Dynamic Congestion Pricing

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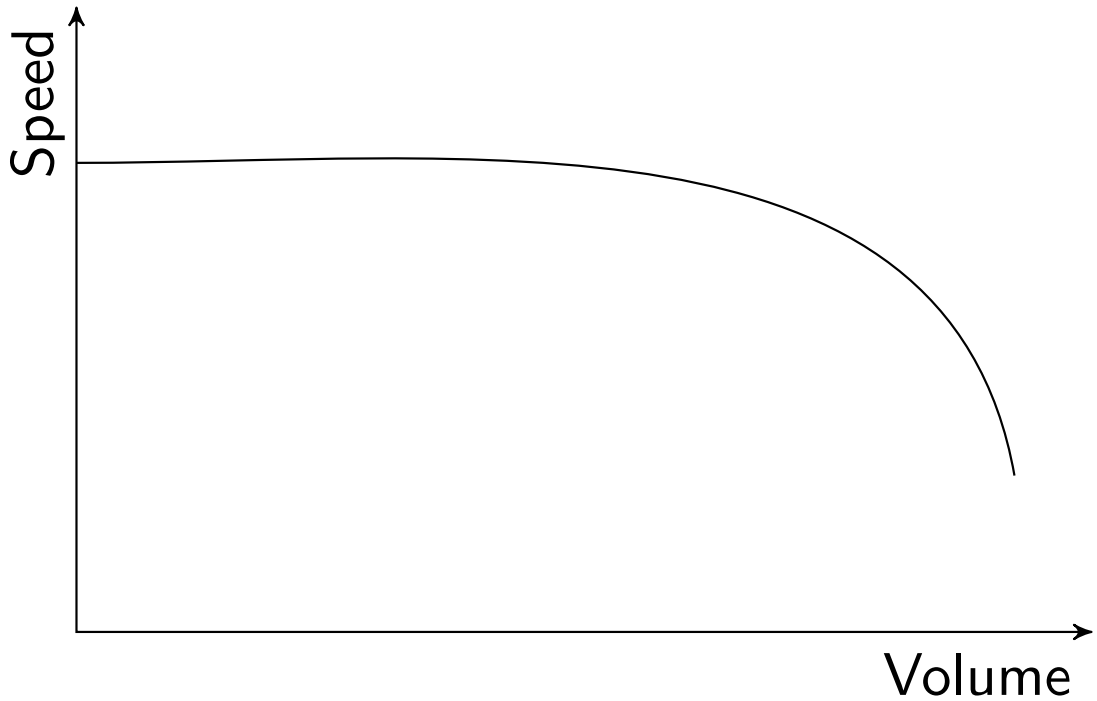
Traffic congestion is a major problem

Costs of traffic congestion in USA

- 52 hr/commuter/yr in major urban areas
  (Schrank et al. 2012)
- 2.2% of annual gasoline consumption
  (Schrank et al. 2012; EIA 2012)
- Additional pollution more than 6 times the amount saved by current fleet of hybrid and electric vehicles
  (Samaras and Meisterling 2008; EPA 2011; Schrank et al. 2012; EIA 2013)
- Pollution responsible for 8,600 pre-term births
  (Currie and Walker 2011)

Congestion occurs when there are too many vehicles on the road

Speed is a function of traffic volume: more cars, lower speeds



Congestion occurs when there are too many vehicles on the road at the same time

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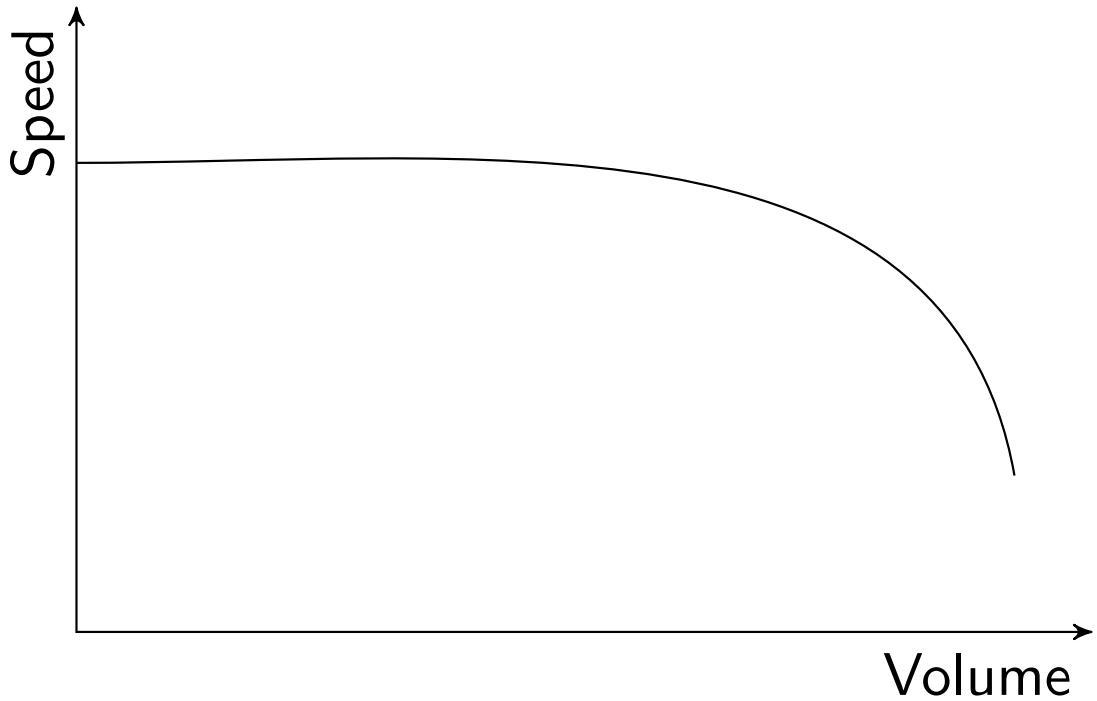

