

Why can adding a road make traffic worse?

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A new road can make traffic worse if it changes the routes people choose in a way that increases congestion. The original roads may remain available, yet the pattern of use can change. Having more possible routes does not guarantee that independently chosen routes will produce a better collective outcome.

This possibility is known as Braess's paradox. It is a conditional result about a network, travel-time functions and route choices. It is not a rule that new roads are harmful. Braess's original analysis, available in an English translation published in 2005, distinguishes a route-choice equilibrium from a flow pattern that minimises travel time. [1]

1. A network we can calculate

Consider a standard illustrative example with 4,000 travellers making the same trip during a modelled period. There are two routes from an origin O to a destination D. The upper route passes through A; the lower route passes through B. There is initially no road between A and B.

On road O-A, travel time in minutes is the number x of travellers using that road divided by 100. On road B-D, the same rule applies to its own flow. The other two roads, A-D and O-B, each take 45 minutes regardless of flow. This is a deliberately simplified static model. It is not a measured road system or a description of queues building minute by minute.

If 2,000 travellers take each route, the variable-time section takes 20 minutes and the fixed-time section takes 45. Each route therefore takes 65 minutes. If substantially more travellers take the upper route, that route becomes slower and the lower route becomes more attractive. The equal split is the equilibrium in the model where each traveller has negligible influence on the total flow.

Here equilibrium means that no traveller can shorten the trip by unilaterally choosing another available route while everyone else's choices remain fixed. It does not mean that the network has achieved every possible social objective, or that real people instantly discover the equilibrium.

2. Add a very attractive connection

Now add a one-way connection A-B with travel time zero. Zero is an idealisation chosen to make the arithmetic transparent. No other road or travel-time function changes, and total demand remains 4,000.

At the original split, a traveller can see an attractive route O-A-B-D: approximately $20 + 0 + 20 = 40$ minutes. That seems much better than 65. But the calculation uses the old congestion while contemplating a new collective pattern. It cannot remain correct if everyone responds in the same way.

At the new equilibrium, all 4,000 travellers take the connecting route. The O-A and B-D sections each take 40 minutes, so the total is 80 minutes. An individual who switches to the old upper route would take $40 + 45 = 85$ minutes; the old lower route would take $45 + 40 = 85$. No individual gains by abandoning the new route.

Thus the model has moved from 65 minutes per traveller to 80, a worsening of 15 minutes. All the old choices remain physically available. What disappeared was the old pattern of

use, not the old roads. This calculation illustrates the mechanism identified by Braess. [1] The numbers used here form a standard illustrative example.

3. Why everyone cannot simply choose the old solution

They could, if their choices were coordinated and maintained. But at the equal split on the old routes, an individual can take the new shortcut and gain. That profitable deviation makes the old allocation unstable under the specified individual-choice rule.

The issue is the cost a traveller imposes on others when joining a congestible section. Each traveller compares personal journey times. The comparison does not automatically include the extra delay imposed on all the other travellers sharing a road. The individually attractive move and the collectively desirable allocation are therefore different optimisation problems.

The model does not accuse travellers of making arithmetic errors. At the new equilibrium, the route each chooses is a best response to the routes others are using. Perfect information about the modelled travel times would not by itself make the old equal split an equilibrium.

A coordinator could forbid the shortcut, or use a suitable incentive scheme, to change the available choices or their costs. That statement identifies a possibility inside the model. It is not a recommendation to close an actual road without considering demand, access, safety, distributional effects and alternative travel modes.

4. What would count as evidence on a real road

To test whether this mechanism matters in a particular network, observing longer journeys after construction is insufficient. Demand may have changed; other streets may have closed; signals, incidents or public transport may differ. We would need route flows and travel times, a credible comparison period or counterfactual, and an explicit account of the other changes.

The mathematical example keeps demand fixed, so its worsening does not require induced demand. Real transport systems may show both effects, but they should not be conflated. More trips after improved access is a different causal route from a worse equilibrium for the same number of trips.

Likewise, short-term adaptation is not identical to the static equilibrium. Drivers learn, receive different information and face different constraints. Some value reliability or toll avoidance more than mean travel time. The point of the simple model is to isolate a possible mechanism before adding these complications, not to assume they are absent from real cities.

5. The answer depends on behaviour as well as roads

Adding an option cannot make the best achievable allocation worse if a coordinator can simply ignore it and everything else stays unchanged. But a self-organised equilibrium is not the same thing as that best achievable allocation. An extra option can destabilise a good allocation and support a worse one.

The title therefore has a precise answer: a new road can redirect individually rational choices onto shared bottlenecks. Whether it does so in a given network is empirical and model-dependent. The mistake is to infer performance from the number of connections alone, without specifying how people choose among them and how their choices change the costs.

Related reading

Article 045, “Can a shape have finite area and infinite perimeter?”, separates two quantities that intuition tends to bind together. Article 047, “How can a positive test be wrong?”, likewise makes an inference depend on its explicit conditions.

References

[1] Braess, D., Nagurney, A., and Wakolbinger, T. “On a Paradox of Traffic Planning.” *Transportation Science* 39(4), 446–450 (2005). English translation of Braess's 1968 paper.
<https://doi.org/10.1287/trsc.1050.0127>