4545 Review Questions - Set 6: congested roads and parks

May 1, 2008

1. Considering efficiency and equity, develop a scheme to achieve the efficient amount of congestion in Yellowstone National Park. As part of your answer, explain what you mean by the efficient amount of congestion. Remember that many people use their limited vacation time to travel large distances to visit Yellowstone.

2. Define congestion

3. Argue that the efficient congestion toll on many roads is zero.

   answer: On many roads the amount of traffic is sufficiently low such that the marginal car has no, or very little, effect on speed of the other cars. As an aside note that if tolls are put on roads that currently have a lot of congestion this will cause cars to shift to roads that were previously uncongested, possibly warranting tolls on these other roads. In theory, tolls should be simultaneously considered for all roads taking account of the fact that increasing the toll on a road will affect the demand for other roads. For many road the optimal toll will be zero.

4. Assume the noted environmental economist Doctor Val Useless has determined that the efficient number of cars in Yellowstone is 5000 per day. His recommendation is that there be no entry fee or reservation system, and everyday the park closes the gate after the 5000th car enters. Assume once a car enters it stays all day, and assume he got the number correct. Discuss whether his method of achieving the efficient number of cars (5000) is efficient. Discuss how, under his scheme, the benefits and costs of visiting Yellowstone by car will be distributed across the U.S. population and who, will and who won't visit the park.

   answer: While Val' scheme will achieve the efficient number of cars to the park, it will not achieve the goal at minimum cost to society – it will not achieve the goal of 5000 cars efficiently. Put simply, we could make everyone, or almost everyone, better off by replacing Val's queue with a reservation system. In explanation, with Val's scheme, every morning there will be a race to the gate (people will likely sleep in their cars). Put, simply, many hours will be wasted sitting in line, and the time is by people with limited vacation time who have already spent many hours in the car driving to Yellowstone. Some people will drive thousands of miles only to not to get in – what a waste. The people who get in will be those with the lowest value of time; that is, those with the greatest willingness to wait. Since kids have trouble sitting for hours in a car without driving their parents crazy, the scheme biases against children, also people with high hourly wages, like lawyers and Finance professors. A lot of the visitors would be retired people with campers or Winnebagos.

Consider an alternative scheme (like the one used for campgrounds in Yellowstone): one goes online and reserves a spot for a particular day – spots are limited to 5000 a day. In this case, there would be the efficient number of cars/visitors and the efficient number would be achieved at a much lower cost: no or little waiting time at the gate, demonstrating that Val's scheme is not efficient. There would be a fine if one did not show up, and failed to cancel the reservation.

Note that I am not saying that an online reservation system with free admission is efficient, just that it is more efficient than Val's scheme, so Val's scheme is not efficient. One could increase the efficiency of a reservation system with free admission if one allowed individuals with reservations to scalp them on Ebay. People with high WTP to get in would buy reservations from those with lower WTP and both parties would be better off.

An issue with free admissions, reservations and Ebay is that the park would get no money and a lot of the benefits of Yellowstone would go to scalpers – this is an equity issue, not an efficiency issue. Yellowstone could limit cars to 5000 by charging an admission fee that would make just 5000 cars want to enter (it would likely have to vary by day of week, etc.). This would achieve efficiency, as long as one could buy tickets in advance for the day you want (a reservation system with a price – like buying concert tickets). Entry would go to the 5000 cars with the highest WTP.

Note that if you get in the park and I do not, and my WTP to visit the park is greater than yours, things are not efficient. I could pay an amount to switch places that would make both of us better off, and no one else worse off.

The park could efficiently achieve the efficient number of cars get more money if, instead of charging everyone the same admission fee, they ran an auction for each day's visitors. Everyone who wants to go next Tuesday enters into a second-price auction. You state your bid/WTP for a ticket. The top 5000 bids get a ticket but you don't pay what you bid, rather you pay what the next highest bidder paid. For example, if your bid was the highest ($5000) and the next highest bid was $20, you would pay $20 for the ticket, not $5000. This is how Ebay auctions work.

Note how the Rockies world-series tickets were sold.

5. Imagine there are roads that you from Here to There. Explain without math or graphs the equilibrium allocation of cars between the two roads.

   answer: In general, equilibrium will be when the cars are allocated across the two roads such that average travel time is the same on both roads. Otherwise, some drivers will be trying to switch roads and it won't be an equilibrium.

   Note that the question asks for the equilibrium allocation of cars between the two road. The equilibrium allocation and the efficient allocation are not necessarily the same thing.

