

ISyE 6203 Transportation and Supply Chain Systems

Spring 2016

Homework 3

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50 points.

Postal Express was started in 1990 with operations in Atlanta. Currently they serve the southeastern United States, and is planning to expand to the rest of the continental United States in the near future. Their current target market consists of businesses and individuals in the city region who want to send packages such as letters and parcels with weight less than 25kg and size less than $2m \times 0.5m \times 0.5m$ between origins and 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 and delivered, are recorded. The information is transmitted in real time to the scheduler who in turn allocates the pickups to a driver.

Postal Express operates with one sortation center (depot) in Atlanta, 50 trucks and 55 drivers. The trucks and drivers do pickups and deliveries of packages, typically in a zone that the driver is familiar with. On a typical route, a driver leaves the sortation center with a number of packages that the driver has to deliver, and a list of packages that the driver has to pick 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 does the 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, as follows:

Type	Explanation
D	Normal drop delivery. This delivery can be dropped in the mailbox and hence does not require the person to go inside and get a signature. Hence it typically takes less time.

S	Delivery/Pickup with Signature. This type requires an acknowledgement signature from the person sending the package or receiving the delivery and hence has higher times and also has higher variability in times.
U	Pickups without signature. Because such a pickup does not require a signature, it takes less time than a pickup with a signature, but it still takes more time than a delivery without a signature because the driver needs to go inside the place and take the package from the sender.
O	This type includes pickups or deliveries which require special activities, such as pickups or deliveries where the driver has to go through security, and hence these typically take the most time of all types of stops.

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 nineties and mid 2000's. However, lately it has started to experience some of the disadvantages of being part of a competitive 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 the traffic patterns, timing and extent of congestion, timing of traffic lights, and one-way streets, and thus it is costly for Postal Express (and its competitors) to hire and train new drivers.

The 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 set of pickups and deliveries on a given route.

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.

As the data have 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 the successive 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.
3. An estimate of the cut-off time such that with probability 0.8 it will take the driver less time than the cut-off time to complete the specified set of pickups and deliveries.

What You Have To Do

1. Inspect the data, describe the data problems found, and explain how you dealt with these problems.
2. Estimate two models to estimate 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 in the models. Evaluate and compare the models, using appropriate statistical tests and your common sense. For example, you may consider the hypothesis that some drivers drive significantly faster than other drivers. Show how you use the data to test this hypothesis, and other hypotheses that you should propose, and how you use the results to choose your eventual models.
3. For each of the following work schedules, use your models to estimate the time $t_{0.8}$, 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 $t_{0.8}$. (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.)
 - (a) Schedule 1, Driver harg:
 - depart from depot, drive 4 miles in zone 2801, pick up 4 packages with signature,
 - drive 3 miles in zone 2803, deliver 13 packages with signature,
 - drive 1 mile in zone 2803, pick up 5 packages without signature,
 - drive 2 miles in zone 2804, pick up 12 “other” packages with signature,
 - drive 3 miles in zone 2805, deliver 8 packages without signature,
 - drive 1 mile in zone 2805, deliver 23 packages with signature,
 - drive 1 mile in zone 2805, deliver 11 packages without signature,
 - drive 2 miles in zone 2805, pick up 10 packages without signature,
 - drive 3 miles in zone 2804, deliver 15 packages with signature,
 - drive 1 mile in zone 2804, pick up 7 packages without signature,
 - drive 1 miles in zone 2805, deliver 2 packages without signature,

- drive 2 mile in zone 2805, deliver 4 packages with signature,
- drive 1 mile in zone 2805, pick up 12 “other” packages with signature,
- drive 2 miles in zone 2805, pick up 3 packages without signature,
- drive 2 miles in zone 2804, deliver 4 packages with signature,
- drive 2 mile in zone 2803, deliver 2 packages without signature,
- drive 1 mile in zone 2803, deliver 1 package with signature,
- drive 8 miles in zone 2801, arrive at depot.

