OFFICE OF INSPECTOR GENERAL
UNITED STATES POSTAL SERVICE

A Framework for Delivery Network Optimization

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Executive Summary

The U.S. Postal Service's delivery network is unparalleled. Consisting of 252,000 carrier routes originating from more than 23,000 delivery facilities, it is the foundation of a universal service infrastructure that spans the vast geography and demography of the United States and reaches every household and business, six days a week. This first and last mile coverage is a core competency. It constitutes a clear comparative advantage for the Postal Service that needs to be maintained and strengthened.

The Postal Service's delivery and retail networks have been coupled organizationally and physically since delivery services were first established almost 150 years ago. Most delivery units house retail service as well as space for carriers to receive mail from the mail processing plant and case it into route sequence. Last year, the U.S. Postal Service Office of Inspector General (OIG) found shared management for retail and delivery no longer made sense. We advocated the strategic decoupling of retail from delivery to allow management to define roles more clearly, measure results more precisely, and design operations more effectively.[1] Delivery operations require low-cost facility space that has easy access to carrier routes, but retail needs convenient customer locations to maximize net revenue.

The OIG has previously presented a strategy for a future mail processing network and a framework for optimizing the retail network.[2] The retail analysis focused on the unique characteristics of retail and did not include the complications from delivery co-location. This paper attempts a similar focus on delivery. Concentrating on each network separately is practical for initial modeling efforts.

The facility needs of the Postal Service's delivery network have changed. As letter and flat mail volumes have declined and more mail is sorted in the same sequence as carriers travel, carriers spend less time in the office casing mail and more time delivering mail on the streets. As a result, the Postal Service has been able to consolidate carrier routes, reducing the need for carrier space in facilities.[3] The average amount of floor space per carrier route in the present network is 366 square feet per carrier route. This exceeds the Postal Service efficiency standard of either 130 or 180

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[1] U.S. Postal Service Office of Inspector General, *Retail and Delivery: Decoupling Could Improve Service and Lower Costs,* Report No. RARC-WP-11-009, September 22, 2011, http://www.uspsoig.gov/foia_files/RARC-WP-11-009.pdf. This report judges that decoupling would have the greatest practical benefit in the urban and suburban areas.

[2] U.S. Postal Service Office of Inspector General, *A Strategy for a Future Mail Processing & Transportation Network*, Report No. RARC-WP-11-006, http://www.uspsoig.gov/foia_files/RARC-WP-11-006.pdf and *Analyzing the Postal Service's Retail Network Using an Objective Modeling Approach* RARC-WP-10-004, June 14, 2010, http://www.uspsoig.gov/foia_files/RARC-WP-10-004.pdf.

[3] In addition, in some cases, there could be excess space due to space planning that was based on past projections of increasing mail volumes. Alternatively, some excess space could also just be a carryover from a time with higher demand or different demographics.

square feet per carrier and represents a significant opportunity for resource savings through a concerted consolidation effort.[4]

This paper presents analysis that focuses on optimizing the use of space in the delivery network by exploring consolidation opportunities within the existing footprint. The analytical model starts with existing delivery units and considers how to make changes that enhance the delivery network's efficiency while meeting the demand for delivery and operational needs. Delivery units must be large enough to accommodate the space needed for in-office work and close enough to carrier routes to minimize total costs. This approach balances the inherent tradeoff of facility and labor costs against carrier travel costs. Because most delivery units also offer retail services, the model assumes that retail services in closed delivery units can transition to other existing retail units.

The results of our analysis show that a much smaller network of 13,917 delivery units — 9,835 fewer than at present — is sufficient to meet existing delivery needs. This new optimized network would reduce Postal Service costs by $1.0 billion per year.[5] A delivery network with fewer units holding more carrier routes would promote drop shipping for mailers by making it easier to achieve minimum volume requirements. These mailer benefits could potentially increase mail volume and improve the sustainability of mail.

The Postal Service could greatly benefit from modeling techniques as it considers strategies for rationalizing the delivery network. Of course, as with all models, the results depend on the inputs and assumptions used. We present two scenarios, but the model presented here could be adapted to allow Postal Service management to evaluate additional alternatives. As the Postal Service reviews its core competency of first and last mile delivery, an operations research modeling framework would help guide decision makers in assessing design alternatives for different future scenarios.

[4] Postal Service engineering standards dictate that the first 25 carrier routes each require 180 square feet while subsequent carrier routes require 130 square feet. The scenarios we consider conservatively require the full 180 square feet for all routes; even so, the space needs of the Postal Service might be different in a world with significantly expanded parcel demand.

[5] This analysis assumes retail units in closed delivery facilities are also closed. The Postal Service could instead choose to keep retail within these facilities or relocate these retail units to maintain service. These options would reduce the cost savings. The model can be adjusted to accommodate these scenarios or any other scenarios the Postal Service chooses.

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A Framework for Delivery Network Optimization

Introduction

The Postal Service faces the challenge of a rapidly changing environment for mail service. The changes have highlighted the need to rationalize the Postal Service's operational networks, including the delivery network. In addition, they have prompted a fundamental reexamination of the services the Postal Service's offers and how they are provided.

Delivery operations have been coupled organizationally and physically with retail since delivery services were first established almost 150 years ago. The location of these facilities, housing both delivery and retail, was primarily determined based on historical patterns or the need for delivery service efficiencies — with retail performance typically being a secondary consideration. The U.S. Postal Service Office of Inspector General (OIG) has advocated the strategic decoupling of retail from delivery, which allows management to define roles more clearly, measure results more precisely, and design operations to be more effective.[6] While delivery operations require low-cost facility space that is easily accessible to carrier routes, retail needs convenient customer locations to maximize net revenue.

As the time carriers spend in the office sorting mail has declined and the amount of time spent delivering mail has increased, the number of carrier routes has declined. The decline in carrier time is a result of both the advancement of automated mail processing technologies and mail volume declines in letters and flats. Fewer carrier routes mean less need for carrier space in facilities. In addition, in some cases, there could be excess space due to space planning that was based on past projections of increasing mail volumes. Alternatively, some excess space could also just be a carryover from a time with higher demand or different demographics.

Delivery unit optimization is motivated by a rapidly changing environment for mail service and a decline in delivery space needs.

This paper seeks to model an efficient way to optimize that excess space. As the Postal Service seeks to address the need for delivery unit optimization, several key questions arise: How can it restructure its delivery network to meet service requirements at a minimal cost? How can it determine which facilities should be closed, which should remain open, and if new space should be acquired? How should carrier routes be assigned to facilities?

[6] U.S. Postal Service Office of Inspector General, *Retail and Delivery: Decoupling Could Improve Service and Lower Costs,* Report No. RARC-WP-11-009, September 22, 2011, http://www.uspsoig.gov/foia_files/RARC-WP-11-009.pdf.

As a practical matter, it is important to consider these questions by starting with the current network, an approach this framework follows. The focus of this work is to explore the issues associated with modeling the dynamics of delivery operations. Because the retail and delivery networks are currently coupled, determining how to treat the retail portion of the network was challenging. In this analysis, retail functions are left unchanged at facilities that are not closed. For facilities that are closed, we assume that the retail functions and their related costs will transition to other existing postal retail units. Although previous OIG research has shown that changing facility locations can have implications for retail revenue, no attempt was made to include these effects.[7] Similarly, the analysis presented here does not include any costs from moving retail services to new locations. If the Postal Service decided to keep the existing retail units either in their current buildings or move them to new locations, the modeling framework could be adjusted to accommodate these decisions.

Current Postal Service Delivery Network Optimization Efforts

The Postal Service has already undertaken some delivery optimization efforts. Postal Service Delivery Unit Optimization (DUO) guidelines inform management of the operational efficiencies available from relocating delivery operations.[8] The main source of cost savings is from consolidating clerk labor and reducing postmaster supervisory levels. The postmaster level computations are complex and based on a number of factors, including the number of carriers.[9] Implementation is further complicated by questions of whether or for how long postmasters retain pay level.

Over the past few years, the Postal Service has added a mapping module that helps delivery specialists perform DUO studies. The module allocates ZIP Codes of routes to facilities within a limited local area. The module computes travel distances between carrier routes and delivery units and factors in facility and labor costs. In addition to analyzing local scenarios, the module suggests alternatives for consideration. Using the DUO guidelines and mapping module, a delivery specialist identifies changes to delivery operations in a local area.

Benefits of a Global Optimization Model

DUO is a useful first step that optimizes a local delivery area; however, a strategic framework and global optimization model that considers all alternatives would enhance these efforts. Computer-aided optimization tools can help to provide optimal, or at least near-optimal, solutions for complex systems. The modeling framework in this paper shows how integer programming location optimization

A strategic framework and global optimization model would enhance the Postal Service's Delivery Unit Optimization efforts.

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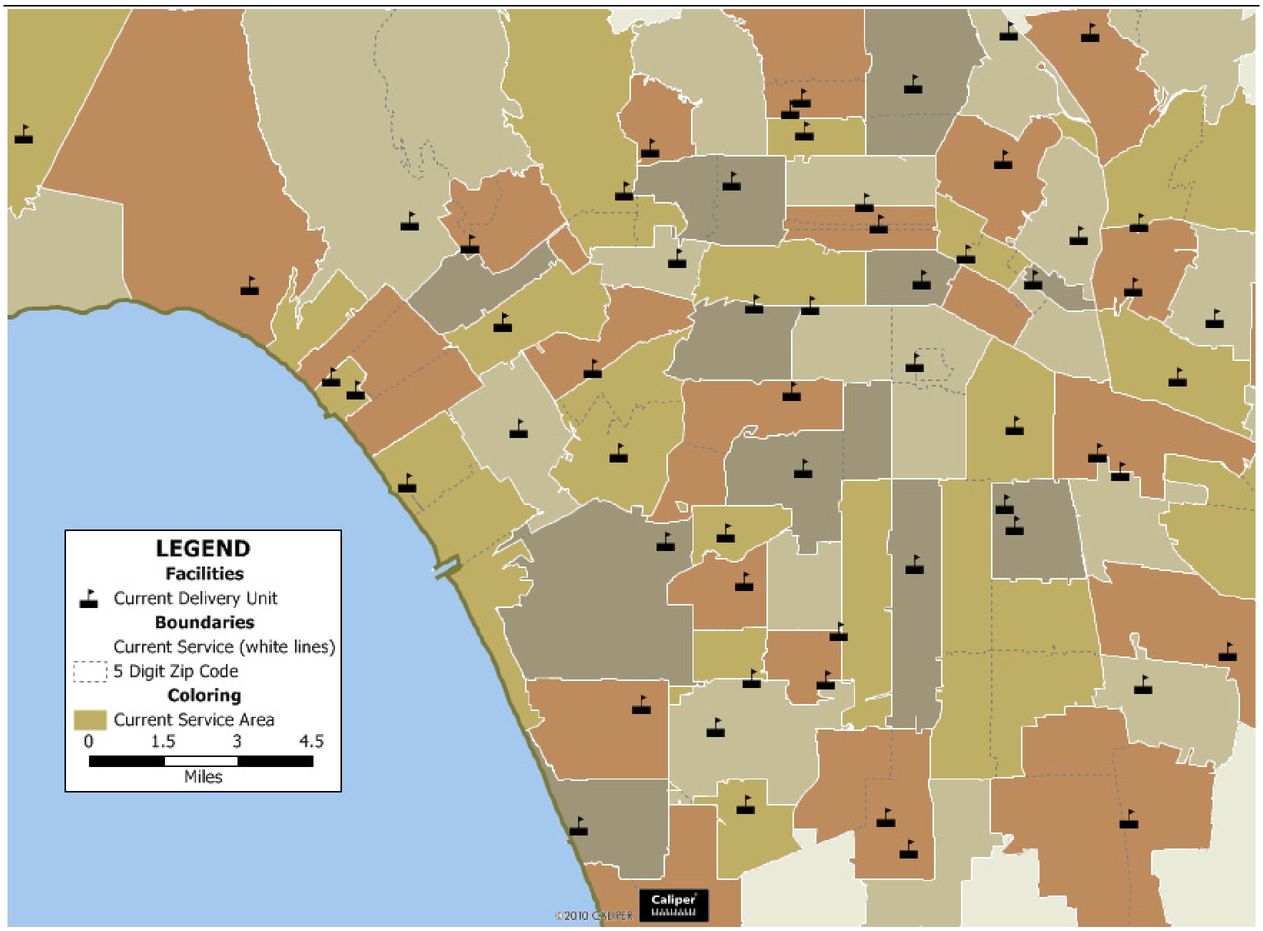
[7] U.S. Postal Service Office of Inspector General, *Analyzing the Postal Service's Retail Network Using an Objective Modeling Approach* RARC-WP-10-004, June 14, 2010, http://www.uspsoig.gov/foia_files/RARC-WP-10-004.pdf.
[8] U.S. Postal Service, *Delivery Unit Optimization Guidelines*, Version 1.1, December 2010.
[9] U.S. Postal Service, PS Form 150: Postmaster Workload Information. The PS Form 150 Auto Worksheet is an Excel macro-based spreadsheet that collects data from several postal data sources to compute Post Office level.

models can be applied to the delivery network. Such models enable management to consider different scenarios and test solution robustness for different forecasts of economic and demographic variables. Model results are based on actual, detailed facility data to minimize facility and labor costs. Making modeling tools like this available to analysts can be of significant assistance to the Postal Service in rationalizing the delivery network.

