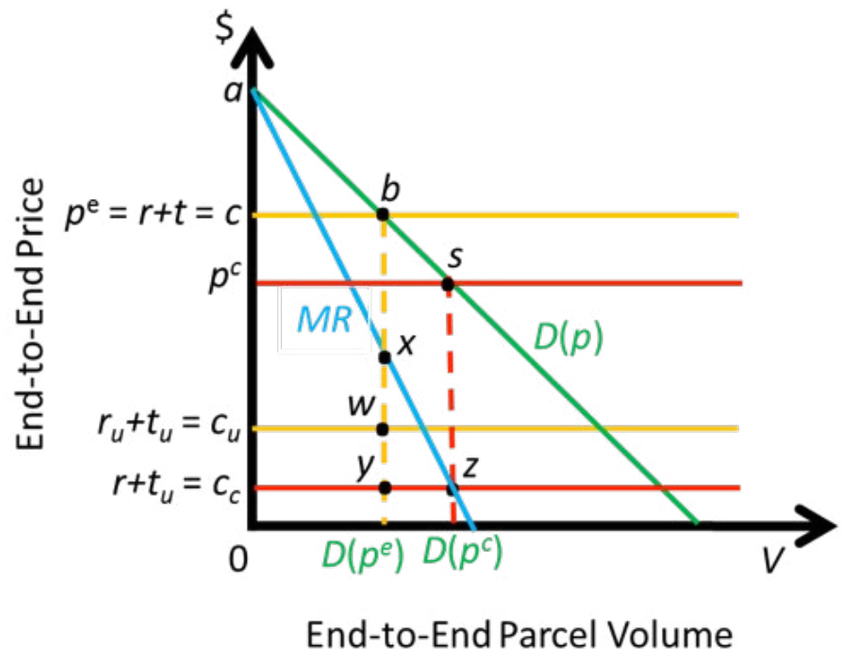


Figure 6

This outcome is illustrated in Figure 6. The initial equilibrium price is (very, very) slightly below the E2E unit cost of the Postal Service: i.e., $p^e = c = r + t$. Consumers' surplus is given by the triangular area *abc* and the profits of Firm *U* by the rectangular area $cbwc_u$. Following the

introduction of the NSA, the E2E unit cost of Firm *U* falls to $c_c$. Firm *U* determines the profit maximizing price and output levels by equating the market marginal revenue curve *MR* to its E2E marginal cost of $c_c = r + t_u$. Consumers' surplus increases (by the area of the trapezoid $cbsp^c$) to the new triangular area $asp^c$. The profits of Firm *U* increase[25] to the rectangular area $p^c szc_c$. Again, these increased profits are shared with the Postal Service through the lump sum payment *L*.

## 5.2 Case 2: Independent Demands

The limiting case of independent demands is conceptually less complicated. This is because the E2E demands of the two firms are not affected by changes in the other firm's prices. Thus, following the NSA, Firm *U* can set the monopoly price associated with the integrated unit cost without concerns about competition from the Postal Service.

25 It may not be immediately obvious from the diagram, but the difference between rectangles $p^c szc_c$ and $cbwc_u$ is equal to the triangular area *xyz*. This follows from the fact that, by definition, the change in profit resulting from an increase in quantity (e.g., from $D(p^e)$ to $D(p^c)$) is equal to the change in revenues less the change in costs. When cost and revenue functions are differentiable, the Fundamental Theorem of the Calculus guarantees that this difference is, in turn, exactly equal to the area *between* the marginal revenue and marginal cost curves over the quantity change in question: i.e., area *xyz* in this example.

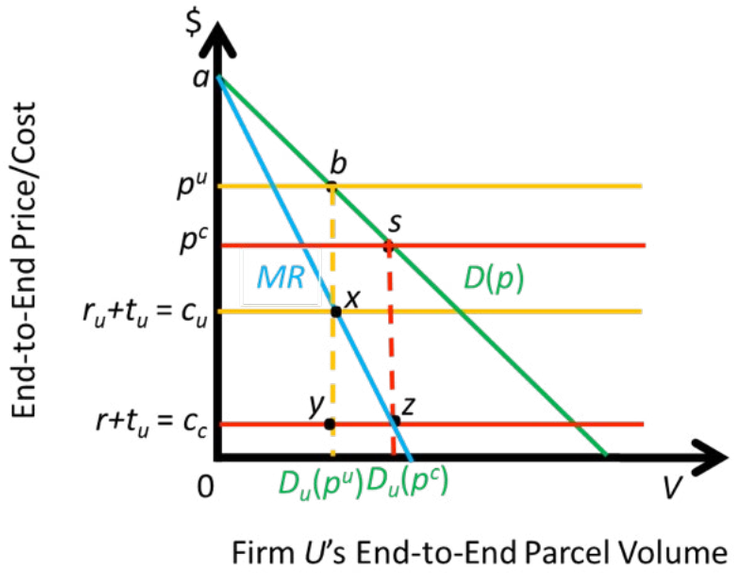


Figure 7

As Figure 7 illustrates, this case is very similar to the *major invention* situation above. Initially, Firm $U$ sets its monopoly price, $p^u$, by equating marginal revenue to its E2E marginal cost $c_u = r_u + t_u$. Initial profits are given be the rectangular area $p^u bxc_u$, with consumers' surplus given by the triangular area $abp^u$. After the NSA is implemented (with $d^* = r$), equating marginal revenue to the lower marginal cost $c_c = r + t_u$, results in the lower monopoly price $p^c$. Consumers' surplus increases (by the area of trapezoid $p^u bsp^c$) to the triangular area $asp^c$. The profits of Firm $U$ also increase (by the triangular area $xyz$) to the rectangular area $p^c szc_c$. Again, a negotiated portion of the increase in industry profits can be transferred to the Postal Service by means of the fixed levy $L$.

