



**UNIVERSITY OF LEEDS**

This is a repository copy of *Supply Curves for Urban Road Networks – a rejoinder.*

White Rose Research Online URL for this paper:

<http://eprints.whiterose.ac.uk/2542/>

---

**Article:**

May, A.D., Shepherd, S.P. and Bates, J.J. (2001) Supply Curves for Urban Road Networks – a rejoinder. *Journal of Transport Economics and Policy*, 35 (2). pp. 349-352.

---

**Reuse**

See Attached

**Takedown**

If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing [eprints@whiterose.ac.uk](mailto:eprints@whiterose.ac.uk) including the URL of the record and the reason for the withdrawal request.



[eprints@whiterose.ac.uk](mailto:eprints@whiterose.ac.uk)  
<https://eprints.whiterose.ac.uk/>



Universities of Leeds, Sheffield and York  
<http://eprints.whiterose.ac.uk/>

ITS

[Institute of Transport Studies](#)  
**University of Leeds**

This is a publisher produced version of a paper from the Journal of Transport Economics and Policy. This final version is uploaded with the permission of the publishers, and can originally be found at <http://www.bath.ac.uk/e-journals/jtep/>

White Rose Repository URL for this paper:  
<http://eprints.whiterose.ac.uk/2542>

---

**Published paper**

A. D. May, S. P. Shepherd, and J. J. Bates (2001) Supply Curves for Urban Road Networks – a rejoinder. Journal of Transport Economics and Policy, 35(2) 349-352

---

---

# Supply Curves for Urban Road Networks

## A Rejoinder

**A. D. May, S. P. Shepherd, and J. J. Bates**

---

Professor Hills is not quite correct to suggest that the origins of our research lay in his criticism (Hills, 1993) of Evans' use of monotonic speed-flow relationships (Evans, 1992). Our interest lay in the more general use of area speed-flow relationships in strategic models, of which Evans' work was an example. However, our research benefited from Hills' analysis, and from his subsequent contributions to our attempts to clarify definitions in this problematic area. It is unfortunate, therefore, that there are still differences in our understanding of these definitions. The differences between us relate to six key issues, which we consider in turn below.

### **Units of demand**

While Hills does not pursue the point in his contribution, we have had an extended debate as to whether to use trips or vehicle-km as a measure of demand in urban networks. While trips are, as Hills contends, the activities that individual drivers demand, some trips have much more impact than others on a network because they involve longer distances (whether measured as crow-fly or shortest-distance paths) than others. We have found it more helpful, therefore, to use vehicle-km than trips when aggregating to a network, and our subsequent definitions are therefore chosen to be consistent with this. However, we accept that either measure could be used, provided that each is related to a given shape of matrix and hence distribution of trip lengths.

### **Rate of demand**

Whichever unit is used to measure demand, it is self-evident that demand will have a more congesting effect if it arises in a short time period than if it is spread over a longer one. For this reason it appears to us essential that demand is measured as a rate (in trips per hour or vehicle-km per hour). This is, after all, the parallel to measuring demand on a link in vehicles per hour, rather than simply vehicles. We have used units of vehicle-km/h consistently throughout the paper except in Figures 4 and 5, and we accept that this may have led to confusion. Strictly, the axes for these Figures should be measured in veh/h, veh-km/h and veh/h. In doing so we have had to define a generating period ( $H_g$ ), since the denominator must be the period during which demand arises. Much of Hills' criticism of our paper relates to his reluctance to accept this, and a resulting confusion between time used in this way and as a cost to individual drivers. He is, we contend, wrong to suggest that the generating period is irrelevant, or that our axes are inappropriate.

### **Units of supplied travel**

Hills introduces two areas of confusion here. First he suggests that the form of our equations (1) (for performed travel) and (4) (for supplied travel) are the same. While the units are the same, the forms, and the ways in which the data are collected from the simulation, are decidedly different. As we explain in the paper, the first measures all vehicle-km of travel on the network in a given time period, regardless of the time period in which the related trips were generated. The second measures only those vehicle-km related to trips demanded in a given generating period, regardless of the time at which they take place in the resulting simulation. The time-space domains for the two are thus demonstrably different, and the values will differ as a result of temporal differences in the demand matrix, in routes taken, and, in the extreme, in ability for trips to be satisfied. In passing, it should be noted that this distinction is even more important when considering the vehicle-hours of travel of these two sets of movements.

