

Outline

- Roles for Cost Models
- Conventional Model Types
 - Fully Allocated Causal Factor Models
 - Temporal Variation Models
 - Incremental Fixed Variable Cost Models

- Predict cost change associated with a service change
 - concerned with marginal (incremental) costs
 - different results over different time periods
 - routine performance monitoring/service policy triggers
- Predict cost change associated with change in production process
 - introduce part-time operators
 - contract out maintenance work
 - contract out suburban routes
 - new fare technology
- Subsidy allocation among jurisdictions
 - fairly allocate joint or overhead costs
 - often critical to participation decision in regional transit authority and even route level of service

Capital Costs

- Vehicles
- Fixed facility construction -- track, garages, stations
- Other long term physical assets

Operating Costs

- Labor wages and benefits
- Materials and supplies
- Agency administration
- Other expenses incurred in operations

1. Fully allocated causal factor models
2. Temporal variation models
3. Incremental fixed/variable cost models

MIT Fully Allocated Causal Factor Models

1. Select causal factors: e.g. vehicle hours, vehicle miles, and peak vehicles.
2. Assign each expense type to appropriate factor. e.g. operator wages and benefits assigned to vehicle hours, fuel assigned to vehicle miles, administration assigned to peak vehicles
3. Calculate average costs per unit of Factor A, B, and C:

e.g. $A = \frac{\text{costs assigned to vehicle hours}}{\text{total vehicle hours}}$ etc.

4. Define cost model as:

$$\text{cost} = (A * \text{vehicle hours}) + B * (\text{vehicle miles}) + (C * \text{peak vehicles})$$

1.258J 11.541J ESD.226J
Lecture 7, Spring 2017

5

MIT Fully Allocated Approach: MBTA 1996 Cost Model: Motor Bus

Basis of Assignment	F/V	Cost Assigned (\$ M)	% of Total	Operating Stat. (Annual)	Unit Costs
Rev. Veh Hours	V	79.0	45.5	2.13 million	37.13
	F	5.7	3.3		2.69
Rev. Veh Miles	V	50.0	28.8	22.0 million	2.27
	F	3.0	1.7		0.14
Peak Vehicles	F	35.9	20.7	775	\$46,323
Total		173.6			

Possible Cost Models:

$$\text{Full Annual Cost} = (39.82 * \text{Rev Veh Hrs} + 2.41 * \text{Rev Veh Miles}) * 1.261$$

$$\text{Full Annual Cost} = (39.82 * \text{Rev Veh Hrs} + 2.41 * \text{Rev Veh Miles}) + (46,323 * \text{Peak Veh})$$

$$\text{Variable Annual Cost} = (37.13 * \text{Rev Veh Hrs} + 2.27 * \text{Rev Veh Miles})$$

1.258J 11.541J ESD.226J
Lecture 7, Spring 2017

6

MIT Temporal Variation Models

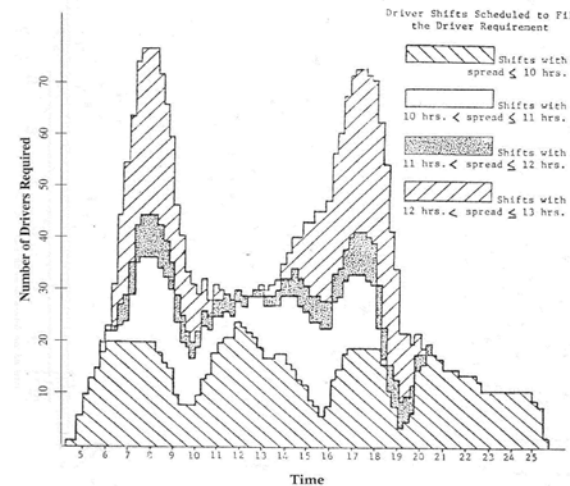
1. Follow fully allocated causal factor model procedure for all except operator (crew) costs.
2. To estimate operator costs, for each 30-min time period t :
 - a. identify all runs, i , with at least 15 minutes of vehicle time in period t
 - b. for each run i compute the average pay per vehicle hour by dividing daily pay W_i by vehicle hours H_i
 - c. find the minimum, average and maximum pay per vehicle hour in period t . Average given by:

$$W_t = \frac{\sum_{i=1}^n \left(\frac{W_i}{H_i} \right)}{n}$$

1.258J 11.541J ESD.226J
Lecture 7, Spring 2017

7

MIT The Driver Requirement for One MBTA Garage



Herzenberg, A.: *Methods of Estimating the Costs of Drivers' Wages for Bus Service*. *Transportation Research Record 947*, 1983, pp. 7-14.