## 6. The Effects of Strategic Behavior by "Large" Parcel Mailers

***The presence of these additional strategic players can substantially complicate the analysis of the parcel market.***

In this section, I shall briefly discuss the market effects caused by the ability of large volume parcel customers to negotiate discounted rates from Firm *U* and/or the Postal Service. As we shall see, the presence of these additional strategic players can substantially complicate the analysis of the parcel market. This occurs for two reasons. First, by forcing carriers to compete directly for their business, large mailers can obtain lower rates, thereby reducing the total profits of carriers. Second, the prospect of directly competing for the business of large mailers will tend to impact the terms of the NSAs agreed to between the Postal Service and rival carriers. This is because the terms of the NSA will affect their competitive positions in the subsequent battle for the large mailers' volumes.

The addition of large mailers as strategic players makes a full general analysis very complex. Therefore, I make simplifying assumptions, which serve to limit the overall market setting to the simplest possible extension of that depicted in Figure 5. In particular, I assume that:

(i) The E2E products of the Postal Service and Firm *U* are perfect substitutes.

(ii) The new E2E technology resulting from co-opetition constitutes only a *minor invention*, so that equilibrium prices in the general E2E and delivery access markets are unchanged as a result of co-opetition: i.e., $p^e = r + t$ and $a^e = r_u$.

(iii) There is only one large mailer that may act strategically, Firm *A*.

(iv) Firm *A's* E2E volume (and demand for parcel delivery services) is price inelastic and equal to the quantity $V$.[26]

(v) Firm $A$ does not sell E2E or delivery services to other firms: i.e., it is not a carrier. However, it has the capability to provide itself with upstream and/or downstream services at unit costs of $t_a$ and $r_a$, respectively.

Even the above simplifications do not serve to reduce the range of possible market outcomes to a manageable number. Therefore, I make two additional assumptions concerning the relative values of the model's parameters.

(vi) Firm $A$'s unit processing cost, $t_a$, is high enough so that, *were it not a strategic player*, it would prefer to purchase E2E services from Firm $U$ rather than process its volumes itself and purchase delivery access services from the Postal Service. That is, $p^e \leq a^e + t_a$, which implies that $t \geq t_a \geq t + r - r_u$. On the other hand, $t_a$ is low enough so that the Postal Service is able to win Firm $A$'s business in direct (Bertrand) price competition with Firm $U$. Thus, $r + t_a \leq r_u + t_u$, which implies that $t_u \leq t_a \leq t_u + r_u - r$.[27]

(vii) Firm $A$'s unit delivery cost is too high to be a competitive factor: i.e., $r_a > r_u > r$.

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26 This assumption is obviously made for analytical convenience. However, since the cost of delivery services is likely to be only a small portion of the cost of producing and marketing its products, Firm $A$'s sales (and delivery) volumes are likely to be very inelastic with respect to changes in the prices it pays for delivery. While Firm $A$'s delivery volumes are assumed to be "large," they are also assumed to account for less than one half of the E2E market.

27 In a more realistic model with multiple delivery markets and products, the choice between Firm $U$ and the Postal Service would not be an "either, or" decision. Firm $A$ would presumably choose to purchase E2E services from Firm $U$ in some markets and delivery access services from the Postal Service in other markets.

It seems natural to assume that NSA arrangements between the Postal Service and Firm *U* are part of an ongoing, long-term relationship, while the parcel delivery needs of Firm *A* are more volatile and harder to predict beyond the short to medium term. Therefore, I assume that the timing of the strategic interaction I analyze is as depicted in Figure 8:

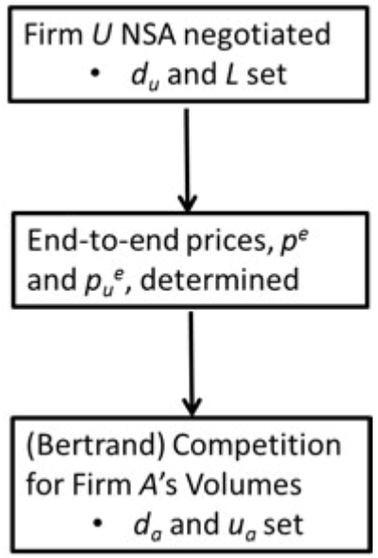


Figure 8

The timing of market interactions is assumed to proceed as follows. The Postal Service and Firm *U* negotiate their NSA agreement. The equilibrium price in the E2E market is, as in Figure 5, is (very, very) slightly below the E2E marginal cost of the Postal Service, so that Firm *U* serves the entire market at a price $p^e$ (approximately) equal to $r + t$. Similarly, the equilibrium price paid by consolidators in the delivery access market is (very, very) slightly below the unit delivery cost of Firm *U*: i.e., $a^e = r_u$. At this stage, if Firm *A* is a strategic player, Firm *U* and the Postal Service directly compete for its business (and its parcel volumes *V*) through their choices of, respectively, E2E and access rates, $u_a$ and $d_a$.