Current Delivery Network

Delivery units provide the facility space and support for carriers to collect and prepare mail before they leave to deliver their route. The basic duties performed at these units include receiving mail from the processing plant, distributing mail to carrier routes, providing a place for carriers to sort mail, and offering space for loading and securing carrier vehicles. In 2011, there were a total of 23,752 delivery units. As an example, Figure 1 shows the delivery units and service areas of the Los Angeles district.

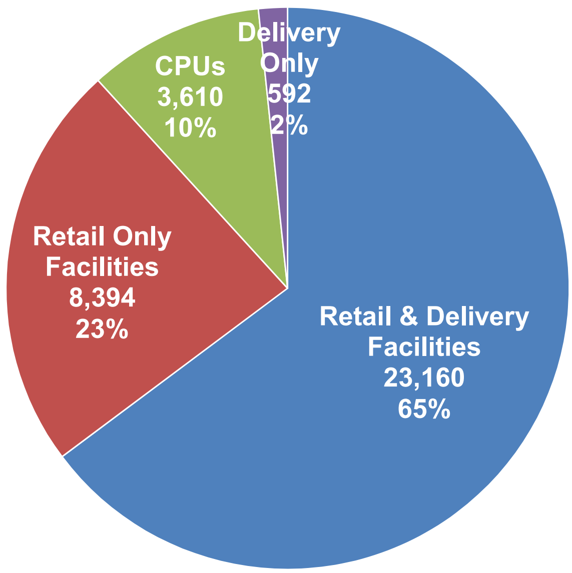
Figure 1: Current Delivery Units and Service Areas for Los Angeles District



Source: U.S. Postal Service Address Information System Data

As mentioned, delivery operations have been coupled traditionally with retail. Figure 2 presents the number of retail and delivery facilities and contract postal units. Nationally, the vast majority of delivery units also provide retail service. Only 592 of these units are carrier annexes that only provide delivery support. The Postal Service offers retail service through 8,394 other retail-only postal facilities and 3,610 Contract Postal Units (CPUs). This framework for delivery network optimization focuses on the 23,752 facilities containing delivery operations, which comprise approximately 67 percent of the 35,756 delivery and retail locations.

Figure 2: Retail and Delivery Facilities and Contract Postal Units



Source: U.S. Postal Service, Fiscal Year (FY) 2011 Annual Report and Address Information System

In 2011, there were a total of 252,006 carrier routes within the United States.[10] Over half of carriers are within 2 miles of their delivery unit and more than 75 percent are within 4 miles of their delivery unit. The average carrier distance to and from their route is 2.8 miles with an average drive time of 4.2 minutes. The total annual cost of carrier travel to and from their routes is $1.26 billion.[11]

Currently, there is 366 square feet of space available per carrier. Operational needs require only 180 square feet.

The total facility space of units that serve carriers is 194.2 million square feet, which corresponds to a total cost of $1.91 billion for rent, maintenance, and utilities, including estimated rental values to represent the opportunity cost of owned buildings.[12] On average, delivery functions occupy 366 square feet per carrier route with an average

[10] U.S. Postal Service, Address Information System (AIS).
[11] See Appendix C for detailed results of OIG's analysis.
[12] U.S. Postal Service, Facility Management System (FMS), and OIG analysis.

cost of $9.78 per square foot. As a carrier route only requires 130 to 180 square feet, this indicates a significant opportunity for consolidation.[13]

Eighty percent of facilities only serve a single ZIP Code and 60 percent of delivery facilities are very small with at most five carrier routes. Only 5 percent of carriers work in very large facilities with over 80 carrier routes.

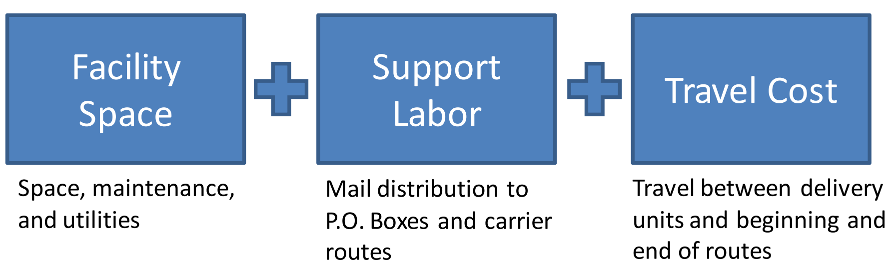
Delivery Model Description

The goal of the model is to obtain a minimum cost delivery network while meeting existing delivery service, consolidating delivery units through facility keep-or-close decisions, and assigning ZIP Codes of carrier routes to facilities.[14] We use a standard modeling approach for location optimization that uses actual location and cost data while ensuring that solutions meet existing operational requirements.[15]

Figure 3 presents the basic cost components that the model minimizes in total: facility space, delivery support labor, and carrier travel. The model balances the cost trade-offs between the number of delivery facilities and carrier travel to and from routes. That is, the model seeks lower-cost facility space that is more conveniently located to carrier routes. Facilities also have a certain amount of fixed labor, which we associate with a minimum number of delivery support labor hours at a facility. Eliminating this fixed labor cost along with facility space costs motivates facility consolidation.

Delivery network optimization minimizes facility space, support labor, and carrier travel costs while meeting delivery service.

Figure 3: Delivery Model Cost Components



[13] U.S. Postal Service, Handbook AS-504, *Space Requirements*, July 1999, Chapter 5, "Delivery Unit Workroom Floor Planning: City, Rural, and Highway Contract Route Delivery," p. 201.
[14] We should also note that the basic unit of delivery assignment is the 5-digit ZIP Code. For logistical reasons, it is difficult to split up ZIP Code service between different delivery units so the model assigns each 5-digit ZIP Code to one and only one delivery unit.
[15] The focus of the model is to explore the data and methodology for optimizing the delivery network. In practice, the retail function will play an important role in rationalizing the delivery network, as the two functions are highly coupled. However, the purpose of this paper is to develop an understanding of the system dynamics of the delivery network.

A more detailed description of the costs components follows:

- ***Facility Space Cost:*** These costs are for facility space, maintenance, and utilities. We base these costs on the 2011 accounting ledger for rent, maintenance, and utilities.[16] For owned facilities, we use estimated rental values to reflect the opportunity cost of the facility.[17]

- ***Support Labor Costs:*** Clerks and small office postmasters at facilities with both delivery and retail offices have two duties: to perform the front-end functions of retail window transactions and the back-end delivery functions of distributing mail to Post Office boxes and to carrier routes. We examine the relationship between these responsibilities and workhours with the following regression equation:[18]

  Labor Hours = 1996.2 + 0.0566 * Transactions + 287.1 * (Carrier Routes Over 5)

  The fixed labor hours of the intercept of 1996.2 represent the minimum service hours of the facility. Up to five carrier routes of support delivery hours are covered by this fixed time; however, the support labor hours increase by 287.1 hours for each additional carrier route. These fixed labor hours and the variable labor hours comprise the delivery support labor hours at the facility. We then use the average clerk salary rate to compute clerk labor costs.[19] Postmasters can also provide some of these functions, particularly at small Post Offices, but since postmasters have higher average salaries than clerks, these cost estimates are conservative. The regression estimates that each thousand retail transactions add 56.6 labor hours to the facility total. For this framework, the transactions of closed offices are transferred to a nearby office thus the total network transactional costs do not change. As mentioned above, for simplicity the model does not attempt to consider the effects of demand changes from moving retail units to new locations.

  About 2,000 hours, the equivalent of a single clerk, is required to support up to five carrier routes.

- ***Travel Cost:*** This cost is for carrier travel between delivery units and carrier routes using real road network routes. We use route mapping software to

[16] U.S. Postal Service, FY 2011 General Ledger costs by Finance number from the Accounting Data Mart, Electronic Data Warehouse (EDW).
[17] The estimated rent computations are by Anthony Yezer, Professor of Economics, The George Washington University. He provided them in support of testimony on Post Office Box pricing for the 2006 rate case. The analysis imputes rental values for Postal Service-owned properties, based on database of Post Office rental properties by 5-digit ZIP Code. The interior square feet data are provided by FMS. U.S. Postal Service, USPS-LR-L-125 – Supporting Materials for Post Office Box and Caller Service, Postal Rate Commission Docket No. R2006-1, May 3, 2006, http://www.prc.gov/prc-pages/library/detail.aspx?docketId=R2006-1&docketPart=Documents&docid=48606.
[18] AIS data provides information on all delivery routes and their associated facilities. Customer Service Variance (CSV) provides labor and retail data for large delivery units and Small Office Variance (SOV) provides labor and retail data for small offices.
[19] U.S. Postal Service, USPS-FY11-7 – Cost Segment 3 Cost Pools & Other Related Information (Public Portion), Postal Regulatory Commission, Docket No. ACR2011, December 29, 2011, http://www.prc.gov/prc-pages/library/detail.aspx?docketId=ACR2011&docketPart=Documents&docid=79103, USPS-FY11-7 part8.xls, tab FY11 Productive Hourly Rates, Clerks A-J.

compute travel times and driving distances from the delivery unit to the first stop of the carrier route and then from the last stop of the route back to the delivery unit.[20] Using a national hourly carrier labor rate[21] and established vehicle rates we compute the total travel costs for this assignment.[22] The model does not seek to change delivery routes, although additional time may translate into route restructuring and additional carriers.

The model considers all solutions that meet certain operational criteria set by the Postal Service. Specifically, for each carrier route, the model allocates 180 square feet of work space at a facility that is no more than 15 miles away.[23] The model uses Postal Service engineering standards to determine the amount of space at facilities that is dedicated to delivery functions.[24] Limiting the distance of carrier travel has the additional implicit advantage of limiting the impact of consolidations on retail service.

Figures 4 and 5 provide a simple illustration of the modeling results given a hypothetical baseline network of four delivery units and six 5-digit ZIP Codes. This baseline network has total facility, support labor, and travel costs of $700. The framework considers all of the possible assignments of ZIP Codes to the surrounding delivery units and determines a least-cost optimal solution. The optimized network results in two out of four facilities. It reassigned three 5-digit ZIP Codes and consolidated two delivery units for a total cost of $585. Certain delivery unit or transportation costs may be higher, but the consolidation of delivery units maintains delivery service and reduces total costs by $115.

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[20] Facility information is provided by FMS. Carrier route information including carrier route type and first and last stop locations are provided by the AIS. We use the PC Miler Batch Pro software to find the drive time and distance of street routes to and from the first and last stops of the delivery route and the facility.

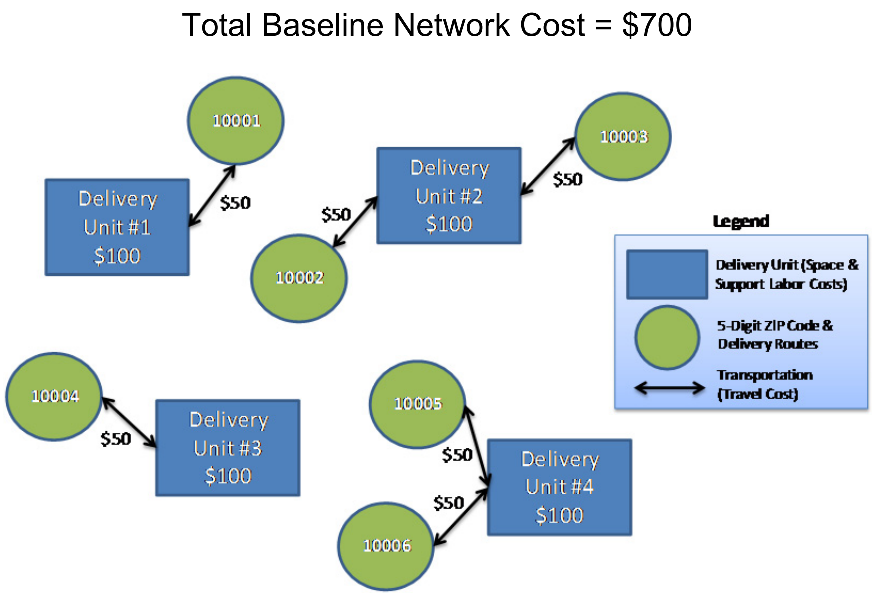
[21] The Postal Service's FY 2011 Annual Compliance Report provides carrier rates per hour. U.S. Postal Service, FY 2011 Annual Compliance Report (ACR), http://www.prc.gov/Docs/79/79166/FY.2011.ACR.pdf.

[22] U.S. Postal Service, Cost Evaluation PS-5505, FY 2011, provides vehicle and tort mileage costs and ownership hourly costs.

