COMPARING THE DURABILITY OF TIRES

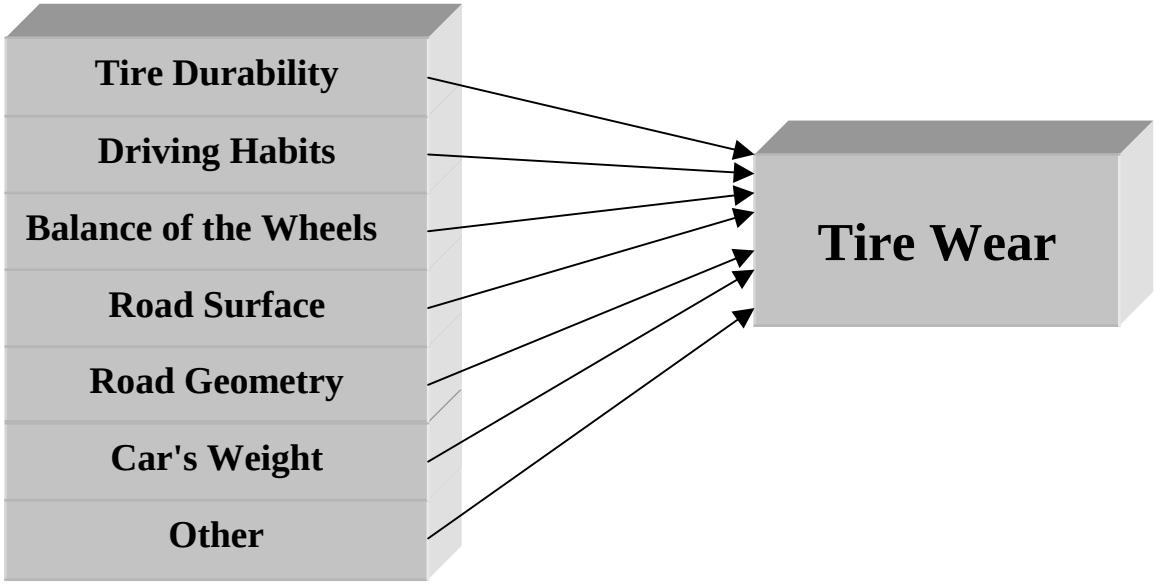
2. Study Design

The inferences we may draw from the data depend crucially on the study's design. Before we will describe random mechanisms used in the experiment, we have to identify important variables affecting tire wear.

2.1 What variables affect the tire wear?
2.2 Can we isolate and measure the effects of the new technology on tire wear?
2.3 How to carry out the randomization?

2.1 What variables affect the tire wear?

The durability of a tire is determined by several factors, among them the quality of the material used to make the tire and the technology used in the manufacturing process. However, durability is only one of a multitude of factors affecting the tire wear. The tire wear is also greatly affected by the driving habits of the driver, the condition and types of roads driven on (road surface and road geometry), the balance of the wheels, the size and weight of the car, the age and condition of the car, climate, etc.



Notice that only some of the factors could be measured somehow whereas tire wear could be measured with satisfactory accuracy. For example, it would be impossible or extremely difficult to describe driver habits or road surface by some quantitative measures. In general, it would be difficult or even impossible to consider all variables affecting tire wear.

It goes without saying that some of the factors affect the tire wear to a larger extent than the other factors. For example, tire durability is certainly more important than balance of the wheels. The variation in tire wear can be attributed to the variation in each of several variables affecting the tire wear. We would like to measure the extent to which tire wear is affected by tire durability but not by the other factors. Thus there is a need to carry out our experiment in such a way so that the effects of the other factors be removed.

2.2 Can we isolate and measure the effects of the new technology on tire wear?

Suppose that it turned out that the new technology tires had significantly larger tread depths. Can this difference be attributed to higher durability? Our conclusions depend on the way the experiment was carried out. It is possible that the smaller wear or equivalently larger tread depth could be attributed to the other factors such as driving habits, balance of the wheels etc. but not necessarily to the higher durability. We want to compare the tire wear that can only be attributed to the tire durability but not to other factors. In other words, we would like to filter out that portion of tire wear that could be attributed to the other factors.