My goal in presenting this example is to attempt to understand the impact of Firm *A* changing from a market price-taker to a *strategic player*: i.e., a firm capable of inducing Firm *U* and the Postal Service to directly compete for its business. To accomplish this requires analyzing market outcomes for four "scenarios." Scenario 1 (S1) is the base case, in which Firm *A* behaves as a price-taker and Firm *U* and the Postal Service have *not* signed an NSA. In Scenario 2 (S2), Firm *A* again behaves as a price-taker, but an NSA between Firm *U* and the Postal Service is in force. In Scenario 3 (S3), Firm *U* and the Postal Service do *not* have an NSA in force, but Firm *A* behaves strategically and forces them to compete directly for its business. Finally, in Scenario 4 (S4), Firm *U* and the Postal Service compete directly for Firm *A*'s business *after* having agreed to the terms of an NSA.

It is important to recall that, because of assumptions (i) and (ii), there are market results common to all scenarios. First, Firm *U* captures the E2E volumes of all price-taking customers at the equilibrium price $p^e = r + t$. Since these volumes do not change across scenarios, denote these volumes by the constant $Q \equiv D(r+t)$. Second, the Postal Service serves consolidators' demand, $W$, for delivery access at the equilibrium price $a^e = r_u$. In all scenarios, these delivery volumes do not change *and* are always delivered by the Postal Service. Therefore, in order to reduce notational clutter, I simply set $W = 0$.

Scenario 1. Due to assumption (vi), Firm *A*'s volumes are just part of the E2E demand curve. As we have seen, Bertrand competition in the E2E market results in Firm *U* capturing the entire market demand at an equilibrium price (very, very) slightly below the unit cost of the Postal Service.

The profits of Firm $U$ would be given by:

(8) $\pi_u^{S1} = (r + t - r_u - t_u)(Q + V)$.

The Postal Service would serve only the equilibrium workshared volumes of consolidators. Since these constant volumes have been normalized to zero across all scenarios, the profits of the Postal Service in Scenario 1 would be

(9) $\pi^{S1} = (r_u - r)W = 0$.

Total parcel industry profits under Scenario 1 are given by:

(10) $\pi_T^{S1} = \pi_u^{S1} + \pi^{S1} = (r + t - r_u - t_u)(Q + V)$.

For comparison purposes, it is useful to note that the total shipping costs incurred by Firm $A$ are given by:

(11) $C_A^{S1} = (r + t)V$.

Scenario 2. Due to assumptions (i) and (ii), the NSA between Firm $U$ and the Postal Service leaves market quantities and prices unchanged from those in Scenario 1. However, all volumes are now delivered by the Postal Service at a per unit rate of $d_u$. In addition, a lump sum payment in the amount $L_{S2}$ is paid by Firm $U$ to the Postal Service. Thus, profits of Firm $U$ are given by

(12) $\pi_u^{S2} = (r + t - d_u - t_u)(Q + V) - L_{S2}$.

Similarly, the profits of the Postal Service are given by

(13) $\pi^{S2} = (d_u - r)(Q + V) + L_{S2}$,

and total industry profits by

(14) $\pi_T^{S2} = \pi_u^{S2} + \pi^{S2} = (t - t_u)(Q + V)$.

Firm *A* continues to purchase at the market E2E rate, so its costs are unchanged:

(15) $C_A^{S2} = (r + t)V$.

As we see from equation (14), the total amount of industry profits does not depend upon neither the lump sum payment, $L_{S2}$, nor the delivery access price, $d_u$, negotiated in the NSA between the Postal Service and Firm *U*.

Thus, in the current example, there is an extra "degree of freedom" available to determine the division of industry profits between Firm *U* and the Postal Service under their NSA. As discussed earlier, one could set $L_{S2} = 0$ and choose *any* negotiated delivery charge, $d_u \in (r, r_u)$, and make both firms strictly better off. However, the Postal Service would clearly prefer a delivery access price toward the top of that interval, while Firm *U* would rather pay one toward the bottom. Where they end up is a matter of bargaining power. There are many ways to attempt to model such bargaining situations.[28] However, the outcome always depends upon the player's *threat points*: i.e., the profits they would earn in the absence of an agreement. For concreteness, I will assume that, in Scenarios 2 and 4, the two firms have *equal bargaining power* so that they split equally the increase in industry profits resulting from their NSAs. In addition, to simplify the algebra, I will assume that the negotiated delivery charges, $d_u$, are set equal to Postal Service

28 Again, see Binmore, Rubenstein and Wolinsky (1986) and Horn and Wolinsky (1988). The classic reference is by Nash (1950).

marginal delivery cost, $r$, so that all Postal Service profits under an NSA result from the lump sum payment that it receives.