6. Consider two roads that go from here to Longmont: a wide road that takes 60 minutes, independent of the level of use and a narrow road where how long it takes depends on the number of trucks on the road. Assume 100 trucks need to get from here to Longmont every day. Specifically assume that the total amount of time it takes T trucks to get to Longmont if they take the narrow road is $C_n(T) = 2T + \beta T^2$.

Assume $B = .2$. If trucks are efficiently allocated between the two roads, how many trucks will take the narrow road? Make sure you explain and provide intuition for your answer.

How many trucks will take the narrow road if it is a common property resource? What is going on?

Now assume $\beta = .6$. If trucks are efficiently allocated between the two roads, how many trucks will take the narrow road? Make sure you explain and provide intuition for your answer. How many trucks will take the narrow road if it is a common property resource?

For the case where $\beta = .2$, how would you regulate access to the road so as to achieve the efficient allocation between the two roads? Convince the reader that your solution would work.

What did you learn from this exercise?

Answer:

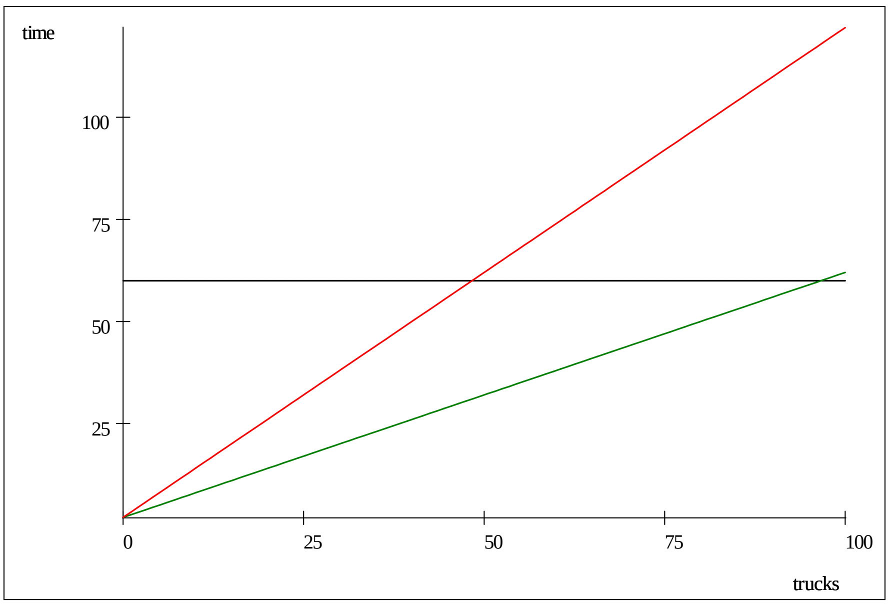
The marginal cost of T trucks on the narrow road is $MC_n(T) = 2 + 2\beta T$ and the average cost is $AC_n(T) = 2 + \beta T$. The degree to which the narrow road is congestible is an increasing function of β. If $\beta = .2$, the narrow road is not very congestible. The marginal cost if there are 100 trucks on the narrow road is $MC_n(100) = 2 + 2(.2)100 = 42.0$ minutes, which is less than 60 minutes. So, in this case, efficiency dictates that all of the trucks take the narrow road - the narrow road is faster even if all the trucks take it.

If the narrow road is common property, all 100 trucks will take the narrow road; it will take $AC_n(100) = 2 + .2(100) .= 22.0$ minutes for each truck, and the common-property solution is efficient. In this case, there is no need to control access. For many roads, the efficient toll is likely zero.

Alternatively, if $\beta = .6$ the narrow road is quite congestible. In this case $MC_n(T) = 2 + 1.2T$ and $AC_n(T) = 2 + .6T$. If access to the narrow road is uncontrolled (common property), trucks will allocate themselves across the two road until in equilibrium average speed on both road is 60 minutes. That is, until $AC_n(T) = 2 + .6T = 60$, Solution is: 96.667, That is, 97 trucks will take the narrow road and 3 will take the wide road.

But this is not the efficient allocation of trucks. The trucks will be efficiently allocated between the two roads when the marginal cost of driving on the narrow road is 60. Solving $60 = 2 + 1.2T$, Solution is: 48.333. There are way too many truck on the narrow road if it is common property.