[23] Postal Service facility space guidelines specify that the first 25 routes each require 180 square feet of space and each additional route requires an additional 130 square feet of space. U.S. Postal Service, Handbook AS-504, *Space Requirements*, July 1999, Chapter 5, "Delivery Unit Workroom Floor Planning: City, Rural, and Highway Contract Route Delivery, p. 201. For our model, if the current work space is less than 180 square feet or at a facility that is more than 15 miles away, we continue to allow this assignment.

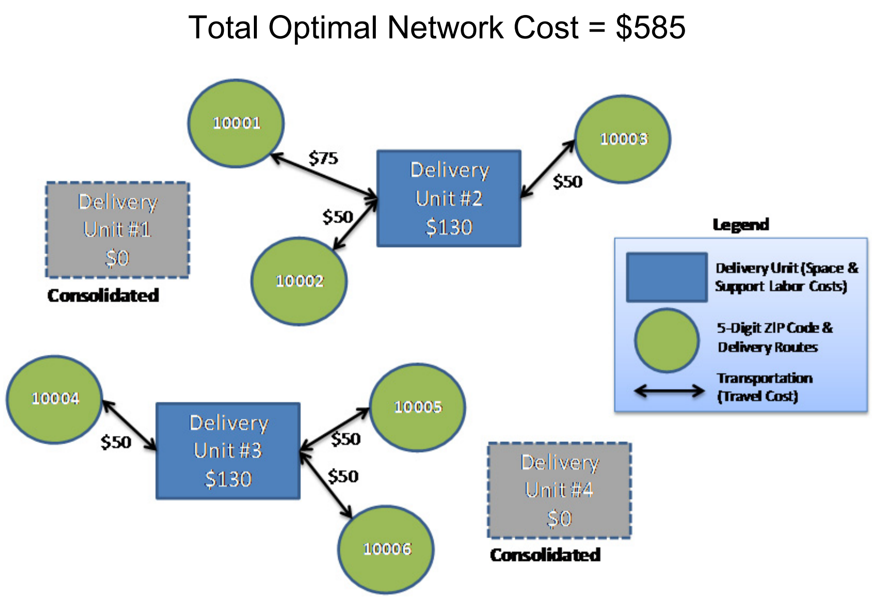
[24] U.S. Postal Service, Handbook AS-504, *Space Requirements,* outlines the recommended building size for various carrier routes allocations. The proportions directly due to the 180 square feet per carrier of the total building size recommendation are averaged to provide the model with guidance as to how much building space is occupied with carrier assignment. Only this average proportion is made available for carrier route model space assignment.

Figure 4: Illustration of Modeling Framework – Baseline Network



Note: This figure is a conceptual illustration of model assignment and not illustrative of actual costs.

Figure 5: Illustration of Modeling Framework – Optimal Network



Note: This figure is a conceptual illustration of model assignment and not illustrative of actual costs.

Delivery Model Results

The delivery framework and model results show a significant opportunity to consolidate the Postal Service's existing national delivery network. Table 1 shows that, in an optimized network, delivery units decrease from 23,752 to 13,917 and total costs decrease by $1.0 billion per year.

Table 1: Delivery Model Results

	Baseline	Optimal	Change
Delivery Units	23,752	13,917	(9,835)
Carrier Routes	252,006	252,006	
Total Cost (millions)	$ 11,185	$ 10,175	$ (1,010)

Source: OIG Analysis

Table 2 presents detailed results.[25] The average space per carrier route decreases by 34 percent (366 to 241 square feet). The greatest opportunities for facility consolidation are with the highest-density ZIP Codes where the space per route is high and other units are nearby; the model consolidates this space by 57 percent (493 to 212 square feet). Conversely, the lowest-density ZIP Codes have the least, although still significant, opportunity for consolidation as the model consolidates only 20 percent of this space (327 to 262 square feet). The model tends to keep facilities with lower costs per square foot. The average cost per square foot of delivery facility space decreases by 11 percent ($9.78 to $8.67 per square foot).

Table 2: Delivery Model Detailed Results

	Baseline	Optimal	Change
Total Facility Space (million sq. ft.)	195.6	126.4	(69.2)
Space per Route (sq. ft.)	366	241	(125)
Average Space Cost	$ 9.78	$ 8.67	$ (1.11)
Average Carrier Travel (miles)	2.8	3.7	0.9
<u>Annual Costs (millions)</u>			
Space Cost	$ 1,913	$ 1,096	$ (817)
Carrier Travel Cost	$ 1,263	$ 1,637	$ 374
Support Labor Cost	$ 3,982	$ 3,416	$ (566)
Retail Labor Cost	$ 4,027	$ 4,027	
<u>Labor Hours (millions)</u>			
Carrier Travel Hours	10.7	13.7	3.0
Support Labor Hours	95.9	82.3	(13.6)
Retail Labor Hours	97.0	97.0	

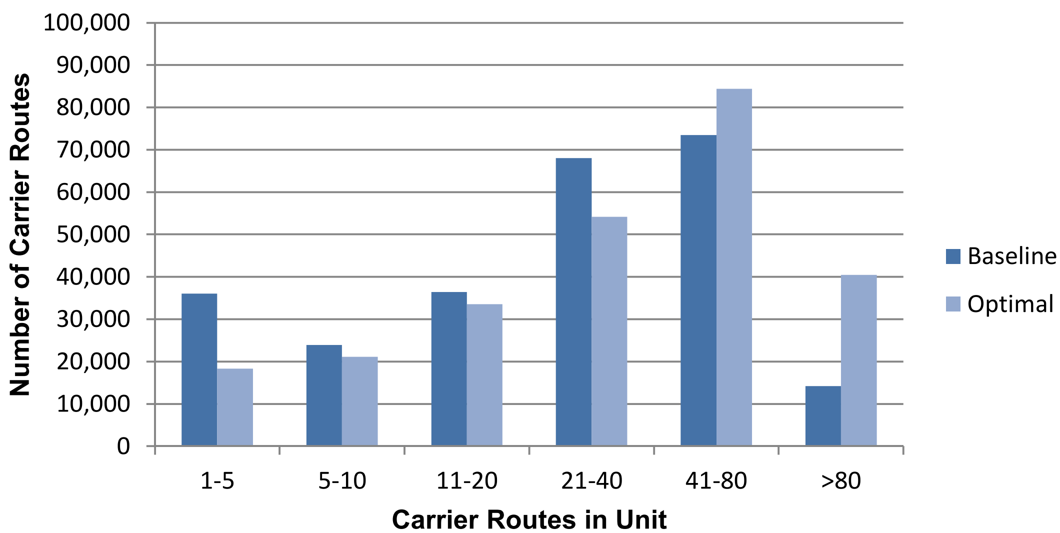
Source: OIG Analysis

[25] See Appendix C for additional detailed analysis and results.

These consolidations reduce facility space costs by $817 million and support labor costs by $566 million, but they also come with additional carrier travel costs of $374 million to obtain the net cost reduction of $1 billion. The model predicts a significant potential savings of 13.6 million delivery support labor hours. These are associated primarily with the consolidation of labor hours of small office postmasters and clerks at the smaller delivery units.

As expected, the consolidation of the delivery network increases the number of carrier routes at units. Figure 6 shows the number of carrier routes that are in different-sized delivery units based on the numbers of routes at the unit. It illustrates significant consolidation as there are notably fewer routes at smaller units with at most 10 routes and significantly more routes at facilities with more than 80 routes.

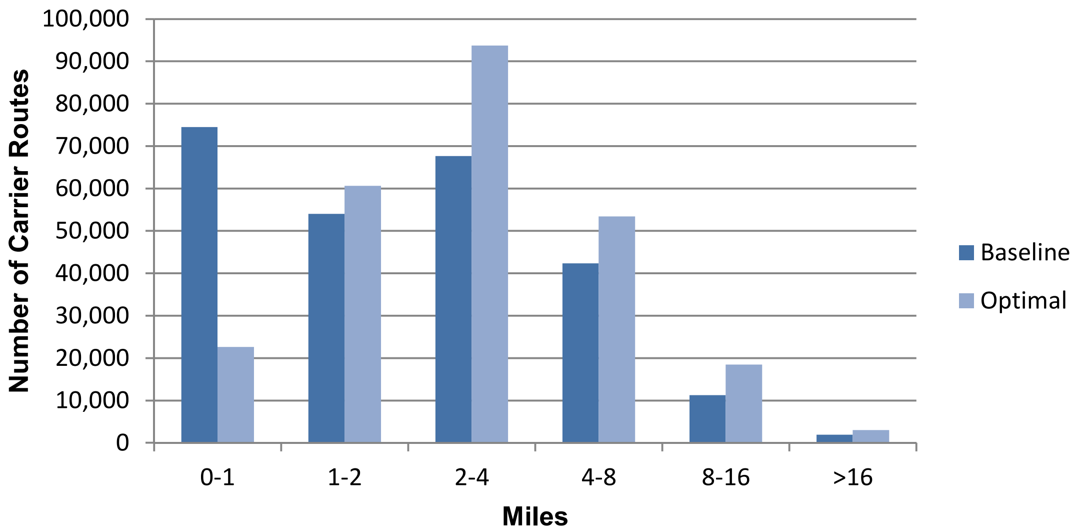
Figure 6: Number of Carrier Routes in Units with Number of Routes



Source: OIG Analysis

These facility consolidations require additional carrier travel time of 3.0 million hours to get to and from routes, increasing average carrier travel from 2.8 miles to 3.7 miles. These average travel distances are impacted the most for the lowest-density ZIP Codes, increasing from 3.4 miles to 5.8 miles. The very high-density ZIP Codes average carrier travel increases from 1.7 miles to 2.3 miles. Figure 7 shows the share of carrier route travel distances. The figure shows a significant decrease in the number of routes less than a mile from the delivery units and many more routes that are more than 2 miles from the facility.

Figure 7: Carrier Routes by Travel Distance

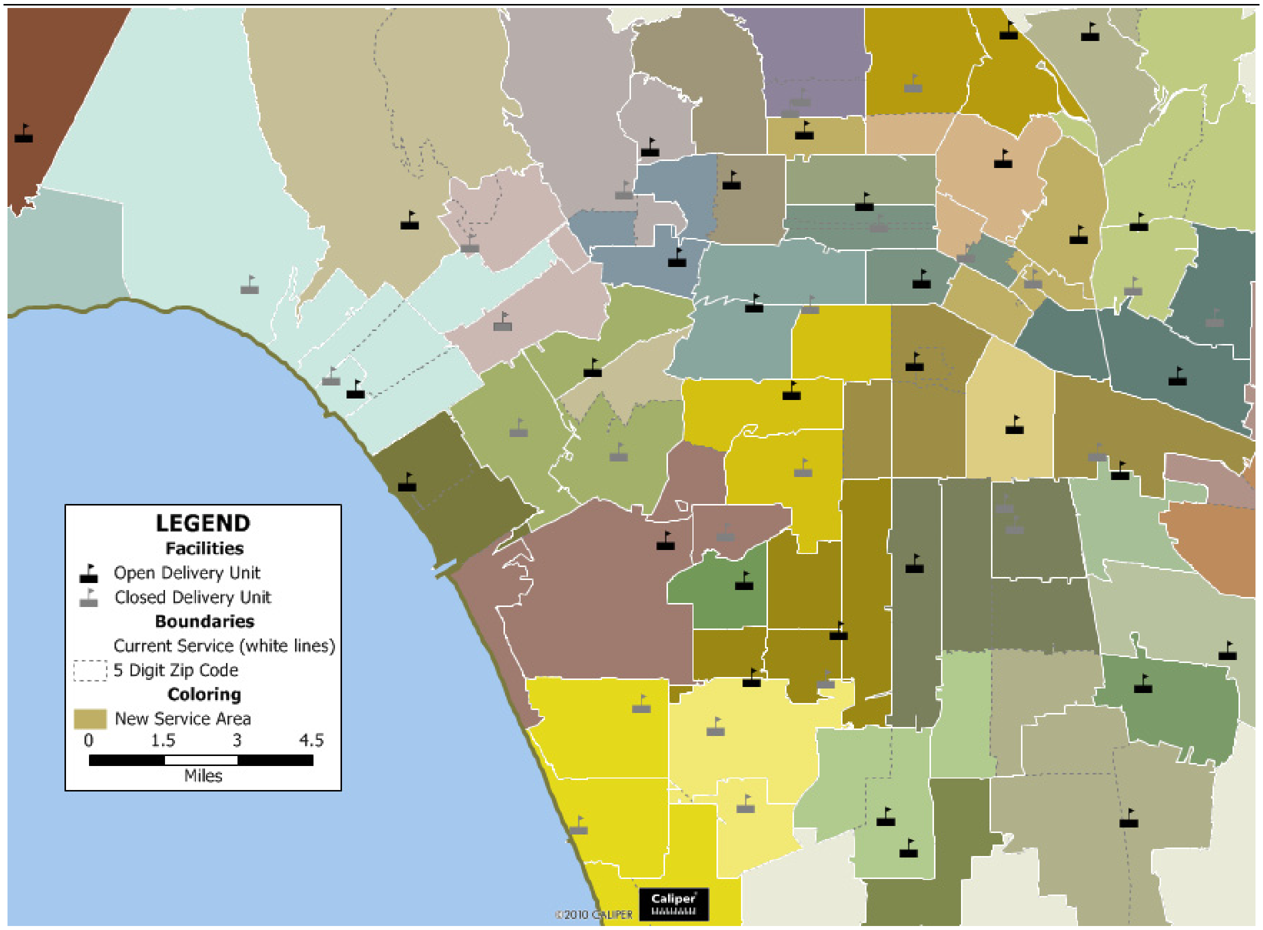


Source: OIG Analysis

Figure 8 illustrates the significant degree to which the model consolidates delivery units in the Los Angeles district. Of the current 69 Los Angeles delivery units, 40 provide the capacity to meet service while lowering costs. Each new service area is differentiated with color. The white boundary lines represent the current service areas of delivery units while the gray dotted lines show the remaining ZIP Code boundaries. The black symbols (58 percent) represent the buildings that are kept while the gray symbols (42 percent) represent closed facilities.