To determine the resulting lump sum payment, $L_{S2}$, we must equate the change in profits for each firm resulting from the NSA when $d_u = r$. For Firm $U$ this is given by

(16) $\Delta\pi_u^2 \equiv \pi_u^{S2} - \pi_u^{S1} = [(t-t_u) - (r + t - r_u - t_u)](Q + V) - L_{S2} = (r_u - r)(Q + V) - L_{S2}$.

For the Postal Service, the change is given by

(17) $\Delta\pi^2 \equiv \pi^{S2} - \pi^{S1} = (r - r)(Q + V) + L_{S2} - 0 = L_{S2}$.

Combining equations (16) and (17) and solving yields

(18) $L_{S2} = \frac{(r_u - r)(Q+V)}{2}$.

Thus, when Firm $A$ is a price-taker, the Postal Service profits resulting from its NSA with Firm $U$ are

(19) $\pi^{S2} = L_{S2} = \frac{(r_u - r)(Q+V)}{2}$.

Scenario 3. Here, it is assumed that Firm $U$ and the Postal Service do not have an NSA in place and are forced to engage in Bertrand competition for the business of Firm $A$. Due to assumption (vi), the Postal Service is the low cost option and it ends up delivering Firm $A$'s volumes at a delivery price $d_a = r_u - t_a + t_u$. Firm $U$ only serves the basic E2E market, earning profits given by

(20) $\pi_u^{S3} = (r + t - r_u - t_u)Q$.

The Postal Service makes a profit given by

(21) $\pi^{S3} = (d_a - r)V = (r_u - t_a + t_u - r)V.$

Total parcel carrier profits are given by

(22) $\pi_T^{S3} = \pi_u^{S3} + \pi^{S3} = (r + t - r_u - t_u)Q + (r_u - r - t_a + t_u)V.$

Because it is able to take advantage of direct (Bertrand) competition between Firm *U* and the Postal Service, Firm *A* is able to reduce its costs relative to those incurred in Scenarios 1 and 2. That is,

(23) $C_A^{S3} = (d_a + t_a)V = (r_u + t_u)V < (r + t)V = C_A^{S1} = C_A^{S2}.$

Scenario 4. In this case, Firm *U* and the Postal Service are assumed to successfully negotiate the terms of an NSA that maximizes their joint profits, while recognizing that they will subsequently compete directly for Firm *A*'s volume. Any joint profit-maximizing NSA must implement the most cost efficient E2E service for all parcel volumes, including those of Firm *A*. Efficiency requires that Firm *U* serve the upstream segment for *all* market volumes, while the Postal Service delivers *all* the parcels. This result can only be achieved if it is possible for Firm *U* to offer a negotiated E2E price to Firm *A*, $u_{a,}$ that is no larger than the lowest E2E unit cost Firm *A* could achieve by partnering with the Postal Service, $t_a + d_a$. The lowest negotiated delivery rate that the Postal Service could profitably offer Firm *A* is, of course, $d_a = r$. Once its NSA with the Postal Service is in place, the lowest negotiated E2E price Firm *U* could profitably offer Firm *A* would be $u_a = t_u + d_u$. Thus, any NSA between Firm *U* and the Postal Service that hopes to maximize

their joint profits must involve a negotiated delivery rate for Firm *U* satisfying the constraint that $d_u \leq r + t_a - t_u$.

As was the case in Scenario 2, the ability of the firms to negotiate lump sum transfers as part of their NSA gives them a certain amount of discretion with respect to the negotiated delivery rate $d_u$. As before, I will assume that the firms choose to set $d_u = r$. Since this clearly satisfies the above constraint, Firm *U* will be able to win the Bertrand competition for Firm *A*'s volumes at a price (very, very) slightly below $t_a + r$. Firm *U*'s profits under the NSA are thus given by

(24) $$\pi_u^{S4} = (r + t)Q + (r + t_a)V - (d_u + t_u)(Q + V) - L_{S4} = (t - t_u)Q + (t_a - t_u)V - L_{S4}.$$

The profits of the Postal Service under these NSA terms are given by

(25) $$\pi^{S4} = (d_u - r)(Q + V) + L_{S4} = L_{S4}.$$

Total parcel industry profits are given by

(26) $$\pi_T^{S4} = \pi_u^{S4} + \pi^{S4} = (t - t_u)Q + (t_a - t_u)V.$$

The costs of Firm *A* are given by

(27) $$C_A^{S4} = (r + t_a)V < (r_u + t_u)V = C_A^{S3} < (r + t)V = C_A^{S1} = C_A^{S2}.$$

Similar to the analysis in Scenario 2, solving for the equal bargaining power transfer, $L_{S4}$, requires equating the changes in firm profits resulting from the NSA. For Firm *U*, this difference is given by