Graphing all of this

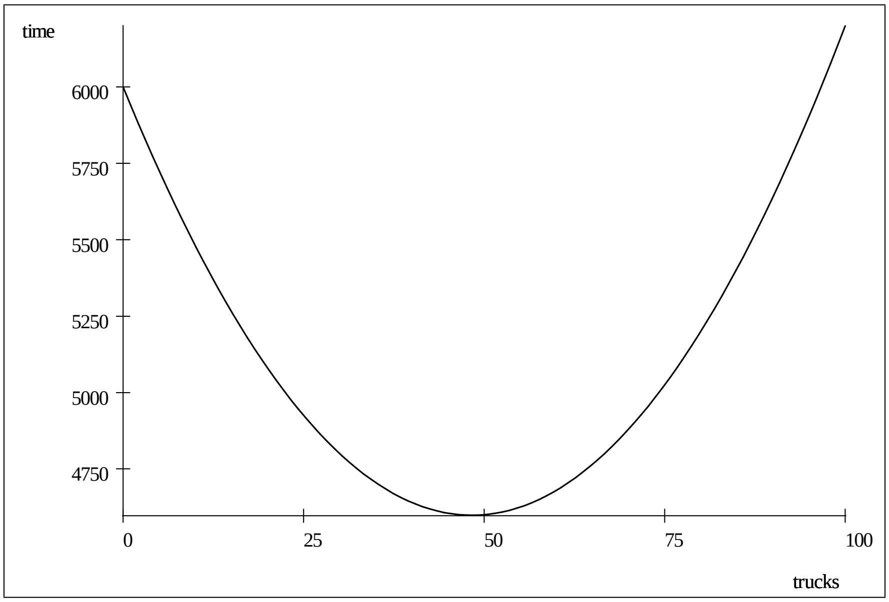


where the green line is $AC_n(T)$ and the red, steeper line is $MC_n(T)$

When $\beta = .6$, how much travel time is lost by the market failure? Total travel time for the 100 trucks is

$$\begin{aligned} C_{w+n}(T) &= C_n(T) + 60(100 - T) \\ &= 2T + \beta T^2 + 60(100 - T) \end{aligned}$$

This is what we want to minimize. Graphing $C_{w+n}(T)$ assuming $\beta = .6$



One can see that total travel time is minimized if only 48 trucks take the narrow road. How much time is wasted if the narrow road has uncontrolled access. Compare $C_{w+n}(96.667)$ and $C_{w+n}(48.33)$.

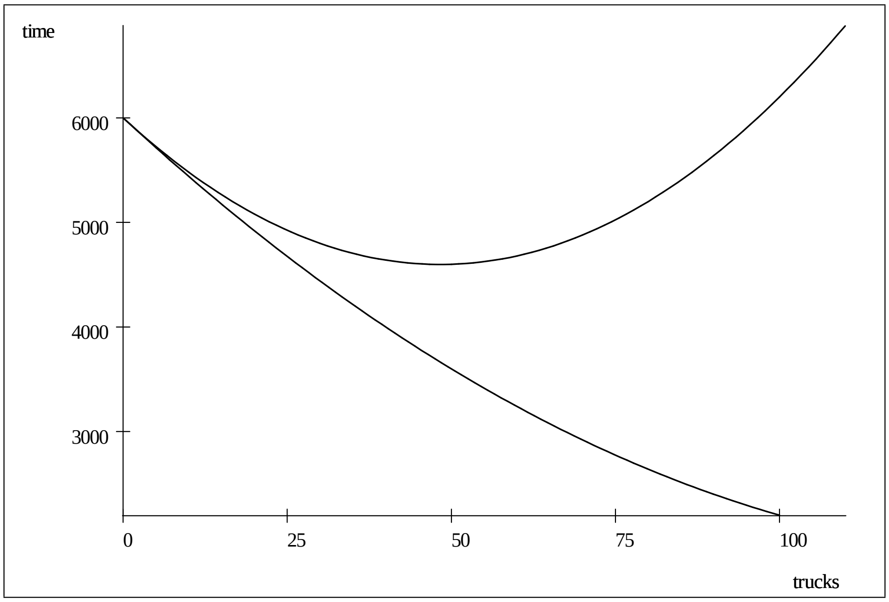
$$C_{w+n}(96.667) = 2(96.667) + .6(96.667)^2 + 60(100 - 96.667) = 6000.0$$

and

$$C_{w+n}(48.33) = 2(48.33) + .6(48.33)^2 + 60(100 - 48.33) = 4598.3$$

$6000 - 4598.3$: 1401.7 minutes are wasted everyday because the narrow road is common property.

Compare total travel time for the 100 trucks for β and .6 and $\beta = .2$ When $\beta = .6$ efficiency dictates 48 trucks on the narrow road, when $\beta = .2$, efficiency dictates 97 trucks on the narrow road.



Obviously, if we could choose at zero cost, we would prefer $\beta = .2$ rather than .6.