In the Los Angeles district the current 69 delivery units are consolidated in 40 units, resulting in 29 that would close.

Figure 8: Optimal Service Areas for Los Angeles District



Source: OIG Delivery Model Results

In addition to making consolidation of delivery units possible, decoupling them from retail enables the Postal Service to focus on the unique needs of delivery operations allowing management, to define delivery roles more clearly, measure results more precisely, and design operations to be more effective.

Delivery unit consolidation may increase drop-ship mail and improve the sustainability of that mail.

Furthermore, there are mailer benefits for increased consolidation of delivery units. It may reduce transportation costs for drop-shipping mailers and it may permit drop shipment of mailings that were previously prohibited from volume discounts due to minimum density requirements due to increased carrier routes in the new optimized network. This can lower the prices for that mail, increase mail volume, and improve the sustainability of mail.

As an additional scenario we consider the lower-bound solution in which no delivery units may be closed. This is the effect of minimizing travel costs without closing any facilities. For this case, the annual savings from delivery network optimization is a mere

$53 million. This savings is the result of lowering costs by better assigning carrier routes to delivery units. As there are barriers to retail optimization, different options could be considered that would preserve these retail services.[26] For example, when the Postal Service closes a delivery unit, it could leave the retail unit open in its existing location while renting out the carrier space that is no longer needed. Alternatively, the Postal Service could relocate the retail unit intact to a new location nearby or contract for services. Furthermore, this modeling framework could be used to evaluate options that use excess mail processing plant space or other low cost space. As the Postal Service considers the needs for the future delivery network, this model could help to plan for such scenarios or for any other alternatives they would like to consider.

As with all cost models, the results are sensitive to the input data and modeling assumptions. By making these models available to managers and decision makers, different scenarios may be considered and the robustness of the results may be evaluated for different economic, regulatory, or labor factors.

The mathematical formulation of the model is presented in Appendix B and the results are summarized in Appendix C.

Conclusion

This paper presents a modeling framework for optimizing the delivery network. Using available Postal Service data and the delivery model, we calculated delivery space and cost reductions. Allowing retail services of closed offices to move to other postal retail locations can decrease delivery units from 23,752 to 13,917 and reduce labor and facility annual costs by $1.0 billion. This solution estimates a savings in 13.6 million delivery support hours and the need for an additional 3.0 million carrier travel hours. Note that although the model predicts support labor savings from changes to the network, it says nothing about how the Postal Service might choose to capture those savings, including reliance upon attrition or even repurposing existing labor.

A framework for delivery network optimization is necessary to inform management of efficient and effective operations and ensure objectivity and transparency to key stakeholders. Further, it enhances the ongoing DUO efforts by the Postal Service and lays a foundation for future modernization efforts.

[26] U.S. Postal Service Office of Inspector General, *Barriers to Retail Network Optimization,* Report No. RARC-WP-11-005, June 9, 2011, http://www.uspsoig.gov/foia_files/RARC-WP-11-005.pdf.

Appendices

Appendix A Workload to Workhour Relationship

The delivery function requires support labor to facilitate the management of carriers and distribute mail between the routes. For model planning we want to know how much of this support labor is required at a facility to support a number of routes. In addition to these back office delivery functions, clerks and small office postmaster labor also perform front-end retail transactions. We regress actual workhours on the number of retail transactions and the number of routes to establish a relationship between workload and workhours.

An interesting observation we found is that clerk and postmaster hours at small delivery units with at most five carrier routes appear to be driven by minimum service hours rather than by workload. For these small delivery units of one to five routes, actual labor hours are relatively constant at about 1996.2 labor hours per year, roughly the number of hours of a full-time equivalent staff. We set this as the intercept of the regression, fitting the regression line to the relevant range of facilities with at least five routes.

The labor regression (and the regression coefficient t-values) are as follows:

WH_j = actual workhours at facility j

T_j = number of retail transactions at facility j

n_j = number of carrier routes over five at facility j

$$WH_j = 1996.2 + 0.0566 * T_j + 287.1 * n_j$$

$$(87.15) \qquad (86.76)$$

We tested scale and cross terms, but employing higher order terms does not cause a significant departure from the linear model results.

Appendix B Model Formulation and Scenarios

Facility Location Problem

The delivery network model we formulate here is a variation of the classical facility location integer programming problem. The objective of this model is to obtain a least cost delivery network by assigning 5-digit ZIP Codes to delivery facilities, deciding which delivery units to keep and which to close. The basic cost components involve facility costs, labor costs, and carrier travel costs to and from routes. After presenting the general model formulation, we discuss how we model the cost data for the Delivery Model in addition to two additional cases that test model robustness. We briefly describe the solution methodology.

Data

$Z =$ set of 5-digit ZIP Codes, $i \in Z$

$F =$ set of facility sites, $j \in F$

$r_i =$ number of carrier routes in 5-digit ZIP Code i

$C_j =$ carrier route capacity at facility j

$t_{ij} =$ carrier travel costs if carrier routes in ZIP Code i are assigned facility j

$u_{ij} = \begin{cases} 1 & \text{if 5-digit ZIP Code } i \text{ may be assigned to facility } j \\ 0 & \text{otherwise} \end{cases}$ [27]

$f_j =$ fixed charge for facility j

$v_j =$ variable costs for more than 5 carrier routes at facility j

Decision Variables

$y_j = \begin{cases} 1 & \text{if keep facility } j \\ 0 & \text{otherwise} \end{cases}$

$x_{ij} = \begin{cases} 1 & \text{if 5-digit ZIP Code } i \text{ is assigned to facility } j \\ 0 & \text{otherwise} \end{cases}$

[27] To limit the problem size, the set of permissible ZIP-to-facility assignments is limited. We set this data to one if the ZIP Code-to-facility assignment is permissible and zero otherwise. An assignment is permissible if (1) the average of the crow's flight distances between the facility and the carrier route first and last stops in the ZIP Code is less than 15 miles, (2) the facility is one of the three closest to the ZIP Code or (3) the ZIP Code is currently assigned to the facility.

m_j = number of routes, at most 5, served by fixed labor at facility j

n_j = number of routes above 5 at facility j

$m_j + n_j$ = number of routes at facility j

Optimization Model

Minimize $\sum_{j \in F} f_j\, y_j + \sum_{j \in F} v_j\, n_j + \sum_{\substack{i \in Z \\ j \in F}} t_{ij}\, x_{ij}$

Subject to

assignment definition	$\sum_{j \in F} x_{ij} = 1$	for all $i \in Z$
link	$x_{ij} \le y_j$	for all $i \in Z, j \in F$
capacity	$\sum_{i \in Z} r_i\, x_{ij} \le C_j\, y_j$	for all $j \in F$
definition of $m_j + n_j$	$m_j + n_j = \sum_{i \in Z} r_i\, x_{ij}$	for all $j \in F$
definition of m_j	$0 \le m_j \le 5$	for all $j \in F$
definition of n_j	$n_j \ge 0$	for all $j \in F$
assignment pruning	$x_{ij} \le u_{ij}$	for all $i \in Z, j \in F$
binary constraints	$x_{ij} \in \{0,1\}$	for all $i \in Z, j \in F$
	$y_j \in \{0,1\}$	for all $j \in F$

Computing Data Elements

Most of the data elements are straightforward computations that do not change for different modeling scenarios. We describe these computations for facility capacity, the cost of carrier travel for a ZIP Code assignment, and the cost of support delivery labor per route. The only data element that we change for robustness analysis is f_j, the fixed facility cost component.

For each current existing delivery unit, most have space dedicated to operational needs outside of delivery such as retail, Post Office Box, or administrative space. However, for the purposes of our model, only the space available to delivery operations should accommodate the carrier assignments. According to Postal Service engineering requirements, there are recommended gross building sizes per average employees and customers. The percentage of a building occupied by delivery can be estimated by calculating the space allocated for the carrier per the 180 square foot per carrier requirement in each recommendation. This space for delivery can be compared to overall recommended space for the co-located operations. From this method, it was determined the delivery space takes up 46 percent of the gross building space. This was used to calculate the space the model could assign for delivery operations. Exterior building requirements such as parking are not considered in the model.

Facility Capacity[28]

$SF_j = 46\% *$ gross building size for facility j

$$C_j = SF_j \ / \ 180 \text{ square feet}$$

Carrier Travel Assignment Costs

M_{ij}[29] = carrier travel distance if all carrier routes in ZIP Code i are assigned facility j

H_{ij}[30] = carrier travel time if all carrier routes in ZIP Code i are assigned facility j

k = vehicle cost per mile = \$1.48 / mile[31]

p = tort cost per mile = \$0.20 / mile[32]

o = ownership cost per hour = \$8.60 / hour

l = carrier labor cost per hour = \$41.93 / hour[33]

$$t_{ij} = 302\ \{\ (k + p) * M_{ij}\ + (l + o) * H_{ij}\ \}$$

Delivery Support Labor Costs

The Delivery Model charges a cost for delivery support labor when a facility has more than five routes. As we observed with the labor regression, the labor associated with the

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[28] U.S. Postal Service, Handbook AS-504, *Space Requirements*, July 1999, Chapter 5, "Delivery Unit Workroom Floor Planning: City, Rural, and Highway Contract Route Delivery," p. 201.
[29] Facility information is provided by FMS. Carrier route first and last stop locations are provided by AIS. Distance to travel to and from the first and last stops of the delivery route and the facility is calculated by PC Miler Batch Pro software.
[30] Time to drive to and from the first and last stops of the delivery route and the facility is calculated by PC Miler Batch Pro software.
[31] U.S. Postal Service, Cost Evaluation PS-5505, FY 2011, provides vehicle and tort mileage costs and ownership hourly costs.
[32] The tort cost component includes expenses related to vehicle accidents.
[33] U.S. Postal Service, Cost Evaluation PS-5505, FY 2011.

first five routes is covered by the fixed labor at the facility. For each route over five at a delivery unit we have a labor cost of

$$v_j = 287.1 * LC$$

where

$$LC = \text{clerk labor cost per hour} = \$41.5148 \text{ / hour.}$$[34]

Facility Fixed Costs

The only model cost element that we adjust to consider different scenarios is fixed cost associated with a facility. For the Delivery Model, this cost is comprised of the facility space costs and the fixed labor costs associated with minimum service hours. The fixed labor hours of 1996.2 associated with a facility are discussed in Appendix A. Note that while retail costs are part of the cost of providing service, in our model they are provided by the Postal Service regardless of a facility decision, thus these costs do not vary with different ZIP Code assignments. Then the fixed facility costs is

$$f_j = \left(L_j + O_j + U_j\right) + (1996.2 * LC)$$

where

L_j = lease cost for facility j[35]

O_j = owned building estimated rent cost equivalent for facility j[36]

U_j = utilities and maintenance cost for facility j[37]

No Facility Closures Scenario

We test the simple scenario where facilities may not be closed to determine if any savings are still possible by moving delivery operations between units. This case may be modeled by simply setting the fixed facility charge to zero. Since the facility may not be closed, the fixed facility costs are unchanged for different ZIP Code assignments.

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[34] U.S. Postal Service, USPS-FY11-7 – Cost Segment 3 Cost Pools & Other Related Information (Public Portion), Postal Regulatory Commission, Docket No. ACR2011, December 29, 2011, http://www.prc.gov/prc-pages/library/detail.aspx?docketId=ACR2011&docketPart=Documents&docid=79103, USPS-FY11-7 part8.xls, tab FY11 Productive Hourly Rates, Clerks A-J.
[35] U.S. Postal Service, FY 2011 General Ledger costs by Finance number from the Accounting Data Mart, Electronic Data Warehouse (EDW).
[36] The estimated rent computations are by Anthony Yezer, Professor of Economics, The George Washington University. He provided them in support of testimony on Post Office Box pricing for the 2006 rate case. The analysis imputes rental values for Postal Service-owned properties, based on database of Post Office rental properties by 5-digit ZIP Code. The interior square feet data are provided by FMS. U.S. Postal Service, USPS-LR-L-125 – Supporting Materials for Post Office Box and Caller Service, Postal Rate Commission Docket No. R2006-1, May 3, 2006, http://www.prc.gov/prc-pages/library/detail.aspx?docketId=R2006-1&docketPart=Documents&docid=48606.
[37] U.S. Postal Service, FY 2011 General Ledger costs by Finance number from the Accounting Data Mart, Electronic Data Warehouse (EDW).