(b) Schedule 2, Driver heft:

- depart from depot, drive 16 miles in zone 2701, deliver 15 packages with signature,
- drive 4 miles in zone 2702, pick up 10 packages without signature,
- drive 2 miles in zone 2702, deliver 20 packages with signature,
- drive 1 mile in zone 2702, pick up 13 packages without signature,
- drive 1 mile in zone 2702, pick up 5 packages with signature,
- drive 4 miles in zone 2704, deliver 14 packages without signature,
- drive 2 miles in zone 2704, pick up 12 “other” packages with signature,
- drive 3 miles in zone 2704, deliver 13 packages without signature,
- drive 1 mile in zone 2704, deliver 5 packages without signature,
- drive 2 miles in zone 2704, deliver 7 packages with signature,
- drive 1 mile in zone 2704, pick up 8 packages with signature,
- drive 5 miles in zone 2702, deliver 6 “other” package with signature,
- drive 1 mile in zone 2702, pick up 7 packages without signature,
- drive 14 miles in zone 2701, arrive at depot.

4. 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 10 packages at a location in zone 3406 which is 9 miles from the last delivery stop scheduled for Driver smit for the shift and 7 miles from the last pickup stop scheduled for Driver wynn for the shift. The distance from the new pickup location to the depot is 11 miles for both drivers. For both drivers, overtime starts if all tasks together take the driver more than 7.5 hours. These drivers already have the following pickups and deliveries scheduled.

(a) Schedule 3, Driver smit:

- depart from depot, drive 7 miles in zone 3403, deliver 14 packages with signature,
- drive 4 miles in zone 3403, deliver 23 “other” packages with signature,
- drive 6 miles in zone 3403, pick up 14 packages without signature,
- drive 5 miles in zone 3404, pick up 15 packages without signature,
- drive 2 miles in zone 3404, pick up 11 “other” packages without signature,

- drive 4 miles in zone 3404, deliver 9 packages with signature,
- drive 6 miles in zone 3403, pick up 7 packages with signature,
- drive 3 miles in zone 3403, deliver 12 packages with signature,
- drive 4 miles in zone 3404, pick up 8 packages without signature,
- drive 2 miles in zone 3404, pick up 5 packages with signature,
- drive 6 miles in zone 3404, deliver 10 packages with signature,
- drive 7 miles in zone 3404, deliver 4 packages without signature,
- drive 4 mile in zone 3403, pick up 4 packages without signature,
- drive 2 miles in zone 3403, deliver 9 “other” packages with signature,
- drive 5 miles in zone 3403, pick up 6 packages without signature,
- drive 6 miles in zone 3403, pick up 7 packages without signature,
- drive 4 miles in zone 3403, deliver 2 packages without signature,
- drive 8 miles in zone 3403, arrive at depot.

(b) Schedule 4, Driver wynn:

- depart from depot, drive 16 miles in zone 3403, deliver 12 packages with signature,
- drive 9 miles in zone 3403, pick up 14 packages without signature,
- drive 4 miles in zone 3403, deliver 12 packages without signature,
- drive 11 miles in zone 3403, pick up 5 packages without signature,
- drive 6 miles in zone 3405, pick up 10 packages without signature,
- drive 2 miles in zone 3405, deliver 6 “other” packages with signature,
- drive 5 miles in zone 3405, deliver 9 packages with signature,
- drive 8 miles in zone 3405, deliver 1 package without signature,
- drive 1 mile in zone 3405, deliver 8 packages without signature,
- drive 12 miles in zone 3405, deliver 5 packages with signature,
- drive 3 miles in zone 3405, pick up 3 “other” packages with signature,
- drive 7 miles in zone 3405, pick up 11 packages with signature,
- drive 5 miles in zone 3405, deliver 13 packages without signature,
- drive 4 miles in zone 3405, deliver 8 packages with signature,
- drive 6 miles in zone 3405, pick up 5 packages without signature,
- drive 8 miles in zone 3403, pick up 5 packages with signature,
- drive 3 miles in zone 3403, pick up 10 packages without signature,
- drive 12 miles in zone 3403, arrive at depot.

Use your models to determine the best driver to do the new pickup. Motivate your recommendation with results obtained from your models.

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's Name : ID of the driver
3. Event : The event for which the measurement was made. The event is either departing the sortation center, denoted by "Inside AM", starting the vehicle, denoted by "KEY-ON", stopping the vehicle, denoted by "KEY-OFF", a delivery, denoted by "DEL", a pickup, denoted by "PU", or arriving at the sortation center, denoted by "Inside PM".
4. Total Actual Time : The measured time taken to complete the preceding activity, in hours. For example, together with "KEY-OFF" is the time taken to drive the specified distance before the "KEY-OFF" 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.
10. Count : It is just a field to count the number of observations taken.