(28) $$\Delta\pi_u^4 \equiv \pi_u^{S4} - \pi_u^{S3} = (t - t_u)Q + (t_a - t_u)V - L_{S4} - (r + t - r_u - t_u)Q$$

$$= (r_u - r)Q + (t_a - t_u)V - L_{S2}.$$

For the Postal Service, the difference in profits is given by

(29) $\Delta\pi^4 \equiv \pi^{S4} - \pi^{S3} = L_{S4} - (r_u - t_a + t_u - r)V.$

Equating (28) to (29) and solving yields

(30) $L_{S4} = \frac{(r_u - t_a + t_u - r)V + (r_u - r)Q + (t_a - t_u)V}{2} = \frac{(r_u - r)(Q+V)}{2}$

Combining equations (25) and (30) yields

(31) $\pi^{S4} = L_{S4} = \frac{(r_u - r)(Q+V)}{2}$

The following table summarizes the results of the parametric examples analyzed in this section. The row entries refer to the market equilibrium values of variables of interest. The column entries list the market scenario under which the various results were obtained.

| Scenario<br>Value of | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 |
|---|---|---|---|---|
| 1. Postal Service Profits | 0 | $\frac{(r_u - r)(Q+V)}{2}$ | $(r_u - t_a + t_u - r)V$ | $\frac{(r_u - r)(Q+V)}{2}$ |
| 2. Total Parcel Carrier Profits | $(r + t - r_u - t_u)(Q+V)$ | $(t - t_u)(Q+V)$ | $(r_u - t_a + t_u - r)V$<br>$+ (r + t - r_u - t_u)Q$ | $(t - t_u)Q + (t_a - t_u)V$ |
| 3. Firm *A* Costs | $(r + t)V$ | $(r + t)V$ | $(r_u + t_u)V$ | $(r + t_a)V$ |
| 4. Total Parcel Sector Costs | $(r_u + t_u)(Q+V)$ | $(r + t_u)(Q+V)$ | $(r_u + t_u)Q + (r + t_a)V$ | $(r + t_u)(Q+V)$ |

Table 1

Row 1 states the equilibrium value of Postal Service profits that occur across the various scenarios. Because consolidator delivery access volumes (*W*) have been set equal to zero, Postal Service profits are zero in Scenario 1; i.e., in the case without an NSA or direct competition

for Firm *A*'s business. Postal Service profits increase under the equal bargaining power NSA of Scenario 2. The Postal Service captures one half of the cost savings, $(r_u - r)(Q+V)$, that result from replacing Firm *U* at the delivery stage. From the Scenario 3 column, we see that, due to assumption (vi), the Postal Service benefits from competition for the business of Firm *A*, even in the absence of an NSA with Firm *U*. Finally, in Scenario 4, the Postal Service receives the same profits following an NSA with Firm *U* even when the two must subsequently directly compete for Firm *A*'s business. This is because the Postal Service's bargaining position is stronger because both parties know that the Postal Service would win the competition *if* the NSA negotiations broke down. Thus, the Postal Service ends up with a larger share of a smaller "pie." In this example, the two effects happen to *exactly* balance each other.

The second row lists total profits of parcel sector *carriers*, i.e., Firm *U* and the Postal Service. Comparisons of the change in equilibrium values between Scenario 2 and Scenario 1 and between Scenario 4 and Scenario 3 illustrate the fact that NSAs between Firm *U* and the Postal Service increase joint profits, regardless of whether the firms must subsequently compete directly for Firm *A*'s volumes.[29] Row 2 also reveals the impact on total profits caused by direct competition for the volumes of Firm *A*. Comparing the amount of profit achieved under Scenario 3 with Scenario 1 shows the change in industry profits resulting from Firm *U* and the Postal Service competing for

29 The profit increase is obvious when moving from Scenario 1 to Scenario 2 because, in both cases, Firm *U* captures the entire E2E market and charges the same price. Subtracting the Scenario 1 profit level from that in Scenario 2 yields: $\nabla\pi_T^{12} = (r_u - r)(Q + V) > 0$. Comparing the difference in total profits between Scenarios 3 and 4 is a little more complicated because both firms are providing both upstream and downstream services in Scenario 3, while they (efficiently) specialize in Scenario 4. In this case,
$\nabla\pi_T^{34} = (t - t_u)Q + (t_a - t_u)V - (r_u - t_a + t_u - r)V - (r + t - r_u - t_u)Q = (r_u - r)(Q - V) + 2(t_a - t_u)V > 0.$

Firm *A*'s business in the absence of an NRA.

(32) $\nabla\pi_T^{13} = (r_u - t_a + t_u - r)V + (r + t - r_u - t_u)Q - (r + t - r_u - t_u)(Q + V).$

In general, the sign of this expression is ambiguous. However, it is possible to rearrange the terms so as to facilitate an intuitive interpretation of the result: i.e.,

(33) $\nabla\pi_T^{13} = [(r_u - r) - (t_a - t_u)]V - [(r + t) - (r_u + t_u)]V.$

The first bracketed term in equation (33) is the difference between the Postal Service's delivery cost advantage and the upstream cost advantage of Firm *U* relative to Firm *A*. This difference is positive by assumption (vi). The second bracketed term is the per unit E2E cost advantage of Firm *U* relative to the Postal Service. Thus, the import of equation (33) is that the change in total carrier profits that results from direct competition for Firm *A*'s business will be positive (negative) if the E2E cost advantage of the Firm *A*/Postal Service partnership relative to Firm *U* is larger (smaller) than the E2E cost advantage of Firm *U* relative to the Postal Service.