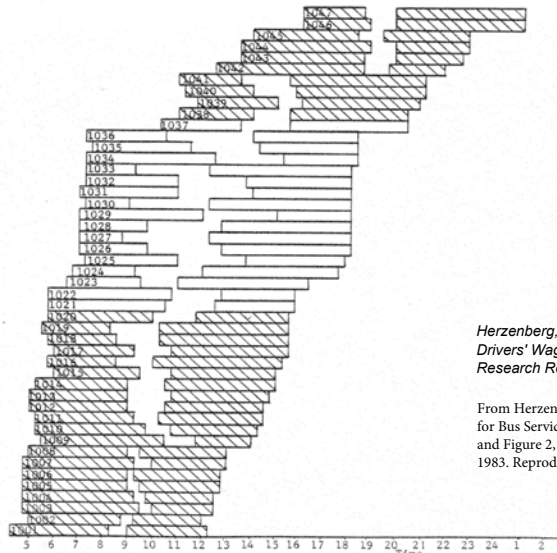
From Herzenberg, A. Method for Estimating the Costs of Drivers' Wages for Bus Services. In *Transportation Research Record 947*, Figure 1, p. 9 and Figure 2, p. 11. Copyright, National of Sciences, Washington, D.C., 1983. Reproduced with permission of the Transportation Research Board.

The figure shows the driver requirement for the Charlestown garage for the schedule period beginning June 22, 1981

1.258J 11.541J ESD.226J
Lecture 7, Spring 2017

8

MIT Driver Runs for One MBTA Garage

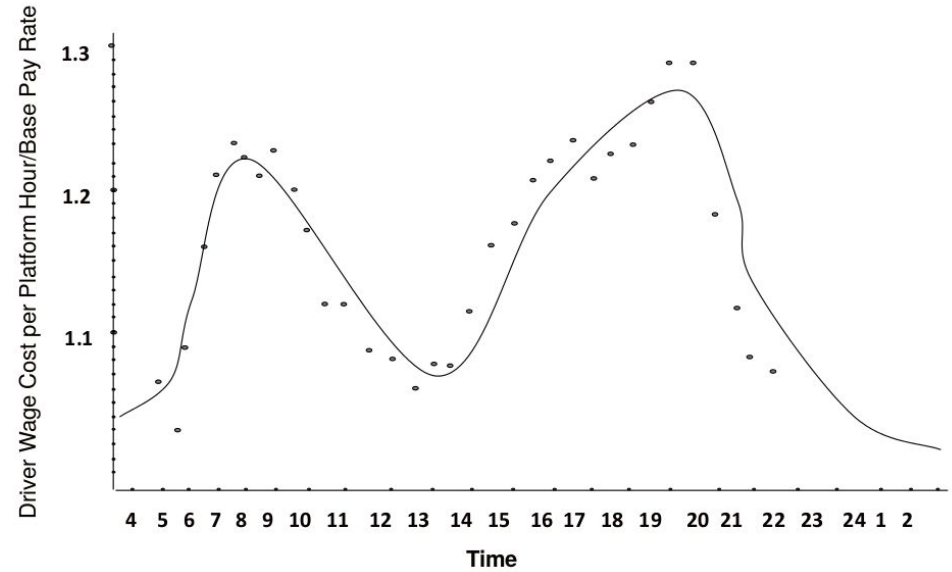


Herzenberg, A.: *Methods of Estimating the Costs of Drivers' Wages for Bus Service.* Transportation Research Record 947, 1983, pp. 7-14.

From Herzenberg, A. Method for Estimating the Costs of Drivers' Wages for Bus Services. In Transportation Research Record 947, Figure 1, p. 9 and Figure 2, p. 11. Copyright, National of Sciences, Washington, D.C., 1983. Reproduced with permission of the Transportation Research Board.

*The exhibit shows the driver runs for the Charlestown Garage for the schedule period beginning June 22, 1981.