The program simply considers if carrier routes can be placed in locations that are more convenient for the routes. As we expect, the savings potential for such a case are not great. The results show a savings of $53 million.

Solution Methodology

We used the Operations Research module developed by SAS to solve this facility location integer programming problem. We used the following techniques to make the problem tractable:

1) Solved each district individually.

2) ZIP Code assignments were limited to facilities that are:

    a. Less than 15 miles from the ZIP Code,

    b. Currently serving the ZIP Code or

    c. One of the three closest facilities.

3) The model first solves the problem excluding the fixed facility and labor costs. This "primer" solution provides a starting feasible solution to the larger problem.[38]

These techniques reduce the processing time to run the model obtaining solutions that are within 3 percent of optimal for all districts.

[38]SAS, *SAS/OR(R) 9.22 User's Guide: Mathematical Programming*, http://support.sas.com/documentation/cdl/en/ormpug/63352/PDF/default/ormpug.pdf, Example 18.3, Facility Location, pp. 1188-96. This example demonstrates a similar SAS OPTMILP formulated problem.

Appendix C Results in Detail

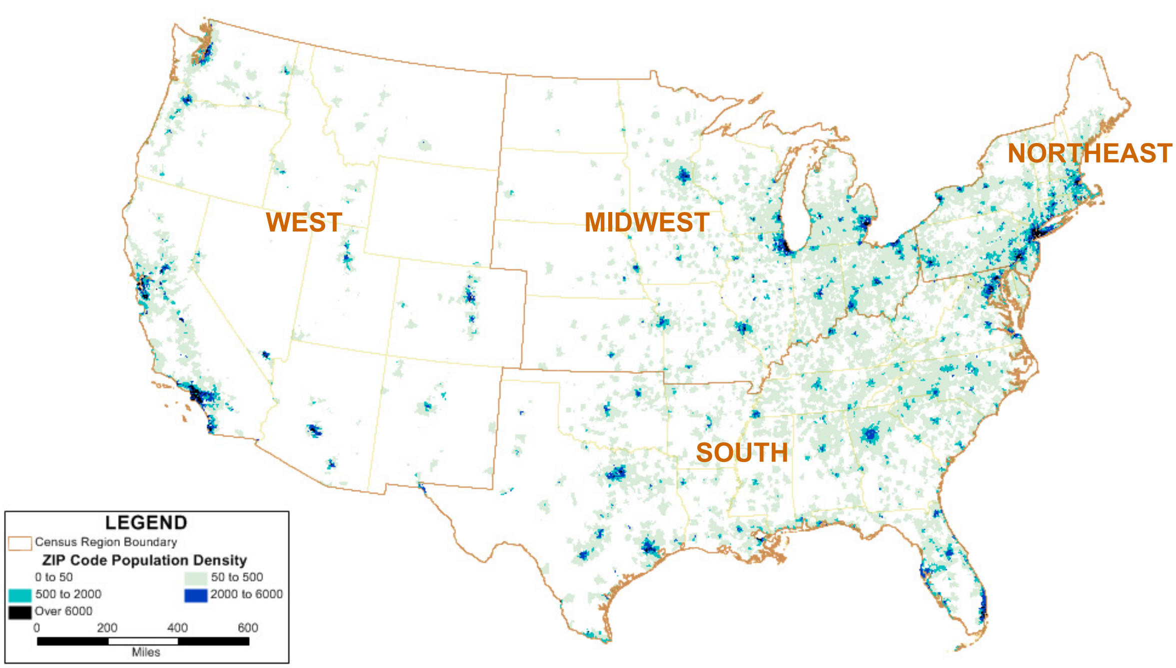
To gain some insight into the national results, we break down the results geographically and by the population density of ZIP Codes. We consider the four census regions of the Northeast, Midwest, South, and West. We categorize 5-digit ZIP Codes into five population density categories shown in Table 3. In Figure 9 we map these geographic regions and ZIP Codes with darker shading for higher-density ZIP Codes.

Table 3: ZIP Code Population Density Categories

ZIP Code Category	Population Density (ppl per sq mile)	Population (millions)	Percent Population
Very High Density	Over 6000	43.8	15.4%
High Density	2000 - 6000	72.2	25.3%
Medium Density	500 - 2000	61.7	21.6%
Low Density	50 - 500	81.5	28.6%
Very Low Density	0 - 50	25.7	9.0%

Source: U.S. Census Bureau, 2010 Zip Code Tabulation Area (ZCTA) Data and OIG Analysis

Figure 9: National Map of Census Regions and Population Density Groups



Source: 2010 Census Zip Code Tabulation Area (ZCTA) Data

Appendix C.1: National Summary Statistics for Delivery Model and No Closures Scenario

	Delivery Model			No Facility Closures		
	Baseline	Optimal	Change	Baseline	Optimal	Change
Delivery Units	23,752	13,917	(9,835)	23,752	22,811	(941)
Delivery Only Units	592	395	(197)	592	549	(43)
Carrier Routes	252,006	252,006		252,006	252,006	
Total Facility Space (million sq. ft.)	195.6	126.4	(69.2)	195.6	182.5	(13.2)
Space per Route (sq. ft.)	366	241	(125)	366	343	(23)
Average Space Cost	$ 9.78	$ 8.67	$ (1.11)	$ 9.78	$ 9.78	
Number ZIP Codes served	29,191	29,191		29,191	29,191	
One ZIP Code Unit	79.9%	42.6%	(37.3%)	79.9%	80.3%	0.4%
2-3 ZIP Code Unit	17.7%	44.8%	27.1%	17.7%	17.9%	0.1%
Over 3 ZIP Code Unit	2.4%	12.6%	10.2%	2.4%	1.9%	(0.5%)
Share Routes in units with						
1-5 Routes	14.3%	7.3%	(7.0%)	14.3%	14.5%	0.2%
6-10 Routes	9.5%	8.4%	(1.1%)	9.5%	9.4%	(0.1%)
11-20 Routes	14.5%	13.3%	(1.1%)	14.5%	14.2%	(0.2%)
21-40 Routes	27.0%	21.5%	(5.5%)	27.0%	27.0%	0.0%
41-80 Routes	29.2%	33.5%	4.3%	29.2%	29.3%	0.2%
Over 80 Routes	5.6%	16.1%	10.4%	5.6%	5.5%	(0.1%)
Average Carrier Travel (miles)	2.8	3.7	0.9	2.8	2.7	(0.1)
Carrier Travel (miles)						
0-1 Miles	29.6%	9.0%	(20.6%)	29.6%	15.1%	(14.5%)
1-2 Miles	21.5%	24.1%	2.6%	21.5%	29.6%	8.1%
2-4 Miles	26.9%	37.2%	10.3%	26.9%	38.3%	11.5%
4-8 Miles	16.8%	21.2%	4.4%	16.8%	14.1%	(2.7%)
8-16 Miles	4.5%	7.3%	2.9%	4.5%	2.5%	(2.0%)
Over 16 Miles	0.8%	1.2%	0.4%	0.8%	0.4%	(0.4%)
Annual Costs (millions)						
Space Cost	$ 1,913	$ 1,096	$ (817)	$ 1,913	$ 1,913	
Carrier Travel Cost	$ 1,263	$ 1,637	$ 374	$ 1,263	$ 1,210	$ (53)
Support Labor Cost	$ 3,982	$ 3,416	$ (566)	$ 3,982	$ 3,982	
Retail Labor Cost	$ 4,027	$ 4,027		$ 4,027	$ 4,027	
Additional CPU Cost						
Total Cost	$ 11,185	$ 10,175	$ (1,010)	$ 11,185	$ 11,132	$ (53)
Labor Hours (millions)						
Carrier Travel Hours	10.7	13.7	3.0	10.7	10.2	(0.5)
Support Labor Hours	95.9	82.3	(13.6)	95.9	95.9	
Retail Labor Hours	97.0	97.0		97.0	97.0	
Cost per Route						
Space Cost per Route	$ 7,590	$ 4,347	$ (3,243)	$ 7,590	$ 7,590	
Average Carrier Travel Cost	$ 5,010	$ 6,494	$ 1,484	$ 5,010	$ 4,802	$ (208)
Support Labor Cost per Route	$ 15,803	$ 13,555	$ (2,248)	$ 15,803	$ 15,803	
Retail Labor Cost per Route	$ 15,980	$ 15,980		$ 15,980	$ 15,980	
Additional CPU Cost per Route						
Total Cost per Route	$ 44,383	$ 40,377	$ (4,007)	$ 44,383	$ 44,175	$ (208)

Appendix C.2: National Statistics by Population Density ZIP Codes

	Very High Density			High Density			Medium Density			Low Density			Very Low Density		
	Baseline	Optimal	Change	Baseline	Optimal	Change	Baseline	Optimal	Change	Baseline	Optimal	Change	Baseline	Optimal	Change
Delivery Units	1,065	719	(346)	2,332	1,828	(504)	2,823	2,281	(542)	8,372	5,957	(2,415)	11,598	7,536	(4,062)
Delivery Only Units	66	41	(25)	134	101	(33)	137	113	(24)	253	197	(56)	139	140	1
Carrier Routes	30,069	30,069		59,345	59,345		52,309	52,309		73,503	73,503		36,749	36,749	
Total Facility Space (million sq. ft.)	32.2	13.2	(19.0)	45.8	27.6	(18.2)	38.6	25.6	(13.0)	54.3	40.2	(14.1)	24.7	19.8	(4.9)
Space per Route (sq. ft.)	493	212	(282)	364	223	(141)	350	235	(115)	347	260	(86)	327	262	(65)
Average Space Cost	$ 10.49	$ 8.22	$ (2.28)	$ 9.44	$ 8.18	$ (1.26)	$ 9.28	$ 8.68	$ (0.60)	$ 9.59	$ 8.82	$ (0.77)	$ 10.66	$ 9.31	$ (1.35)
Number ZIP Codes served	1,316	1,316		2,973	2,973		3,248	3,248		9,146	9,146		12,504	12,504	
One ZIP Code Unit	55.3%	22.5%	(32.8%)	45.5%	19.5%	(26.0%)	51.7%	21.0%	(30.8%)	74.2%	33.2%	(41.0%)	83.3%	39.2%	(44.1%)
2-3 ZIP Code Unit	33.2%	43.8%	10.6%	42.5%	50.9%	8.4%	38.3%	49.2%	10.9%	21.9%	47.1%	25.2%	15.0%	48.1%	33.2%
Over 3 ZIP Code Unit	11.5%	33.7%	22.2%	11.9%	29.5%	17.6%	10.0%	29.9%	19.8%	3.9%	19.7%	15.7%	1.7%	12.6%	10.9%
Share Routes in units with															
1-5 Routes	0.4%	0.0%	(0.4%)	0.7%	0.1%	(0.6%)	2.1%	0.4%	(1.7%)	15.1%	6.1%	(9.0%)	63.5%	36.9%	(26.6%)
6-10 Routes	1.0%	0.2%	(0.8%)	1.6%	0.4%	(1.2%)	4.0%	1.6%	(2.4%)	17.6%	13.1%	(4.5%)	20.8%	28.3%	7.5%
11-20 Routes	8.5%	2.1%	(6.4%)	8.7%	3.7%	(5.1%)	13.6%	8.2%	(5.4%)	24.6%	24.7%	0.1%	9.5%	22.6%	13.1%
21-40 Routes	36.5%	14.8%	(21.7%)	34.6%	20.7%	(13.9%)	34.5%	26.4%	(8.1%)	23.6%	28.5%	4.9%	3.0%	7.3%	4.3%
41-80 Routes	42.0%	38.2%	(3.7%)	45.2%	49.4%	4.2%	39.4%	47.7%	8.3%	16.8%	23.3%	6.5%	2.9%	4.0%	1.1%
Over 80 Routes	11.7%	44.7%	33.0%	9.2%	25.7%	16.6%	6.4%	15.7%	9.3%	2.3%	4.4%	2.0%	0.3%	0.9%	0.6%
Average Carrier Travel (miles)	1.7	2.3	0.6	2.5	3.0	0.5	3.1	3.6	0.5	3.1	3.8	0.8	3.4	5.8	2.4
Carrier Travel (miles)															
0-1 Miles	36.3%	12.5%	(23.9%)	20.9%	3.3%	(17.6%)	18.5%	2.0%	(16.5%)	31.6%	9.6%	(21.9%)	50.0%	24.0%	(26.0%)
1-2 Miles	33.1%	43.4%	10.3%	26.7%	29.2%	2.4%	20.9%	17.9%	(2.9%)	18.2%	21.3%	3.1%	10.8%	14.4%	3.6%
2-4 Miles	24.9%	33.2%	8.3%	35.8%	46.0%	10.2%	33.4%	48.1%	14.7%	22.8%	34.7%	11.9%	12.8%	15.5%	2.8%
4-8 Miles	5.1%	9.8%	4.7%	15.6%	20.1%	4.5%	23.5%	28.1%	4.6%	19.5%	24.2%	4.7%	13.6%	16.6%	2.9%
8-16 Miles	0.5%	1.0%	0.4%	0.9%	1.2%	0.3%	3.7%	3.7%	0.0%	7.2%	9.7%	2.5%	9.1%	23.0%	13.8%
Over 16 Miles	0%	0.2%	0.2%	0.1%	0.2%	0.1%	0.1%	0.3%	0.1%	0.7%	0.5%	(0.2%)	3.5%	6.4%	2.9%
Annual Costs (millions)															
Space Cost	$ 338	$ 109	$ (229)	$ 432	$ 226	$ (207)	$ 358	$ 222	$ (136)	$ 521	$ 355	$ (167)	$ 264	$ 184	$ (79)
Carrier Travel Cost	$ 96	$ 127	$ 30	$ 267	$ 323	$ 56	$ 284	$ 333	$ 49	$ 393	$ 485	$ 92	$ 222	$ 368	$ 146
Support Labor Cost	$ 383	$ 370	$ (12)	$ 757	$ 736	$ (21)	$ 690	$ 657	$ (33)	$ 1,157	$ 997	$ (160)	$ 996	$ 655	$ (341)
Retail Labor Cost	$ 502	$ 502		$ 859	$ 859		$ 827	$ 827		$ 1,310	$ 1,310		$ 529	$ 529	
Total Cost	$ 1,319	$ 1,108	$ (211)	$ 2,315	$ 2,144	$ (172)	$ 2,158	$ 2,039	$ (119)	$ 3,381	$ 3,147	$ (234)	$ 2,011	$ 1,737	$ (274)
Labor Hours (millions)															
Carrier Travel Hours	0.9	1.1	0.3	2.3	2.8	0.5	2.4	2.8	0.4	3.2	3.9	0.7	1.9	3.0	1.1
Support Labor Hours	9.2	8.9	(0.3)	18.2	17.7	(0.5)	16.6	15.8	(0.8)	27.9	24.0	(3.8)	24.0	15.8	(8.2)
Retail Labor Hours	12.1	12.1		20.7	20.7		19.9	19.9		31.6	31.6		12.7	12.7	
Cost per Route															
Space Cost per Route	$11,231	$ 3,613	$ (7,618)	$ 7,281	$ 3,802	$ (3,480)	$ 6,839	$ 4,246	$ (2,593)	$ 7,092	$ 4,825	$ (2,267)	$ 7,177	$ 5,018	$ (2,159)
Average Carrier Travel Cost	$ 3,205	$ 4,216	$ 1,011	$ 4,504	$ 5,444	$ 940	$ 5,424	$ 6,365	$ 941	$ 5,344	$ 6,602	$ 1,258	$ 6,047	$10,019	$ 3,972
Support Labor Cost per Route	$12,723	$12,308	$ (415)	$12,755	$12,404	$ (351)	$13,191	$12,563	$ (628)	$15,738	$13,567	$ (2,171)	$27,094	$17,823	$ (9,271)
Retail Labor Cost per Route	$16,695	$16,695		$14,475	$14,475		$15,808	$15,808		$17,822	$17,822		$14,395	$14,395	
Total Cost per Route	$43,854	$36,832	$ (7,021)	$39,015	$36,125	$ (2,890)	$41,262	$38,982	$ (2,280)	$45,996	$42,817	$ (3,179)	$54,714	$47,255	$ (7,458)