***Not surprisingly, Firm A's shipping costs are reduced when Firm U and the Postal Service must compete directly for Firm A's volumes.***

Row 3 turns attention to Firm *A*. When Firm *A* is a price-taker, its total costs are the same, regardless of whether or not Firm *U* and the Postal Service have an NSA in place. Not surprisingly, Firm *A*'s shipping costs are reduced when Firm *U* and the Postal Service must compete directly for Firm *A*'s volumes. Because full market efficiency is achieved, it turns out that the shipping reduction is even larger when the two firms have an NSA in place (i.e., in Scenario 4).

To facilitate comparisons of overall sectoral efficiency, row 4 presents the equilibrium values of *total* parcel sector costs for each scenario. In the present example, changes in total costs exactly correspond to the negative of changes in total economic surplus.[30] Moving from column S1 to column S2, we see that total sector costs decrease as a result of the NSA between Firm *U* and the Postal Service. In Scenario 2, *all* volumes are handled by the most efficient carrier at each stage, resulting in the lowest possible sectoral total costs. Comparing columns S1 and S3, we see that direct competition for Firm *A*'s volumes results in greater efficiency, even without an NSA in place between Firm *U* and the Postal Service. Finally, column S4 reveals that it is possible to achieve full sectoral cost efficiency even when an NSA is combined with direct competition for Firm *A*'s business.

The results of this section can be summarized as follows. Strategic behavior by large volume parcel mailers as strategic players was introduced using a very simple example involving only one such customer, Firm *A*. In reality, negotiations between such buyers and the Postal Service and its rivals can be quite complicated, each involving perhaps complex NSAs. To keep the strategic analysis simple, I essentially endow Firm *A* with *all* the bargaining power. That is, I assume that it can compel Firm *U* and the Postal Service to engage in head-to-head price competition in order to obtain its business. Such aggressive (Bertrand) price competition leads to the low cost provider obtaining all of Firm *A*'s volumes at a price of (very, very) slightly below

30 This follows from the assumptions that (i) co-opetition constitutes a minor invention and (ii) Firm *A*'s parcel volume is price inelastic. The first assumption ensures that the equilibrium prices facing E2E consumers and consolidators are the same in each scenario. The second assumption means that, across all scenarios, a change in Firm *A*'s change in profits is exactly equal to the negative of the change in its total shipping costs.

***The ability of the Postal Service to compete directly for the delivery volumes of large mailers improved its NSA bargaining position, allowing it to obtain a larger share of the (lower) total carrier profits.***

the unit costs of the high cost provider. The four scenarios analyzed allow one to compare the results of the introduction of NSAs between the Postal Service and Firm *U* with and without the presence of large buyers with strategic power.

In general, it remains possible for the Postal Service and Firm *U* to negotiate an *efficient* NSA: i.e., Firm *U* handles the upstream processing of Firm *A*'s volumes and the Postal Service delivers them. Not surprisingly, the ability of large parcel mailers to induce rival carriers to directly compete for their business enables them to fulfill their E2E shipping needs at a lower cost. The effect of this exercise of buyer-side market power is, of course, to lower total carrier profits. However, the prospect of such direct competition also affects the terms of the efficient NSAs that can be negotiated between the Postal Service and Firm *U*. In the example analyzed, the ability of the Postal Service to compete directly for the delivery volumes of large mailers *improved* its NSA bargaining position, allowing it to obtain a larger share of the (lower) total carrier profits. These gains came at the expense of Firm *U*, not Firm *A* or other consumers.

## 7. Conclusion

Co-opetition in the parcel delivery market constitutes a technological advance for the postal sector. By combining the strengths of the Postal Service and its E2E rivals, it has the effect of introducing a new, *low cost* rival into the marketplace. As is the case with an innovative firm employing a more efficient technology, the co-opetition option must compete with the existing E2E options. Thus, as in the standard economic analysis of process innovations, one would expect the primary impact of co-opetition to be on the production process rather than the E2E

prices faced by consumers. However, it is possible that the integrated cost savings are large enough that lower E2E consumer prices also result. That is, the result of co-opetition is either "win – win" or "win – win – win."

Finally, it should be pointed out that parcel delivery co-opetition follows in the long tradition of efficiency enhancing worksharing in the postal sector. Worksharing discounts were introduced in order to replace some of the (relatively) inefficient upstream mail processing done by the Postal Service with the operations of more efficient "outsiders." Parcel delivery co-opetition replaces (relatively) inefficient delivery by "outsiders" with lower cost delivery by the Postal Service.

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# Appendices

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# Appendix A: Modelling Delivery Competition as a Supermodular Game

## Appendix: Modelling Delivery Competition as a Supermodular Game

### A.1. Introduction to "Smooth" Supermodular Games.

The price-setting (Bertrand) duopoly interaction between the Postal Service and Firm *U* that is modelled in this paper can be usefully analyzed using the theory of *supermodular games*. Theoretical analyzes of supermodular games and their applications to oligopoly theory have advanced rapidly in recent years.[31] The theory is quite general and can, at times, seem quite abstract. However, the most straightforward version of the theory fits quite nicely into the mathematical framework introduced in the text. In particular, the assumptions that the demand and cost functions used are twice continuously differentiable, allow me to model the Postal Service/Firm *U* duopoly as a *smooth supermodular game* (SSG).

