A brief introduction to marginal analysis for the micro-economics principles course

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ABSTRACT

This brief note provides a simple, yet powerful example of how the marginal cost/marginal benefit principle can be used in everyday life. Using the decision of the optimal choice of speed on the highway, this note was developed for use as one of the first readings in an introductory microeconomics course. It is clear in this demonstration that marginal cost is increasing, while marginal benefit is decreasing, and how the intersection of these two curves shows the optimal choice. In addition, shifts in the curves can easily be demonstrated as an introduction to supply and demand.

Introduction

While each individual must make their own decision about how fast to drive, some general economic principles should be kept in mind. Here we describe some factors that enter into the decision.

In general, we can boil down the costs and benefits of driving faster than the speed limit this way: Driving faster benefits us by saving time, but results in an increased risk of receiving a ticket and the associated pecuniary and non-pecuniary costs of a ticket. Additionally, as one drives faster there is an increased risk of an accident, and increased fuel costs. Most drivers ignore the increased fuel costs: While the cost of gas is significant, the *marginal* cost of fuel from driving faster is fairly small.[2] When a cost is so small that we can ignore it for decision-making purposes, economists usually call it a "*second-order*" cost.

Let us construct a simple *model* for driving. Suppose that we need to drive exactly 60 miles, and get exactly 30 miles to the gallon. The road that we will be driving on has a speed limit of 55. The total cost of driving this distance will be 2 gallons of gas, plus some wear and tear on the vehicle, plus the value of our time. Therefore, the benefits of driving faster are reductions in this driving time.

The Marginal Benefit of Driving Faster

If we drive 55miles per hour, we can calculate the time that the trip will take in the following manner:

(1) distance = speed*time , therefore

(2) $\text{time} = \dfrac{\text{distance}}{\text{speed}}$, so time =60/55 = 1.091 hours.

It may be more convenient to calculate the time in minutes. To do this, divide the speed by 60:

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[2] The wind resistance on a vehicle is proportional to the square of speed, so you will use a little more gas per mile as you drive faster. In 1973 Richard Nixon signed a bill into law requiring a national speed limit of 55mph in order to save gasoline. Although repealed partially in 1987 and altogether in the 1990's, in July 2008 a bill was filed in the U.S. Congress to reinstate a national speed limit.

(3) $\text{time} = \frac{60}{55/60} = \frac{3600}{55} = 65.45 \text{ minutes.}$

Should we drive faster? We first need to calculate the marginal benefit of driving faster. That is, we need to figure out how much additional time we save each time we go a little faster. We can start by calculating the time difference of increasing/decreasing our speed from 55 miles per hour in increments of 2 miles per hour (using our cruise control):

Table 1. Calculating the Marginal Benefit of Driving Faster

Speed	Time	*Total* time saved (compared to 55 mph)	*Marginal* Benefit
53	67.92453	-2.47	-2.47
55	65.45455	-------	-------
57	63.15789	2.30	2.30
59	61.01695	4.44	2.14
61	59.01639	6.44	2.00
63	57.14286	8.31	1.87
65	55.38462	10.07	1.76
67	53.73134	11.72	1.65
69	52.17391	13.28	1.56

Notice that the *marginal benefits* are going down as you go faster and faster! This is related to the idea that you must increase your speed by 100% in order to cut your driving time by only 50%. If we assume some dollar value for our time, say $.50 per minute, we can calculate the dollar value of the benefit of increasing our speed.