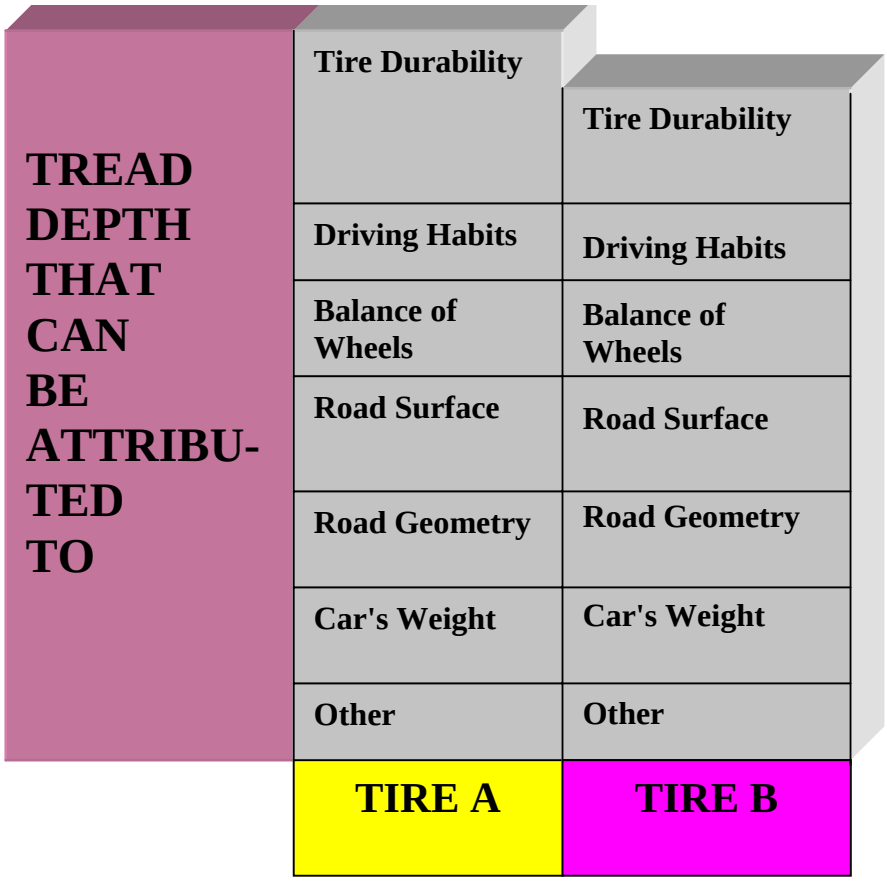
In order to neutralize the other factors affecting tire wear, we will use a very special design called matched pairs design. The design in our experiment can be implemented in the following way. First 20 tires of brand A and 20 tires of brand B will be selected at random. It is very important to make sure that the process is indeed random i.e. the selected tires are representative of their respective populations, otherwise any inferences to the populations based on the samples will be incorrect.

Then twenty cars will be selected randomly and a pair of tires (one brand A, one brand B) will be installed on the rear wheel of each car. On each automobile, an A tire is randomly assigned to one of the rear wheels and a B tire is assigned to the other rear wheel. This procedure tends to eliminate the effects of the car-to-car variability and yields more information on the differences in the wearing quality of the two brands. Each driver will be driving the car 20,000 km under normal circumstances, and then the tread depth will be determined for each of them.

Notice that the rear wheels are considered because the wear on the rear wheels tends to be different from the wear on the front wheels. If some of the tires were mounted on the rear wheels, some on the front wheels, it would make our comparison even more difficult because of the extraneous causes of wear due to the location of the tire on the car. Thus, either rear or front wheels should be used to make a comparison.

We have used a random mechanism to decide how a particular pair of one A and one B tire will be assigned to a particular car (left wheel or right wheel). Alternatively, we could divide the 20 cars into two groups of 10, and then install the brand A tire on the left wheel in the first group, and the brand A tire on the right wheel in the other group. This procedure eliminates the effects of different wear characteristics on right and left sides of cars. If we used the random mechanism to decide the assignment, it would be possible (although not very likely) that the number of brand A tires mounted on the right wheels would be very different from the number of brand A tires mounted on the left wheels.

Observe that by assigning one A and one B tire to each of the twenty cars, the tires A and B were affected by the same driving habits (same driver), by the same balance of wheels (same car), the same conditions, and so on. Assigning two different brands of tires A and B to each particular automobile eliminates the effect of the car-to-car variability. Thus, any differences in the tire wear should be attributed to the differences in the durability of the two tires. This idea is illustrated on the following picture.



Since the various cars, drivers, and conditions are the same for each pair of tires mounted on the rear wheels of a particular automobile, it would make sense to calculate the difference D=A-B, where A and B are the tread depths of the tires A and B, respectively. Then D expresses the real difference in the durability of the two tires. Looking at the differences in the two measurements for each car neutralizes the variability among the cars.