The defining characteristic of such games is that the partial derivative of each player's payoff function be an increasing of its rival's price: i.e., that 2nd order cross-partial derivatives of the firms' profit functions be nonnegative. As we shall see, the only additional assumption required in the context of the present model is that the cross-partial derivatives of the firms' demand functions be nonnegative. The desired cross-partial derivatives can be obtained by differentiating the firms' (own-price) first order partial derivatives, developed in equations (4) and (3) in the text, with respect to the *other* firm's price. Thus, differentiating the Postal Service own-price partial derivative in equation (8) with respect to the price of Firm *U* yields:

31 Vives (1999) provides a very useful guide to the theory and its applications.

(A1) $\frac{\partial^2 \pi}{\partial p \partial p_u} = (p - t - r)\frac{\partial^2 D}{\partial p \partial p_u} + \frac{\partial D}{\partial p_u} \geq 0.$

Similarly, differentiating Firm *U*'s own-price partial derivative in equation (4) with respect to the Postal Service price yields

(A2) $\frac{\partial^2 \pi^u}{\partial p_u \partial p} = (p_u - t_u - r_u)\frac{\partial^2 D^u}{\partial p_u \partial p} + \frac{\partial D^u}{\partial p} \geq 0.$

Given the assumptions already made, equations (A1) and (A2) reveal that the supermodularity condition will be satisfied if the cross-partial derivatives of the firms' demand functions are nonnegative.[32]

SSGs have very convenient properties for economic modelling. (Pure strategy) Nash Equilibria are guaranteed to exist. In addition, it is often possible to derive interesting results concerning the way the equilibrium values respond to changes in the underlying parameters of the problem. In the present case, this establishes the result that the equilibrium E2E prices of both firms will be an increasing function of the per unit delivery price charged to Firm *U*. Thus, let me preview the strategy behind the analysis of the next two sections. *If* it were the case that the relevant profit objective was *always* an increasing function of $d_u$, then the optimal delivery price would be (very, very) slightly less than $r_u$. (At any higher price, Firm *U* would not choose to have its volumes delivered by the Postal Service.) However, as discussed below, this monotonicity may not result if the E2E demand for Firm *U* is sufficiently price elastic.

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32 Clearly, this condition is *sufficient* but not *necessary* because the assumption that the products are substitutes ensures that the second term in each equation is positive. This "substitution effect" may be strong enough to achieve supermodularity even when the demand cross-partials take on relatively small negative values.

## A.2. Analysis of Co-opetition under TIOLI Delivery Pricing

As explained in the text, the ability of the Postal Service to offer Firm *U* a TIOLI offer to deliver its volumes at a price $d_u$ transforms the parcel delivery market into a two stage interaction. In the first stage, the Postal Service selects $d_u$. Then, taking this delivery price as given, the firms compete in the E2E parcel market. Of course, when setting the delivery price, the Postal Service takes into account that the firms will later be competing in the E2E market, and that the results of that competition will be affected by its choice of $d_u$. Equilibrium in the price-setting second stage will be characterized by the following system of equations:

(A3) $$\frac{\partial \pi(p^e, p_u^e)}{\partial p} = (p^e - t - r)\frac{\partial D(p^e, p_u^e)}{\partial p} + D(p^e, p_u^e) = 0,$$

(A4) $$\frac{\partial \pi^u(p^e, p_u^e, d_u)}{\partial p_u} = (p_u^e - t_u - d_u)\frac{\partial D^u(p^e, p_u^e)}{\partial p_u} + D^u(p^e, p_u^e) = 0.$$

The solutions to this system will depend upon the delivery price, $d_u$, which is a parameter of the system when the E2E market opens: i.e., $p_u^e = p_u^e(d_u)$ and $p^e = p^e(d_u)$.

An important result from the theory of SSGs[33] is that an increase in a parameter such as $d_u$ results in an increase in *both* equilibrium prices if the second order cross partial derivatives of firm profits with respect to that parameter are nonnegative. Differentiating equations (A3) and (A4) yields

(A5) $$\frac{\partial^2 \pi(p^e, p_u^e)}{\partial p \partial d_u} = 0 \geq 0,$$

(A6) $$\frac{\partial^2 \pi^u(p^e, p_u^e, d_u)}{\partial p_u \partial d_u} = -\frac{\partial D^u(p^e, p_u^e)}{\partial p_u} > 0.$$

Therefore, $\partial p_u^e / \partial d_u \geq 0$ and $\partial p^e / \partial d_u \geq 0$.