MIT Wage per Platform Hour for MBTA Drivers



MIT Cost Estimation Exercise

For an agency which cannot employ part-time operators, the following operator costs have been determined based on an analysis of existing operator runs:

	Peak	Off-peak	Combined
Minimum cost/operator hour	\$30	\$30	\$30
Average cost/operator hour	\$38	\$31	\$35
Maximum cost/operator hour	\$45	\$33	\$45

What would you estimate the incremental cost impact per operator hour to be for the following possible service changes:

1. Proportional increases in both peak and off peak services.
2. Proportional decreases in both peak and off peak services.
3. Increases in peak period services only.
4. Decreases in peak period services only.
5. Increases in off peak period services only.
6. Decreases in off peak period services only.

MIT Allocation of Fixed Costs Example: MBTA Bus (1996)

Total fixed costs to be allocated (see p. 8) = \$44.6 mill

	Weekday	Sat	Sun		
	Peak	Base	Evening		
# Buses operating	775	375	250	375	250
Hours/day	4.5	6	4	12	12

1. Allocate share of fixed costs for 250 buses across all time periods:

- Share of fixed costs to be allocated $250/775 = 32\%$
- Fixed costs to be allocated = $44.6 \times 0.32 = \$14.4$ mill
- Annual bus hours operated by 250 buses
 $= 250(\text{wkday hrs} + \text{Sat hrs} + \text{Sun hrs})$
 $= 250(14.5 \times 250 + 12 \times 58 + 12 \times 57)$
 $= 1.25$ mill
- Average Cost/bus hour = \$11.52

MIT Allocation of Fixed Costs Example: MBTA Bus (1996)

- Allocate share of fixed costs for next 125 buses across all time periods except Sundays and weekday evenings
 - Fixed costs to be allocated = $44.6(125/775) = \$7.2$ mill
 - Annual bus hours operated by 125 buses = $125(10.5*250 + 12*58) = 0.42$ mill
 - Average Cost/bus hour = \$17.14
- Allocate remaining fixed costs to weekday peak service:
 - Fixed costs to be allocated = \$23 mill
 - Annual bus hours operated by peak buses only = $400*4.5*250 = 0.45$ mill
 - Average Cost/bus hour = \$51.11
- Fixed costs will increase the variable vehicle hourly cost (\$37.13) by:
 - \$11.52 for Sunday/evening service
 - \$13.97 for Saturday and weekday base service ($11.52*250/375 + 17.14*125/375$)
 - \$32.86 for weekday peak service ($11.52*250/775 + 17.14*125/775 + 51.11*400/775$)

MIT Comparison of Traditional and Peak/Base Models: MBTA 1996 Cost Model: Motor Bus

- Traditional Model
 - Full Annual Cost = $((39.82*Rev Veh Hrs)+(2.41*Rev Veh Miles)) *1.261$
- Variable Cost Model:
 - Variable Cost = $(37.13*Rev Veh Hrs)+(2.27*Rev Veh Miles)$
- Peak Period Model:
 - Full Annual Peak Cost = $(69.99*Peak Rev Veh Hrs) + (2.41*Peak Rev Veh Miles)$
- Off-Peak Period Model:
 - Full Annual Base Cost = $(50.04*Off-Peak Rev Veh Hrs) + (2.41*Off-Peak Rev Veh Miles)$

MIT Incremental Fixed/Variable Models

- Classify costs on the basis of variable, semi-variable, and fixed as well as the causal factors.
- Determine unit costs for each cell of the matrix.

	Variable	Semi-Variable	Fixed
Vehicle Hours	X	X	X
Vehicle Miles	X	X	X
Peak Vehicles	X	X	X

- Apply the 9 variable cost model.

MIT Fixed/Variable Approach Example Expense Assignment

Expense	Resource			Cost Type		
	Bus Hours	Bus Miles	Peak Buses	Variable	Semi-Variable	Fixed
Crew Wages	x			x		
Vehicle Servicing			x	x		
Fuel		x		x		
Tires		x		x		
Insurance		x		x		
Traffic Staff	x				x	
Misc. Traffic Expenses	x				x	
Maintenance Supervisors		x			x	
Vehicle Maintenance		x			x	
Workshop Expenses		x			x	
Tickets			x		x	
Publicity			x		x	
Vehicle Depreciation			x		x	
Licenses			x		x	
Vehicle Leasing			x		x	
Administrative Staff Costs			x			x
Rent			x			x
Building Maintenance			x			x
Building Utilities			x			x
Staff Cars			x			x
General Expenses			x			x

MIT OpenCourseWare
<https://ocw.mit.edu/>

1.258J / 11.541J Public Transportation Systems
Spring 2017

For information about citing these materials or our Terms of Use, visit: <https://ocw.mit.edu/terms>.