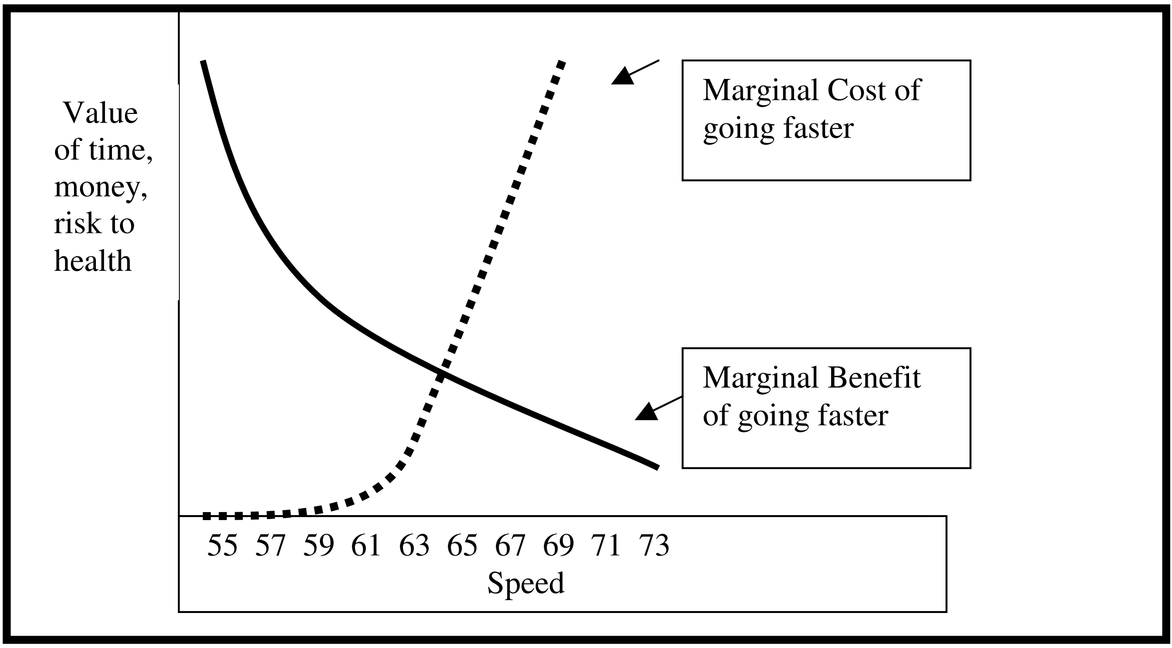
The Marginal Costs of Driving Faster

Of course, as you drive faster, your chances of being in a wreck, and the wreck being more serious increases with speed. Kloeden et al. (1997) found that for each additional 5km/hr (≈ 3 miles per hour) increase in speed, the probability of being involved in a serious crash involving an injury doubles. However, the main cost on a driver's mind is usually the cost of getting a ticket. In some states if you have no speeding tickets on your record, and you get one speeding ticket for no more than 9 miles per hour over the speed limit, you must pay the ticket and court costs, but your insurance rates will not go up. However, if you get a second ticket within 5 years, both tickets will increase your insurance. However, in some states you can remove one ticket from your record by going to "driving school".

So, if a driver has no tickets on their record, they could drive up to 64 miles per hour, and if ticketed, pay around $150 plus the lost time of being pulled over and mailing in the ticket. Driving a little faster than 64 miles per hour would result in the same penalty, because you can normally go to court and "plea down" a ticket of up to 14 miles per hour over the speed limit down to 9 miles over. But, the cost increases when you factor in taking a day off of work and going to court (or hiring an attorney to do this for you).

However, it is reasonable to expect that the probability of getting a speeding ticket is (*almost*) zero if you are within 5 miles of the speed limit. So, increasing your speed from 55 to 60 miles per hour would generate no additional risk of a ticket. In fact, in many cities, one can go at least 7 miles per hour over the speed limit, and face almost no chance of getting a ticket. Going 9 miles per hour over greatly increases your chances of a ticket. It is common practice that police officers will pull you over with certainty (if they see you) at 11+ miles over the speed limit. Of course, you *could* drive a long distance without even seeing a police car. If we were to put the previously mentioned costs and benefits on a graph, they might look like Figure 1 for a typical driver:

Figure 1. Graphing the Marginal Cost and Benefit for Various Speeds



Starting at a speed of 55 miles per hour, we should continue to go faster as long as the additional costs do not outweigh the additional benefits. According to the graph above, how fast should this driver go? (The marginal cost and marginal benefit curves intersect at around 65 miles per hour, suggesting that this is the optimal speed.) However, suppose that the driver depicted in Figure 1 looked down at the speedometer and saw that he was going 69 miles per hour. What should he do, and why? (He should slow down, because the additional cost of speeding up to 69 far outweighs the additional benefits.)

Shifts in the Marginal Benefit Curve

How would your decision change if you were in a big hurry to get somewhere? Perhaps you are late for work. The value of your time might increase from $.50 to $1.00. Looking at the graph above, what will happen to the marginal benefit curve? How will this affect your speed? How will this affect your risk of a ticket? (Your marginal benefit of driving faster would increase, shifting the curve upward. The resulting optimal speed is higher. You are willing to take a higher risk of a ticket because of the situation.)

Shifts in the Marginal Cost Curve

Suppose that you will lose your insurance if you get another speeding ticket. How will that affect your marginal cost curve? (The marginal cost of increasing your speed will be higher, shifting the marginal cost curve upward. This results in an optimal speed that is lower.)

What if you can go to driving school and get a ticket removed? Will this cause you to drive faster, or slower? (If the cost of going to driving school is lower than the cost of a ticket, it would lower the marginal cost of driving faster.)

Lastly, suppose you buy a vehicle that is very safe, perhaps a Volvo Sport Utility Vehicle. How will that affect your driving behavior? (Since you feel safer, the lower risk of injury will lower the marginal cost of speeding up, resulting in a faster optimal speed.)

References

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