

ISyE 3013 Supply Chain Modeling: Logistics

Spring 2006

Homework 5

Issued: February 21, 2006

Due: March 7, 2006

100 points.

Note that this homework count double as much as most other homeworks, and that additional time is allowed for this homework. Each person must do his/her own work. No two people should make the same mistakes. Submit this homework through ITWeb at <http://itweb.isye.gatech.edu>.

Driver Workloads at Postal Express

Background

Postal Express was founded in 1990. Currently the company serves the Atlanta metropolitan region and nearby counties, and is hoping to expand to other regions in the near future. Postal Express' current target market consists of businesses and individuals in the region who want to send packages such as letters, documents, parcels, appliances etc. to destinations within the region. Customers can call the Postal Express call center to request pickups, or they can request pickups through Postal Express' web page. Either way, customer information such as customer name, pickup and delivery addresses, pickup and delivery phone numbers, number and type of packages to be picked up, and the time window within which the packages are to be picked up, are recorded. The information is transmitted in real time to a scheduler who in turn allocates the pickups to a driver.

Postal Express operates with one sortation center in Atlanta, 18 trucks and 15 drivers. Each driver handles pickups and deliveries, and usually operates within a zone with which the driver is familiar. On a typical route, a driver leaves the sortation center with a number of packages to be delivered, and a list of packages to be picked up. While a driver is busy with a route, the scheduler can allocate additional pickups to the driver, as the requests are received from customers. The scheduler performs this allocation on a computer, after which the data, including the customer name, pickup address, phone number, and number and type of packages to be picked up, are transmitted automatically to the driver's handheld computer. Upon completion of the route, the driver returns to the sortation center with the packages that were picked up. These packages are then sorted according to destination zone, and assigned to drivers for delivery. If a customer requests a package to be picked up before 10:00am, then the package can be picked up, routed through the sortation center, and delivered on the same day; if a customer requests a package to be picked up before 4:00pm, then the package can be picked up and sorted at the sortation center on the same day, but it will be delivered in the morning of the next business day; otherwise, if a customer requests a package to be picked up after 4:00pm, then the package is picked up, routed through the sortation center, and delivered on the next business day. Special provision can be made for emergency shipments (at a higher price), with response times (from pickup to delivery) of no more than 1.5 hours.

There are 4 types of packages that drivers pick up or deliver. The table below describes the types:

Type	Explanation
D	Normal drop delivery. Can be dropped in the mailbox and hence does not require the delivery-person to obtain a signature, and therefore it typically takes less time.
S	Delivery/Pickup with signature. Requires an acknowledgement signature from the person sending the package or receiving the delivery and hence requires more time. Required time is also more highly variable.
U	Pickup without signature. Requires more time than a normal drop delivery since the driver still needs to enter the building and receive the package from the sender.
O	Other. Includes pickups or deliveries that require special activities, such as appliances, and hence typically require the most stopped time.

Postal Express has enjoyed the benefits of being part of a growing industry. For part of its short history it has had bumper profits, especially during the boom times of the late 1990s. However, lately it has started to experience some of the disadvantages of being part of a growing industry, such as intense competition from other companies such as FedEx, UPS, DHL, and others. Postal Express has to compete with these companies for customers as well as for workers. Competition for customers has become more difficult as the economy has stagnated. Although the slowdown in the economy has brought about a large supply of unemployed potential workers, Postal Express and its competitors have nevertheless been struggling with the retention of workers, especially drivers. This problem is caused to some extent by the perception among workers that the assignment of work to drivers is done in an arbitrary and unfair way. In addition, it takes some time for a driver to become familiar with the zone in which the driver operates, including its traffic patterns, one-way streets, timing and extent of congestion, and timing of traffic lights, and thus it is costly for Postal Express (and its competitors) to hire and train new drivers.

Decision support for scheduling drivers

Postal Express' scheduler needs a decision support tool to facilitate improved workload design for drivers. Such a decision support tool should perform many functions, including the assignment of pickups and deliveries to drivers, and the design of routes for each driver. **As a first step, a model has to be developed to accurately estimate the time that it will take a particular driver to complete a given route of pickups and deliveries.**

To enable such a model to be developed, Postal Express hired an industrial engineering consulting firm to collect the necessary data. For the past 3 months employees of the consulting firm have traveled with the drivers on their routes and have recorded data, using motion and time study methods with stopwatches, barcode readers, and computers, about the different activities which are performed by drivers in the process of making pickups and deliveries.

A small subset of the data is given in the file `driverdata.txt`. Appendix 1 describes the contents of the fields in the data set.

Since the data has been collected in the real world, there are some inconsistencies in the data, which need to be taken into account and dealt with. For example, the data collected about the miles traveled between stops is of integer type, and unfortunately all distances within one mile have been truncated to zero. This data characteristic has to be dealt with.

The next step is to develop a model to accurately estimate the time that it will take a given driver to complete a given set of pickups and deliveries on a given route. Specifically, the model should take as input the following:

1. The ID of the driver.
2. The list of pickups and deliveries to be completed by the driver, including the number and type of packages involved with each pickup or delivery, and the zone in which each pickup or delivery is to take place. (The purpose of the zone data is to enable the model to capture the effect of the zone in the city on the time that the driver will take, as average travel speeds vary significantly with zone in the city.)
3. The distances to be traveled by the driver between successive pickup or delivery points, including the distance to be traveled from the sortation center to the first pickup or delivery point, and the distance to be traveled from the last pickup or delivery point back to the sortation center.