Second, he again questions the use of a rate, and confuses our use of a rate with that conventionally used for flow. As we have explained, we have defined demanded travel in relation to the length of the generating period, and we need to be consistent in our definition of supplied travel by also dividing supplied vehicle-km by the length of the generating period. Thus our vehicle-km/h do not, as Hills suggests, measure the rate at which demand is satisfied, but the travel that takes place, throughout the simulation, as a result of a given rate of demand. In passing, we accept that our

use of an adjusted generating period is not well justified, and we will want to address this further in subsequent research.

### **“Throughput”**

Hills introduces the term “throughput” without defining it precisely, and implies that we have suggested that demanded travel and supplied travel are measures of travel. We have avoided the term, but we understand it to describe traffic passing through the network in a given time period, and hence to be related to our performed travel. We would certainly not suggest that either our demanded travel or our supplied travel measured throughput in this sense.

### **Units of cost**

As noted above, our research was stimulated by a debate on the nature of area speed-flow relationships and their inverses. We were thus concerned to understand how speed, in km/h, and its inverse, in h/km, were affected by changing levels of demand in a given network. Hills, in his criticism of Evans, was more concerned with the cost of journeys, which, as we have noted, will include elements of operating cost as well as time. In our analysis we have measured time per km of travel demanded, to be consistent with our measure of demand. It would be equally appropriate to use time per trip, if that was the measure of demand. Given this, the area under our supply curves, in Figures 8 and 12, has dimensions of  $(h/km * veh - km)$  per hour of the generating period, or  $veh-h/h$ . This is consistent with our use of demand rates and is not, as Hills suggests, an inappropriate measure of cost.

### **Units of supplied time per km**

Unfortunately, Hills then detracts from his arguments by confusing the use of time as a cost to the driver and as a measure of the elapsed period over which demand arises, and accuses us of further dimensional inaccuracy. A reference to our section 2.4 will make clear that we define supplied time per km as the ratio of supplied time (in  $veh-h/h$ ) to demand travel (in  $veh-km/h$ ) and that the units are clearly h/km rather than, as Hills suggests,  $h^2/km$ .

### **Conclusion**

- . We accept that demand could be measured either in trips or in  $veh-km$  for a given matrix configuration;

- . we are clear that the rate of demand, by reference to a given generating period, is needed to reflect the impact on congestion, and that our use of time in the denominator of our definitions and axes is appropriate;
- . we stress that supplied travel and performed travel are measured in different time–space domains, and are therefore different, but we accept that the use of an adjusted generating period requires further consideration;
- . we suggest avoiding the term “throughput” unless it is more precisely defined;
- . we confirm that time per km is an appropriate, if limited, measure of the costs of travel and that it, and the area under the curves in Figures 8 and 12, are consistent with our definition of demanded travel per unit length of generating period;
- . we refute the suggestion that our measure of time/km is dimensionally inaccurate.

Despite any remaining differences between us, we are in full agreement with Hills on the need to extend this analysis to further networks and matrix patterns, and to assess its implications for the assessment of restraint strategies. However, in stressing the need also to understand the effects of temporal dependency, we were concerned not solely with the treatment of a given generating period, but with the differences which arise when a given generating period follows on the one hand a period of light demand and on the other a period of heavy demand. This, we suspect, will be the most problematic of the issues still to be resolved.

## References

- Evans, A. W. (1992): “Road Congestion Pricing: When is it a good policy?” *Journal of Transport Economics and Policy*, 26, 213–43.
- Hills, P. J. (1993): “Road Congestion Pricing: When is it a good policy? A Comment”. *Journal of Transport Economics and Policy*, 27, 91–99.



Universities of Leeds, Sheffield and York  
<http://eprints.whiterose.ac.uk/>

ITS

[Institute of Transport Studies](#)  
**University of Leeds**

This is a publisher produced version of a paper from the Journal of Transport Economics and Policy. This final version is uploaded with the permission of the publishers, and can originally be found at <http://www.bath.ac.uk/e-journals/jtep/>

White Rose Repository URL for this paper:  
<http://eprints.whiterose.ac.uk/2542>

---

**Published paper**

A. D. May, S. P. Shepherd, and J. J. Bates (2001) Supply Curves for Urban Road Networks – a rejoinder. Journal of Transport Economics and Policy, 35(2) 349-352

---