Appendix C.3: Summary Statistics for Very High-Density ZIP Codes

	Northeast			Midwest			South			West		
	Baseline	Optimal	Change	Baseline	Optimal	Change	Baseline	Optimal	Change	Baseline	Optimal	Change
Delivery Units	447	259	(188)	153	125	(28)	126	105	(21)	295	211	(84)
Delivery Only Units	23	13	(10)	5	5		10	10		18	12	(6)
Carrier Routes	11,274	11,274		4,673	4,673		3,477	3,477		9,702	9,702	
Total Facility Space (million sq. ft.)	12.3	4.8	(7.5)	4.1	2.0	(2.1)	2.7	1.6	(1.1)	9.9	4.4	(5.5)
Space per Route (sq. ft.)	481	200	(281)	417	211	(206)	379	227	(152)	483	220	(263)
Average Space Cost	$ 12.58	$ 9.59	$ (2.99)	$ 6.97	$ 6.20	$ (0.77)	$ 9.43	$ 8.05	$ (1.37)	$ 8.24	$ 7.49	$ (0.75)
Number ZIP Codes served	528	528		181	181		158	158		395	395	
One ZIP Code Unit	65.3%	18.9%	(46.4%)	53.6%	37.6%	(16.0%)	50.8%	19.0%	(31.7%)	43.1%	20.4%	(22.7%)
2-3 ZIP Code Unit	25.1%	43.2%	18.2%	33.3%	33.6%	0.3%	36.5%	47.6%	11.1%	43.7%	50.7%	7.0%
Over 3 ZIP Code Unit	9.6%	37.8%	28.2%	13.1%	28.8%	15.7%	12.7%	33.3%	20.6%	13.2%	28.9%	15.7%
Share Routes in units with												
1-5 Routes	0.6%	0.0%	(0.6%)	0.2%	0%	(0.2%)	0.1%	0%	(0.1%)	0.2%	0%	(0.2%)
6-10 Routes	2.0%	0.3%	(1.7%)	0.5%	0.2%	(0.3%)	0%	0%	0%	0.4%	0%	(0.4%)
11-20 Routes	12.3%	2.8%	(9.5%)	4.9%	2.2%	(2.7%)	9.5%	1.9%	(7.7%)	5.7%	1.4%	(4.3%)
21-40 Routes	40.6%	14.6%	(26.0%)	35.9%	23.6%	(12.3%)	44.3%	14.2%	(30.1%)	27.9%	11.2%	(16.7%)
41-80 Routes	37.8%	34.9%	(3.0%)	46.2%	39.2%	(7.0%)	39.5%	44.5%	5.0%	45.6%	40.9%	(4.6%)
Over 80 Routes	6.7%	47.4%	40.6%	12.3%	34.8%	22.4%	6.5%	39.4%	32.8%	20.3%	46.5%	26.2%
Average Carrier Travel (Miles)	1.3	2.1	0.8	1.7	2.0	0.3	1.9	2.7	0.8	2.0	2.4	0.4
Carrier Travel (Miles)												
0-1 Miles	52.0%	21.0%	(31.0%)	30.5%	6.6%	(23.9%)	24.9%	5.8%	(19.2%)	25.8%	7.5%	(18.3%)
1-2 Miles	29.1%	41.6%	12.5%	38.3%	57.2%	18.9%	36.2%	38.4%	2.2%	34.1%	40.6%	6.5%
2-4 Miles	15.2%	26.3%	11.1%	26.8%	29.9%	3.1%	33.8%	39.5%	5.7%	31.6%	41.1%	9.5%
4-8 Miles	3.7%	9.3%	5.6%	4.3%	6.3%	1.9%	5.1%	15.0%	10.0%	7.3%	9.7%	2.5%
8-16 Miles	0.0%	1.5%	1.5%	0.1%	0%	(0.1%)	0%	0.9%	0.9%	1.2%	0.9%	(0.3%)
Over 16 Miles	0%	0.2%	0.2%	0%	0%	0%	0%	0.5%	0.5%	0%	0.2%	0.2%
Annual Costs (millions)												
Space Cost	$ 155	$ 46	$ (109)	$ 29	$ 13	$ (16)	$ 26	$ 13	$ (13)	$ 81	$ 33	$ (48)
Carrier Travel Cost	$ 29	$ 46	$ 17	$ 14	$ 17	$ 3	$ 12	$ 17	$ 5	$ 37	$ 43	$ 6
Support Labor Cost	$ 145	$ 139	$ (7)	$ 59	$ 58	$ (1)	$ 44	$ 43	$ (1)	$ 122	$ 119	$ (3)
Retail Labor Cost	$ 232	$ 232		$ 50	$ 50		$ 49	$ 49		$ 152	$ 152	
Total Cost	$ 561	$ 462	$ (99)	$ 151	$ 137	$ (15)	$ 130	$ 121	$ (9)	$ 392	$ 347	$ (45)
Labor Hours (millions)												
Carrier Travel Hours	0.3	0.4	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.3	0.4	0.1
Support Labor Hours	3.5	3.3	(0.2)	1.4	1.4	(0.0)	1.1	1.0	(0.0)	2.9	2.9	(0.1)
Retail Labor Hours	5.6	5.6		1.2	1.2		1.2	1.2		3.7	3.7	
Cost per Route												
Space Cost per Route	$ 13,749	$ 4,066	$ (9,683)	$ 6,154	$ 2,715	$ (3,439)	$ 7,436	$ 3,738	$ (3,698)	$ 8,369	$ 3,381	$ (4,988)
Average Carrier Travel Cost	$ 2,577	$ 4,060	$ 1,482	$ 3,082	$ 3,625	$ 543	$ 3,415	$ 4,770	$ 1,355	$ 3,791	$ 4,440	$ 650
Support Labor Cost per Route	$ 12,885	$ 12,308	$ (578)	$ 12,571	$ 12,361	$ (210)	$ 12,642	$ 12,338	$ (304)	$ 12,581	$ 12,279	$ (302)
Retail Labor Cost per Route	$ 20,585	$ 20,585		$ 10,610	$ 10,610		$ 13,965	$ 13,965		$ 15,683	$ 15,683	
Total Cost per Route	$ 49,797	$ 41,018	$ (8,778)	$ 32,417	$ 29,311	$ (3,106)	$ 37,457	$ 34,811	$ (2,646)	$ 40,424	$ 35,783	$ (4,641)

Appendix C.4: Summary Statistics for High-Density ZIP Codes

	Northeast			Midwest			South			West		
	Baseline	Optimal	Change	Baseline	Optimal	Change	Baseline	Optimal	Change	Baseline	Optimal	Change
Delivery Units	568	405	(163)	512	408	(104)	687	549	(138)	483	405	(78)
Delivery Only Units	22	17	(5)	33	21	(12)	40	37	(3)	34	27	(7)
Carrier Routes	10,691	10,691		14,058	14,058		18,684	18,684		13,913	13,913	
Total Facility Space (million sq. ft.)	9.4	4.7	(4.7)	11.8	6.8	(5.0)	13.1	8.3	(4.8)	9.2	6.6	(2.6)
Space per Route (sq. ft.)	415	212	(203)	390	227	(163)	334	216	(118)	315	232	(83)
Average Space Cost	$ 13.24	$ 10.93	$ (2.32)	$ 7.30	$ 6.55	$ (0.75)	$ 8.86	$ 8.00	$ (0.86)	$ 8.49	$ 7.78	$ (0.71)
Number ZIP Codes served	633	633		684	684		927	927		627	627	
One ZIP Code Unit	65.5%	24.0%	(41.5%)	42.0%	22.5%	(19.4%)	40.2%	18.8%	(21.4%)	33.3%	14.1%	(19.3%)
2-3 ZIP Code Unit	27.1%	45.7%	18.6%	43.0%	44.4%	1.4%	47.3%	51.4%	4.1%	52.8%	60.7%	7.9%
Over 3 ZIP Code Unit	7.4%	30.4%	23.0%	15.0%	33.1%	18.0%	12.5%	29.9%	17.4%	13.9%	25.2%	11.3%
Share Routes in units with												
1-5 Routes	2.3%	0.2%	(2.1%)	0.4%	0.1%	(0.4%)	0.2%	0%	(0.2%)	0.3%	0.0%	(0.2%)
6-10 Routes	6.2%	1.6%	(4.6%)	0.8%	0.1%	(0.7%)	0.5%	0.0%	(0.4%)	0.5%	0.0%	(0.5%)
11-20 Routes	14.9%	6.9%	(8.0%)	6.6%	2.9%	(3.7%)	9.0%	3.5%	(5.5%)	5.1%	2.1%	(3.0%)
21-40 Routes	31.9%	23.0%	(8.9%)	37.0%	22.1%	(15.0%)	38.2%	21.1%	(17.1%)	28.7%	17.5%	(11.2%)
41-80 Routes	37.8%	43.6%	5.8%	43.9%	48.4%	4.6%	45.9%	51.0%	5.1%	51.4%	52.2%	0.7%
Over 80 Routes	7.0%	24.8%	17.8%	11.3%	26.4%	15.1%	6.2%	24.3%	18.1%	14.0%	28.2%	14.2%
Average Carrier Travel (miles)	2.3	3.3	0.9	2.4	2.9	0.4	2.6	3.2	0.6	2.5	2.8	0.3
Carrier Travel (miles)												
0-1 Miles	28.6%	8.0%	(20.6%)	20.3%	2.3%	(18.0%)	18.0%	1.9%	(16.1%)	19.7%	2.7%	(17.0%)
1-2 Miles	27.0%	27.0%	0.0%	27.4%	32.5%	5.1%	25.8%	23.6%	(2.2%)	27.2%	35.2%	8.0%
2-4 Miles	30.1%	40.7%	10.6%	36.6%	47.0%	10.4%	37.9%	50.3%	12.3%	37.2%	44.8%	7.5%
4-8 Miles	13.3%	21.4%	8.1%	15.1%	17.2%	2.1%	17.2%	23.2%	5.9%	15.1%	16.3%	1.1%
8-16 Miles	0.8%	2.2%	1.3%	0.6%	1.0%	0.4%	1.1%	0.9%	(0.2%)	0.8%	1.1%	0.3%
Over 16 Miles	0.0%	0.6%	0.6%	0.1%	0%	(0.1%)	0.0%	0.3%	0.2%	0.0%	0.0%	0%
Annual Costs (millions)												
Space Cost	$ 124	$ 52	$ (73)	$ 86	$ 45	$ (41)	$ 116	$ 67	$ (49)	$ 78	$ 51	$ (27)
Carrier Travel Cost	$ 47	$ 65	$ 18	$ 61	$ 71	$ 10	$ 86	$ 104	$ 18	$ 62	$ 70	$ 8
Support Labor Cost	$ 142	$ 134	$ (8)	$ 178	$ 174	$ (4)	$ 236	$ 232	$ (5)	$ 175	$ 172	$ (3)
Retail Labor Cost	$ 185	$ 185		$ 172	$ 172		$ 258	$ 258		$ 208	$ 208	
Total Cost	$ 498	$ 436	$ (62)	$ 497	$ 462	$ (35)	$ 697	$ 660	$ (36)	$ 524	$ 502	$ (22)
Labor Hours (millions)												
Carrier Travel Hours	0.4	0.6	0.2	0.5	0.6	0.1	0.7	0.9	0.1	0.5	0.6	0.1
Support Labor Hours	3.4	3.2	(0.2)	4.3	4.2	(0.1)	5.7	5.6	(0.1)	4.2	4.1	(0.1)
Retail Labor Hours	4.5	4.5		4.1	4.1		6.2	6.2		5.0	5.0	
Cost per Route												
Space Cost per Route	$ 11,629	$ 4,841	$ (6,788)	$ 6,112	$ 3,172	$ (2,941)	$ 6,215	$ 3,567	$ (2,648)	$ 5,638	$ 3,700	$ (1,938)
Average Carrier Travel Cost	$ 4,399	$ 6,116	$ 1,717	$ 4,336	$ 5,052	$ 716	$ 4,623	$ 5,575	$ 951	$ 4,469	$ 5,053	$ 584
Support Labor Cost per Route	$ 13,266	$ 12,500	$ (766)	$ 12,659	$ 12,383	$ (275)	$ 12,652	$ 12,399	$ (253)	$ 12,592	$ 12,360	$ (233)
Retail Labor Cost per Route	$ 17,288	$ 17,288		$ 12,252	$ 12,252		$ 13,793	$ 13,793		$ 14,954	$ 14,954	
Total Cost per Route	$ 46,582	$ 40,745	$ (5,837)	$ 35,359	$ 32,859	$ (2,500)	$ 37,284	$ 35,334	$ (1,949)	$ 37,653	$ 36,067	$ (1,586)