33 See Vives (1999), pp. 34-36.

These results enable us to analyze the optimal choice of $d_u$ by the Postal Service at the first stage of the interaction. As discussed in the text, one would intuitively expect that the Postal Service would want to set $d_u$ as high as possible, i.e., to (very, very) slightly below $r_u$. However, one cannot definitively reach this conclusions based upon the assumptions made so far. To see this, consider the total 1st stage profits of the Postal Service as a function of $d_u$:

(A7) $$\pi^{TOILI}\left(p^e(d_u), p_u^e(d_u)\right) = \pi\left(p^e(d_u), p_u^e(d_u)\right) + (d_u - r)D^u\left(p^e(d_u), p_u^e(d_u)\right).$$

For the Postal Service to have the incentive to raise $d_u$ up to the ceiling imposed by Firm *U*'s unit cost of $r_u$, it must be the case that the derivative of the above expression be positive. Differentiating with respect to $d_u$ yields

(A8) $$\frac{\partial \pi^{TOILI}}{\partial d_u} = \frac{\partial \pi(p^e, p_u^e)}{\partial p}\frac{\partial p^e}{\partial d_u} + \frac{\partial \pi(p^e, p_u^e)}{\partial p_u^e}\frac{\partial p_u^e}{\partial d_u} + D^u(p^e, p_u^e) + (d_u - r)\left[\frac{\partial D^u}{\partial p_u}\frac{\partial p_u^e}{\partial d_u} + \frac{\partial D^u}{\partial p}\frac{\partial p^e}{\partial d_u}\right].$$

Substituting (A3) into (A8) simplifies the expression somewhat:

(A9) $$\frac{\partial \pi^{TOILI}}{\partial d_u} = \frac{\partial \pi(p^e, p_u^e)}{\partial p_u^e}\frac{\partial p_u^e}{\partial d_u} + D^u(p^e, p_u^e) + (d_u - r)\left[\frac{\partial D^u}{\partial p_u}\frac{\partial p_u^e}{\partial d_u} + \frac{\partial D^u}{\partial p}\frac{\partial p^e}{\partial d_u}\right].$$

Unfortunately, the expression still cannot be unambiguously signed. SSG theory guarantees that the first two terms are positive. However, the sum in square brackets cannot be signed. Intuitively, the prospect of greatly expanding Firm *U*'s E2E market from cutting $d_u$ may out weight the higher equilibrium Postal Service price that results from setting $d_u = r_u$.

## A.3. Delivery Pricing under Co-opetition

The analysis is distinctly different under NSA co-opetition. In this case, as discussed in the text, in the first stage, the parties negotiate an agreement on the per unit delivery charge $d_u$ that maximizes the total equilibrium second stage duopoly profits. They are also able to negotiate a lump sum transfer $L$ that serves to divide up the gains from co-opetition.

In equilibrium, total industry profits are given by the sum of Postal Service profits and Firm $U$ profits: i.e.,

$$\text{(A10)}\quad \pi^I = \pi\left(p^e(d_u), p_u^e(d_u)\right) + (d_u - r)D^u\left(p^e(d_u), p_u^e(d_u)\right) + \pi^u(p^e(d_u), p_u^e(d_u), d_u).$$

From the total profit point of view, the payments to the Postal Service for delivering Firm $U$'s volumes cancel out, so that equation (A10) simplifies to

$$\text{(A11)}\quad \pi^I = \pi\left(p^e(d_u), p_u^e(d_u)\right) + (p_u^e(d_u) - t_u - r)D^u\left(p^e(d_u), p_u^e(d_u)\right).$$

Differentiating with respect to $d_u$ and substituting in equation (A3) yields:

$$\text{(A12)}\quad \frac{\partial \pi^I}{\partial d_u} = \frac{\partial \pi(p^e, p_u^e)}{\partial p_u^e}\frac{\partial p_u^e}{\partial d_u} + D^u(p^e, p_u^e)\frac{\partial p_u^e}{\partial d_u} + (p_u^e(d_u) - t_u - r)\left[\frac{\partial D^u}{\partial p_u}\frac{\partial p_u^e}{\partial d_u} + \frac{\partial D^u}{\partial p}\frac{\partial p^e}{\partial d_u}\right].$$

As in the TIOLI pricing case, the sign of the derivative of industry profits with respect to the negotiated delivery price is ambiguous. (All the terms are positive, except the first product in square brackets, which is negative.)

# Appendix B: Management's Comments

GARY C REBLIN
VICE PRESIDENT
NEW PRODUCTS & INNOVATION

UNITED STATES POSTAL SERVICE

October 22, 2015

RENEE SHEEHY
DIRECTOR, RARC CENTRAL, RISK ANALYSIS RESEARCH CENTER

SUBJECT: Final Draft Co-opetition in Parcel Delivery: An Exploratory Analysis

The United States Postal Service has reviewed and acknowledges the Co-opetition in Parcel Delivery: An Exploratory Analysis report. We will further consider and look into the opportunities.

This report and managements' response does not contain information that should be exempt from disclosure under the Freedom of Information Act.

Gary C. Reblin

475 L'ENFANT PLAZA SW
WASHINGTON DC 20260-5005

OFFICE OF
INSPECTOR
GENERAL
UNITED STATES POSTAL SERVICE

U.S. Postal Service Office of Inspector General
1735 N. Lynn Street
Arlington, VA 22209

Telephone: 703-248-2100
www.uspsoig.gov

For media inquiries, contact Agapi Doulaveris
Telephone: 703-248-2286
adoulaveris@uspsoig.gov