AUTOMOBILE	BRAND A	BRAND B	DIFFERENCE
1	8.46	8.05	0.41
2	6.47	5.95	0.52
3	6.63	6.33	0.30
4	5.98	5.52	0.46
5	6.61	6.29	0.32
6	6.06	5.40	0.66
7	5.77	5.88	-0.11
8	6.62	6.17	0.45
9	5.32	5.55	-0.23
10	6.31	6.03	0.28
11	6.51	6.02	0.49
12	6.18	6.38	-0.20
13	5.95	5.83	0.12
14	6.62	6.57	0.05
15	6.68	6.25	0.43
16	6.52	6.03	0.49
17	6.68	6.73	-0.05
18	6.48	5.98	0.50
19	5.89	5.30	0.59
20	7.00	6.95	0.05
AVERAGE	6.44	6.16	0.28

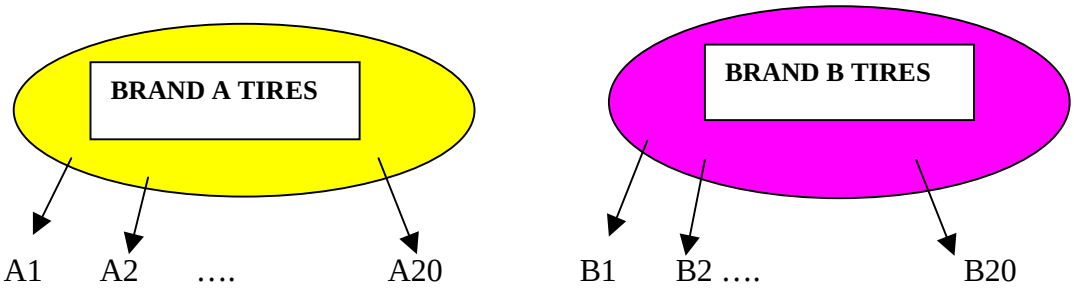
Summarizing, we can isolate and measure the effects of tire durability on tire wear or equivalently tread depth by using matched pairs design and applying statistical tools to the differences.

Can we use the same design to isolate and measure the effects of the new technology on tire wear? The answer to the question depends on the conditions the new technology was implemented under. The new technology might be implemented in different conditions, in a different factory building, by a different group of workers, and so on. It is possible that the smaller tire wear could be attributed to these factors, but not to the new technology.

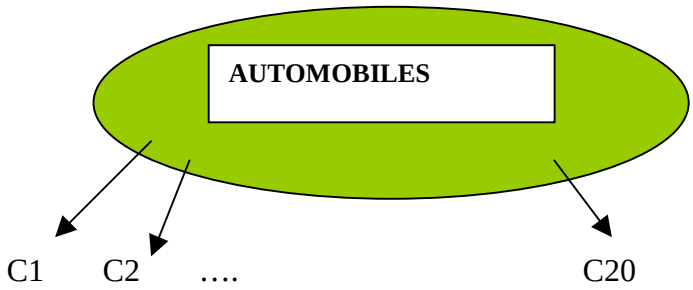
2.3 How to carry out the randomization?

The randomization process can be carried out in the following steps:

1. Random selection of 20 brand A tires and 20 brand B tires.



2. Random selection of 20 automobiles.



3. Random allocation of one A and one B tire to each of the 20 cars.

SELECTED BRAND A TIRES	A1	A2	……	…..	A20
CAR NUMBER	12	2			8

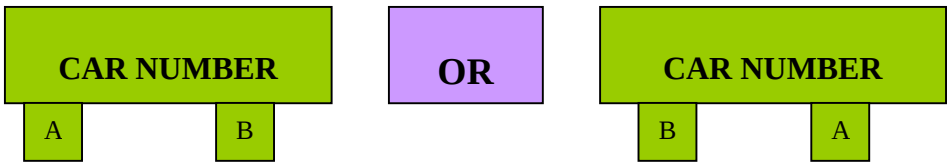
Read successive two-digit numbers between 1 and 20 from a table of random digits or use the random number generation feature in a computer software

SELECTED BRAND A TIRES	B1	B2	……	…..	B20
CAR NUMBER	4	19			6

The same random generation mechanism as described above

4. Random decision about the location of each tire on each car

   In the previous step, one brand A and one brand B tire is selected for each car. We have still to decide which tire goes to which wheel. Two possible solutions are:



In order to make the random decision, you can flip a coin. If the head occurs, assign the A tire to the left wheel, otherwise assign the B tire to the left wheel.

Our randomization process is complete. Now it is time to carry out the experiment and collect the data.