Appendix C.5: Summary Statistics for Medium-Density ZIP Codes

	Northeast			Midwest			South			West		
	Baseline	Optimal	Change	Baseline	Optimal	Change	Baseline	Optimal	Change	Baseline	Optimal	Change
Delivery Units	818	579	(239)	600	514	(86)	853	724	(129)	390	337	(53)
Delivery Only Units	26	20	(6)	38	31	(7)	36	33	(3)	27	25	(2)
Carrier Routes	12,110	12,110		12,162	12,162		17,344	17,344		7,963	7,963	
Total Facility Space (million sq. ft.)	9.5	5.6	(3.8)	8.7	6.0	(2.7)	12.5	8.4	(4.1)	5.4	4.1	(1.3)
Space per Route (sq. ft.)	368	222	(147)	344	240	(105)	343	234	(109)	322	247	(75)
Average Space Cost	$ 11.67	$ 10.54	$ (1.13)	$ 7.41	$ 7.25	$ (0.16)	$ 8.56	$ 8.13	$ (0.42)	$ 9.51	$ 8.79	$ (0.72)
Number ZIP Codes served	875	875		731	731		1,013	1,013		456	456	
One ZIP Code Unit	68.9%	24.4%	(44.6%)	42.0%	21.0%	(21.0%)	43.7%	18.5%	(25.2%)	38.5%	16.0%	(22.4%)
2-3 ZIP Code Unit	26.7%	43.7%	17.0%	43.0%	45.3%	2.3%	44.4%	52.2%	7.8%	48.5%	56.1%	7.6%
Over 3 ZIP Code Unit	4.4%	32.0%	27.6%	15.0%	33.7%	18.7%	11.8%	29.3%	17.4%	13.1%	27.9%	14.8%
Share Routes in units with												
1-5 Routes	3.8%	0.4%	(3.4%)	1.5%	0.5%	(0.9%)	1.4%	0.3%	(1.1%)	1.4%	0.4%	(0.9%)
6-10 Routes	8.8%	2.9%	(5.9%)	1.8%	0.7%	(1.1%)	2.5%	1.1%	(1.3%)	1.6%	0.5%	(1.1%)
11-20 Routes	25.0%	14.2%	(10.7%)	10.1%	6.7%	(3.3%)	10.5%	6.2%	(4.4%)	8.6%	5.1%	(3.6%)
21-40 Routes	33.1%	28.2%	(4.9%)	34.4%	26.7%	(7.7%)	34.6%	25.8%	(8.8%)	32.1%	23.6%	(8.6%)
41-80 Routes	22.7%	36.4%	13.7%	45.5%	49.0%	3.5%	46.3%	52.5%	6.2%	44.7%	54.0%	9.3%
Over 80 Routes	6.7%	17.9%	11.3%	6.7%	16.3%	9.5%	4.7%	14.1%	9.4%	11.6%	16.4%	4.9%
Average Carrier Travel (miles)	2.6	3.5	0.9	2.9	3.4	0.4	3.5	3.9	0.4	3.0	3.5	0.4
Carrier Travel (miles)												
0-1 Miles	27.7%	3.9%	(23.8%)	17.3%	1.7%	(15.6%)	13.7%	0.8%	(13.0%)	17.1%	1.3%	(15.8%)
1-2 Miles	22.0%	25.9%	3.9%	22.6%	20.3%	(2.3%)	18.5%	10.5%	(8.1%)	21.7%	19.9%	(1.8%)
2-4 Miles	28.8%	40.7%	11.8%	35.4%	50.8%	15.4%	34.5%	52.3%	17.8%	35.1%	48.6%	13.4%
4-8 Miles	18.7%	25.3%	6.6%	22.2%	24.2%	2.0%	27.6%	31.8%	4.2%	23.1%	26.9%	3.7%
8-16 Miles	2.8%	3.6%	0.8%	2.5%	2.7%	0.3%	5.5%	4.5%	(1.0%)	2.6%	3.2%	0.6%
Over 16 Miles	0.0%	0.6%	0.6%	0.0%	0.3%	0.2%	0.1%	0.1%	(0.0%)	0.2%	0.0%	(0.2%)
Annual Costs (millions)												
Space Cost	$ 110	$ 59	$ (51)	$ 65	$ 44	$ (21)	$ 107	$ 68	$ (39)	$ 51	$ 36	$ (15)
Carrier Travel Cost	$ 57	$ 75	$ 18	$ 63	$ 72	$ 9	$ 105	$ 117	$ 12	$ 43	$ 49	$ 6
Support Labor Cost	$ 167	$ 153	$ (14)	$ 159	$ 152	$ (6)	$ 225	$ 217	$ (8)	$ 102	$ 99	$ (3)
Retail Labor Cost	$ 222	$ 222		$ 160	$ 160		$ 261	$ 261		$ 117	$ 117	
Total Cost	$ 557	$ 510	$ (47)	$ 446	$ 427	$ (18)	$ 698	$ 663	$ (34)	$ 314	$ 301	$ (12)
Labor Hours (millions)												
Carrier Travel Hours	0.5	0.6	0.1	0.5	0.6	0.1	0.9	1.0	0.1	0.4	0.4	0.1
Support Labor Hours	4.0	3.7	(0.3)	3.8	3.7	(0.2)	5.4	5.2	(0.2)	2.5	2.4	(0.1)
Retail Labor Hours	5.4	5.4		3.8	3.8		6.3	6.3		2.8	2.8	
Cost per Route												
Space Cost per Route	$ 9,118	$ 4,913	$ (4,205)	$ 5,314	$ 3,593	$ (1,720)	$ 6,160	$ 3,940	$ (2,220)	$ 6,428	$ 4,504	$ (1,924)
Average Carrier Travel Cost	$ 4,729	$ 6,216	$ 1,487	$ 5,156	$ 5,902	$ 746	$ 6,042	$ 6,752	$ 711	$ 5,439	$ 6,193	$ 754
Support Labor Cost per Route	$ 13,800	$ 12,667	$ (1,133)	$ 13,048	$ 12,532	$ (515)	$ 12,998	$ 12,522	$ (476)	$ 12,840	$ 12,486	$ (354)
Retail Labor Cost per Route	$ 18,357	$ 18,357		$ 13,121	$ 13,121		$ 15,038	$ 15,038		$ 14,676	$ 14,676	
Total Cost per Route	$ 46,003	$ 42,153	$ (3,850)	$ 36,638	$ 35,149	$ (1,490)	$ 40,237	$ 38,252	$ (1,986)	$ 39,382	$ 37,858	$ (1,524)

Appendix C.6: Summary Statistics for Low-Density ZIP Codes

	Northeast			Midwest			South			West		
	Baseline	Optimal	Change	Baseline	Optimal	Change	Baseline	Optimal	Change	Baseline	Optimal	Change
Delivery Units	2,012	1,192	(820)	2,219	1,691	(528)	3,079	2,254	(825)	804	630	(174)
Delivery Only Units	50	32	(18)	73	64	(9)	86	67	(19)	32	33	1
Carrier Routes	11,809	11,809		19,439	19,439		29,400	29,400		9,979	9,979	
Total Facility Space (million sq. ft.)	9.7	5.9	(3.8)	13.2	10.8	(2.4)	21.6	16.2	(5.4)	7.8	5.8	(2.0)
Space per Route (sq. ft.)	365	236	(129)	323	266	(57)	347	261	(86)	368	275	(93)
Average Space Cost	$ 12.31	$ 11.40	$ (0.91)	$ 7.77	$ 7.32	$ (0.45)	$ 9.18	$ 8.69	$ (0.49)	$ 9.82	$ 8.94	$ (0.88)
Number ZIP Codes served	2,098	2,098		2,381	2,381		3,460	3,460		909	909	
One ZIP Code Unit	82.6%	33.5%	(49.1%)	72.5%	37.4%	(35.1%)	72.3%	33.0%	(39.3%)	65.3%	24.3%	(41.0%)
2-3 ZIP Code Unit	15.8%	43.5%	27.8%	22.7%	43.5%	20.8%	23.6%	48.7%	25.1%	28.5%	55.1%	26.6%
Over 3 ZIP Code Unit	1.6%	23.0%	21.3%	4.8%	19.1%	14.3%	4.2%	18.3%	14.2%	6.2%	20.6%	14.4%
Share Routes in units with												
1-5 Routes	29.5%	9.8%	(19.6%)	14.5%	7.8%	(6.7%)	12.5%	5.0%	(7.5%)	8.2%	2.5%	(5.7%)
6-10 Routes	25.4%	17.8%	(7.6%)	20.1%	14.0%	(6.1%)	16.0%	12.6%	(3.4%)	9.4%	8.3%	(1.2%)
11-20 Routes	24.1%	27.5%	3.4%	27.0%	28.7%	1.6%	24.5%	23.1%	(1.4%)	19.8%	18.2%	(1.6%)
21-40 Routes	14.6%	23.6%	9.0%	21.3%	25.8%	4.5%	27.3%	31.8%	4.5%	26.3%	28.9%	2.6%
41-80 Routes	5.7%	18.2%	12.5%	15.2%	19.8%	4.6%	17.4%	23.6%	6.1%	30.2%	33.6%	3.3%
Over 80 Routes	0.7%	3.0%	2.3%	1.9%	4.0%	2.1%	2.3%	3.9%	1.7%	6.0%	8.6%	2.6%
Average Carrier Travel (miles)	2.0	3.7	1.7	2.4	3.0	0.6	3.7	4.4	0.7	3.5	3.9	0.4
Carrier Travel (miles)												
0-1 Miles	47.7%	18.1%	(29.6%)	39.3%	16.0%	(23.4%)	24.1%	4.5%	(19.6%)	22.9%	4.7%	(18.2%)
1-2 Miles	18.0%	28.6%	10.6%	20.0%	31.6%	11.7%	16.9%	13.6%	(3.3%)	19.4%	18.7%	(0.7%)
2-4 Miles	18.4%	19.1%	0.7%	20.8%	30.9%	10.1%	24.5%	41.0%	16.5%	26.5%	40.9%	14.4%
4-8 Miles	12.5%	20.8%	8.3%	15.2%	15.0%	(0.2%)	23.6%	29.4%	5.8%	21.6%	26.5%	4.9%
8-16 Miles	3.3%	13.0%	9.7%	4.5%	6.1%	1.6%	9.7%	10.9%	1.3%	8.5%	8.8%	0.3%
Over 16 Miles	0.1%	0.4%	0.3%	0.2%	0.4%	0.2%	1.2%	0.6%	(0.6%)	1.1%	0.4%	(0.6%)
Annual Costs (millions)												
Space Cost	$ 119	$ 67	$ (52)	$ 102	$ 79	$ (23)	$ 198	$ 140	$ (58)	$ 76	$ 52	$ (25)
Carrier Travel Cost	$ 42	$ 76	$ 34	$ 81	$ 99	$ 18	$ 188	$ 219	$ 31	$ 62	$ 69	$ 7
Support Labor Cost	$ 218	$ 165	$ (52)	$ 302	$ 267	$ (35)	$ 452	$ 397	$ (55)	$ 143	$ 130	$ (13)
Retail Labor Cost	$ 239	$ 239		$ 312	$ 312		$ 508	$ 508		$ 186	$ 186	
Total Cost	$ 617	$ 546	$ (71)	$ 797	$ 757	$ (40)	$ 1,346	$ 1,264	$ (82)	$ 468	$ 437	$ (30)
Labor Hours (millions)												
Carrier Travel Hours	0.4	0.6	0.3	0.7	0.8	0.1	1.5	1.8	0.2	0.5	0.6	0.1
Support Labor Hours	5.2	4.0	(1.3)	7.3	6.4	(0.8)	10.9	9.6	(1.3)	3.4	3.1	(0.3)
Retail Labor Hours	5.7	5.7		7.5	7.5		12.2	12.2		4.5	4.5	
Cost per Route												
Space Cost per Route	$ 10,074	$ 5,678	$ (4,395)	$ 5,259	$ 4,066	$ (1,192)	$ 6,746	$ 4,776	$ (1,969)	$ 7,642	$ 5,182	$ (2,460)
Average Carrier Travel Cost	$ 3,554	$ 6,394	$ 2,840	$ 4,166	$ 5,093	$ 926	$ 6,392	$ 7,439	$ 1,047	$ 6,213	$ 6,896	$ 684
Support Labor Cost per Route	$ 18,420	$ 13,997	$ (4,423)	$ 15,548	$ 13,752	$ (1,796)	$ 15,368	$ 13,488	$ (1,881)	$ 14,319	$ 13,040	$ (1,279)
Retail Labor Cost per Route	$ 20,205	$ 20,205		$ 16,052	$ 16,052		$ 17,290	$ 17,290		$ 18,681	$ 18,681	
Total Cost per Route	$ 52,253	$ 46,274	$ (5,979)	$ 41,025	$ 38,963	$ (2,062)	$ 45,796	$ 42,993	$ (2,803)	$ 46,855	$ 43,800	$ (3,055)