The model should provide as output the following:

1. An estimate of the time that it will take the driver to complete the specified set of pickups and deliveries.
2. An estimate of the standard deviation of the time estimated above.

What You Have To Do

1. Inspect the data, describe any inconsistencies found, and explain how you dealt with any problems.
2. Estimate two regression models to forecast the time that it will take a given driver to complete a given set of pickups and deliveries on a given route, as described above. You should analyze the data, use plots, and conduct tests to determine the appropriate forms of the explanatory variables for the models. Explain why you decided to use the particular forms of the explanatory variables (factors) in the models. Evaluate and compare the models.
3. For each of the work schedules below, use one of your models to forecast the time that the driver will take to complete the work in the schedule. (Note: When the driver returns to the depot, the driver has to deliver at the depot all the packages that were picked up on the route.)
4. Estimate the standard error of each of your time forecasts above.
5. The length of a driver shift is 3.5 hours. Estimate the probability for each of the work schedules below that the driver's work time will exceed the length of a shift.
6. For each of the work schedules below, estimate the time $\tau_{0.8}$, such that with probability 0.8, the driver will be able to complete the work in the schedule in an amount of time no more than $\tau_{0.8}$.
7. Consider a situation often faced by the Postal Express scheduler. The scheduler has already dispatched the drivers with some assigned tasks in the morning. At some point in the morning it receives another request from a customer requiring a pickup before the end of the current

shift. The scheduler has to assign the best driver to make this pickup. It is up to you to decide how to determine the best driver, but you should take into account both the additional distance traveled as well as the probability that the additional assignment will cause a driver to work overtime. How can the scheduler use your models as an aid to decide which driver to assign to the new pickup request?

Consider the following example: The scheduler receives a request for a pickup (type O) of 11 packages at a location in zone 3406. Drivers fred and lisa already have the pickups and deliveries scheduled that are given below. If Driver fred is assigned to the new pickup request, then it will require Driver fred to travel an additional distance of 10 miles, and if Driver lisa is assigned to the new pickup request, then it will require Driver lisa to travel an additional distance of 1 mile. The cost per mile of travel is \$1 per mile. If a driver works overtime, then the driver has to be paid an additional fixed amount of \$25. For each of the drivers, use one of your models to estimate the expected additional cost if the driver is assigned to the new pickup request, and determine the best driver to do the new pickup.

(a) Schedule 1, Driver fred:

- depart from depot, drive 4 miles in zone 3403, pick up 2 packages without signature,
- drive 2 miles in zone 3403, deliver 4 packages with signature,
- drive 3 miles in zone 3405, pick up 5 packages without signature,
- drive 2 miles in zone 3405, pick up 1 “other” package with signature,
- drive 1 mile in zone 3405, deliver 14 packages with signature,
- drive 1 mile in zone 3403, pick up 2 packages with signature,
- drive 2 miles in zone 3403, deliver 12 packages with signature,
- drive 1 mile in zone 3405, pick up 3 packages without signature,
- drive 3 miles in zone 3405, pick up 5 packages with signature,
- drive 1 miles in zone 3405, deliver 10 packages with signature,
- drive 1 mile in zone 3405, deliver 2 packages without signature,
- drive 4 mile in zone 3403, pick up 4 packages without signature,
- drive 2 miles in zone 3403, deliver 1 “other” package with signature,
- drive 1 mile in zone 3403, pick up 2 packages without signature,
- drive 1 mile in zone 3403, pick up 7 packages without signature,
- drive 2 miles in zone 3403, deliver 2 packages without signature,
- drive 4 miles in zone 3403, arrive at depot.

(b) Schedule 2, Driver lisa:

- depart from depot, drive 16 miles in zone 2701, deliver 3 packages with signature,
- drive 4 miles in zone 2701, pick up 5 packages without signature,
- drive 2 miles in zone 2701, deliver 1 “other” packages with signature,
- drive 5 miles in zone 2702, deliver 6 packages with signature,
- drive 1 mile in zone 2702, deliver 1 package without signature,
- drive 1 mile in zone 2702, deliver 3 packages without signature,
- drive 2 miles in zone 2702, deliver 5 packages with signature,
- drive 1 miles in zone 2702, pick up 2 “other” packages with signature,
- drive 1 miles in zone 2702, pick up 12 packages with signature,

- drive 2 miles in zone 2702, deliver 3 packages without signature,
- drive 1 miles in zone 2701, deliver 14 packages with signature,
- drive 2 miles in zone 2701, pick up 4 packages without signature,
- drive 3 miles in zone 2701, pick up 5 packages with signature,
- drive 2 miles in zone 2701, pick up 1 package without signature,
- drive 1 mile in zone 2701, arrive at depot.

Appendix 1

Description of the data fields in the dataset collected by the industrial engineering consultants:

1. **Date:** The date on which the data for the driver was collected.
2. **Driver Name:** ID of the driver
3. **Event:** The event for which the measurement was made. The event is either a delivery, denoted by DEL, or a pickup, denoted by PU.
4. **Total Actual Time:** The measured time taken to complete the event.
5. **Total Planned Time:** The standard time predicted by a previous motion and time study to complete the event. (You may compare your predicted times with these times predicted by the old study to check whether you can at least do better.)
6. **Unit #:** The identification number of the zone in the city where the driver was traveling.
7. **Stop Type:** The ID for the type of stop. Its value can be D for Delivery only (without signature), S for Pickup/Delivery with signature, U for Pickup only without signature, and O for other.
8. **# of Packages:** The number of packages picked up or delivered at the stop.
9. **Miles:** The number of miles that the driver traveled prior to the stop.