Appendix C.7: Summary Statistics for Very Low-Density ZIP Codes

	Northeast			Midwest			South			West		
	Baseline	Optimal	Change	Baseline	Optimal	Change	Baseline	Optimal	Change	Baseline	Optimal	Change
Delivery Units	1,061	703	(358)	4,723	3,061	(1,662)	3,661	2,297	(1,364)	1,881	1,308	(573)
Delivery Only Units	8	13	5	44	45	1	41	47	6	41	34	(7)
Carrier Routes	2,954	2,954		14,392	14,392		11,421	11,421		7,004	7,004	
Total Facility Space (million sq. ft.)	1.6	1.3	(0.3)	8.3	7.1	(1.2)	8.3	6.5	(1.9)	5.7	4.4	(1.3)
Space per Route (sq. ft.)	271	216	(56)	284	243	(42)	348	270	(78)	390	303	(86)
Average Space Cost	$ 17.59	$ 13.68	$ (3.91)	$ 8.76	$ 7.95	$ (0.81)	$ 10.37	$ 9.43	$ (0.94)	$ 11.16	$ 9.54	$ (1.62)
Number ZIP Codes served	1,107	1,107		5,162	5,162		3,867	3,867		2,094	2,094	
One ZIP Code Unit	88.0%	40.5%	(47.5%)	80.5%	43.3%	(37.2%)	84.8%	31.7%	(53.0%)	84.6%	42.0%	(42.6%)
2-3 ZIP Code Unit	11.1%	40.1%	29.0%	17.6%	45.6%	27.9%	13.7%	53.5%	39.8%	13.2%	48.8%	35.5%
Over 3 ZIP Code Unit	0.8%	19.3%	18.5%	1.9%	11.1%	9.3%	1.5%	14.7%	13.2%	2.2%	9.3%	7.1%
Share Routes in units with												
1-5 Routes	81.1%	42.5%	(38.6%)	68.4%	43.9%	(24.6%)	62.2%	31.0%	(31.2%)	50.3%	31.8%	(18.4%)
6-10 Routes	13.1%	23.9%	10.8%	21.0%	27.1%	6.2%	22.8%	32.4%	9.6%	18.5%	25.6%	7.1%
11-20 Routes	3.7%	20.1%	16.5%	8.1%	21.1%	13.0%	9.7%	25.1%	15.3%	14.5%	21.7%	7.2%
21-40 Routes	0.4%	8.7%	8.3%	2.0%	6.4%	4.4%	2.6%	7.4%	4.8%	6.5%	8.0%	1.5%
41-80 Routes	1.8%	2.3%	0.5%	0.4%	1.2%	0.8%	2.2%	3.6%	1.3%	9.7%	11.2%	1.5%
Over 80 Routes	0%	2.6%	2.6%	0.1%	0.3%	0.2%	0.5%	0.6%	0.1%	0.5%	1.7%	1.2%
Average Carrier Travel (miles)	1.6	5.1	3.4	2.8	5.3	2.6	3.5	6.0	2.5	5.4	6.7	1.3
Carrier Travel (miles)												
0-1 Miles	64.9%	31.5%	(33.4%)	59.3%	32.3%	(27.0%)	43.3%	17.7%	(25.5%)	36.6%	15.5%	(21.0%)
1-2 Miles	11.2%	13.6%	2.5%	8.6%	15.1%	6.5%	12.5%	14.2%	1.7%	11.9%	13.7%	1.8%
2-4 Miles	11.5%	9.6%	(1.9%)	10.2%	11.6%	1.4%	15.6%	17.7%	2.1%	13.7%	21.0%	7.3%
4-8 Miles	8.2%	17.9%	9.7%	11.1%	11.8%	0.7%	16.2%	18.9%	2.6%	16.6%	22.3%	5.7%
8-16 Miles	3.8%	23.2%	19.3%	7.8%	22.9%	15.1%	9.5%	25.8%	16.2%	13.2%	17.6%	4.4%
Over 16 Miles	0.4%	4.2%	3.8%	2.9%	6.3%	3.3%	2.8%	5.7%	2.9%	7.5%	9.4%	1.8%
Annual Costs (millions)												
Space Cost	$ 28	$ 17	$ (10)	$ 72	$ 56	$ (16)	$ 86	$ 61	$ (25)	$ 64	$ 42	$ (21)
Carrier Travel Cost	$ 9	$ 26	$ 17	$ 69	$ 130	$ 60	$ 70	$ 119	$ 49	$ 69	$ 83	$ 14
Support Labor Cost	$ 86	$ 54	$ (33)	$ 398	$ 265	$ (133)	$ 312	$ 194	$ (118)	$ 175	$ 126	$ (49)
Retail Labor Cost	$ 40	$ 40		$ 161	$ 161		$ 171	$ 171		$ 136	$ 136	
Total Cost	$ 162	$ 137	$ (26)	$ 701	$ 612	$ (89)	$ 639	$ 545	$ (94)	$ 443	$ 387	$ (56)
Labor Hours (millions)												
Carrier Travel Hours	0.1	0.2	0.1	0.6	1.0	0.5	0.6	1.0	0.4	0.6	0.7	0.1
Support Labor Hours	2.1	1.3	(0.8)	9.6	6.4	(3.2)	7.5	4.7	(2.8)	4.2	3.0	(1.2)
Retail Labor Hours	1.0	1.0		3.9	3.9		4.1	4.1		3.3	3.3	
Cost per Route												
Space Cost per Route	$ 9,349	$ 5,854	$ (3,495)	$ 5,029	$ 3,899	$ (1,129)	$ 7,566	$ 5,347	$ (2,220)	$ 9,103	$ 6,056	$ (3,047)
Average Carrier Travel Cost	$ 2,915	$ 8,740	$ 5,825	$ 4,812	$ 9,012	$ 4,199	$ 6,118	$ 10,435	$ 4,317	$ 9,783	$ 11,807	$ 2,024
Support Labor Cost per Route	$ 29,264	$ 18,254	$ (11,010)	$ 27,672	$ 18,407	$ (9,266)	$ 27,319	$ 16,983	$ (10,337)	$ 25,002	$ 18,007	$ (6,996)
Retail Labor Cost per Route	$ 13,453	$ 13,453		$ 11,208	$ 11,208		$ 14,934	$ 14,934		$ 19,428	$ 19,428	
Total Cost per Route	$ 54,981	$ 46,301	$ (8,680)	$ 48,721	$ 42,525	$ (6,196)	$ 55,938	$ 47,699	$ (8,239)	$ 63,316	$ 55,298	$ (8,019)

Appendix D Data Sources

Address Information System (AIS) provided various data including:

1. The entire Postal Service address database and the eLOT file, which provides sequence numbers for carrier routes. These data sources were used to identify the first and last stop for existing carrier routes.
2. The current 5-digit ZIP Codes to facilities assignment file which was used as a basis for the existing or baseline network. This file also included geocodes for 21,779 of the 23,866 delivery facilities.[39]

FMS and Facility Database (FDB) information regarding facilities was obtained from Electronic Data Warehouse (EDW) including:

3. The square footage information available for delivery operations. The square footage was increased for 680 facilities when the square footage required by the existing assigned carrier routes exceeded the amount of available according to FMS. The square footage was decreased for processing facilities identified through an FDB category field by limiting them to a maximum space that could hold 80 carriers.
4. The geocodes for 1,971 facilities without geocodes from assignment file #2.
5. Additional facility information for the facilities identified in the assignment file #2.

General ledger

6. The Postal Service general accounting ledger for fiscal year (FY) 2011 was used to obtain lease costs (line item #41), maintenance costs (line items #37, 3F, and 49), and also utility costs (line item #42).
7. The ledger was also used to determine the retail revenue per facility (line items #3, 4, and 5).

Variance programs

8. Variance program data (specifically the Customer Service Variance, or CSV, and Small Office Variance, or SOV, files) from the Postal Service were used to assess labor data and transactional data at delivery units. Hours related to Labor Distribution Codes 41(automation), 42 (mech), 44 (P.O. Box), and 46 (Vending) were removed because they were found to be unrelated to routes. LDC45 (Window), was kept in for two reasons –
    a. the SOV file doesn't separate this work
    b. at CSV locations, clerks rotate back and forth while serving customers as they arrive

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[39] In order to determine the most desirable geocode source, the accuracy of the AIS information was compared to that from FMS. Most geocodes were identical, but in the cases where the two differ, an experiment was designed to study the more accurate source. In the experiment, the different geocodes were gathered and then a random sample of 40 of these differing geocodes was analyzed for accuracy. The results showed AIS had a significantly more accurate geocode for 36 out of the 40 and FMS was accurate only once out of the 40 samples.

Appendix E Actual versus Baseline

To test the model's accuracy, the current assignment of ZIP Codes to delivery units was input through the model and compared to the actual costs and statistics from the postal data systems listed in Appendix C. As shown in Table 4 below, the model reflects the actual costs of the operations considered within 1.8 percent.

Table 4: Model Reflection of Current Costs versus the Actual Costs

NAME	Fiscal Year 2011 USPS	Model Baseline
Total Facilities	23,752	23,752
Delivery Only Facilities	592	592
Retail Only Facilities	-	-
Delivery & Retail Mixed Facilities	23,160	23,160
Square Foot for Delivery (million sq ft)	195.6	195.6
Carrier Routes	252,006	252,006
Sqft / Car	776	776
Zips	29,196	29,196
Routes / Facility	10.6	10.6
Zips / Fac	1.2	1.2
Labor Hours (Clerk, SV, PMs) (millions)	194.9	192.9
Labor Costs (Clerk, SV, PMs) (billions)	$7.88	$8.05
Transactions (billions)	1.84	1.72
Revenue (billions)	$10.21	$10.12
# of Leased Facilities	17,307	17,307
# of Owned Facilities	6,559	6,559
Lease Costs (millions)	$702.6	$721.0
Owned "Valuations" (millions)	-	$848.9
Utilities / Maintenance (millions)	$342.7	$342.8

Source: U.S. Postal Service, FY 2011 General Ledger