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- Example:
  - Should I drive or take transit to the movie theater?

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    - Comfort
  - But an important issue is ignored
    - If I drive, I slow other drivers down
    - If I slow down 900 other drivers for 1 second each $\Rightarrow$ additional social cost of 15 minutes

Ideal solution: Tolls

How can we help drivers consider the total social cost of their choices?

- Charge a toll that equals the additional social cost
- First suggested by Alfred Pigou in 1920
- Often called congestion pricing
- Ideal tolls would vary with traffic conditions

Optimal toll would impact choices in six ways

- Whether to travel
- Where to travel
- Mode choice—car vs. bus vs. walk
- Route choice
- Time of travel—peak vs. off-peak
- Land use

A barrier to congestion pricing is the belief that it hurts many road users

- Academics

  "First-best congestion pricing . . . introduces severe disparities in direct welfare impact." Small, Winston, and Yan, 2005

- Policy makers

  "[Congestion pricing is] unfair in terms of the economic impact." Maryland Gov. Parris Glendening

- Pundits

  "Exalted [toll] lanes leave the average Joe in the dust." Marc Fisher, The Washington Post

- Public

  "Turkeys don't vote for Christmas and motorists won't vote for more taxes to drive." Voter in Manchester, UK

Key result: A carefully designed toll on a portion of the lanes can help everyone, even before revenue is spent

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- Time varying
- Collected electronically
- Set to maximize throughput, not profits or social welfare

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- Give up some potential efficiency gains in order to help everyone
- If this allows us to overcome political opposition then we're trading potential efficiency gains for actual efficiency gains
- What allows me to get this new result?
  - Identifying a second externality using insights from traffic engineering literature

An additional driver can impose two externalities

1. Lengthen the line

2. Reduce throughput/reduce speed at which line moves

There are two ways congestion reduces throughput

- Once queue forms throughput at bottleneck drops
  - e.g. throughput on I-805N at 47th St. in San Diego regularly falls by 12% once a queue forms (Chung et al. 2007)
  - cf. Banks (1990), Hall and Agyemang-Duah (1991), Banks (1991), Persaud et al. (1998), Cassidy and Bertini (1999), Bertini and Malik (2004), Zhang and Levinson (2004), Bertini and Leal (2005), Cassidy and Rudjanakanoknad (2005), Rudjanakanoknad (2005), Chung et al. (2007), Guan et al. (2009), Oh and Yeo (2012), Srivastava and Geroliminis (2013)

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- Queue behind bottleneck blocks upstream traffic
  - e.g. throughput on I-880N near San Francisco regularly falls by 25% due to queue spillovers from I-238 (Munoz and Daganzo 2002)

By delaying some departures, everyone can arrive sooner

How tolls can increase throughput

- On a free road:

  Too many cars on road $\Rightarrow$ queues $\Rightarrow$ lower throughput

- With time-varying tolls:

  Spread out departures $\Rightarrow$ no queues $\Rightarrow$ higher throughput

▸ Additional detail

When there are rich and poor drivers it is harder to make everyone better off

What happens when we price the entire road?

- Increase speeds and throughput
- Change currency from time to money

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By only pricing a portion of the lanes we can still help everyone

Intuition for pricing a portion of the lanes

	Both lanes free	
	Lane 1	Lane 2
Pricing	Free	Free
Avg. queue length	long	long
Throughput	low	low
Travel time	long	long
Share of trips	50%	50%

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Intuition for pricing a portion of the lanes

	Both lanes free		Price one lane	
	Lane 1	Lane 2	Lane 1	Lane 2
Pricing	Free	Free	Toll	Free
Avg. queue length	long	long	0	$\downarrow$
Throughput	low	low	$\uparrow$	–
Travel time	long	long	$\downarrow$	$\downarrow$
Share of trips	50%	50%	$\uparrow$	$\downarrow$

Pricing all of the road hurts the inflexible poor

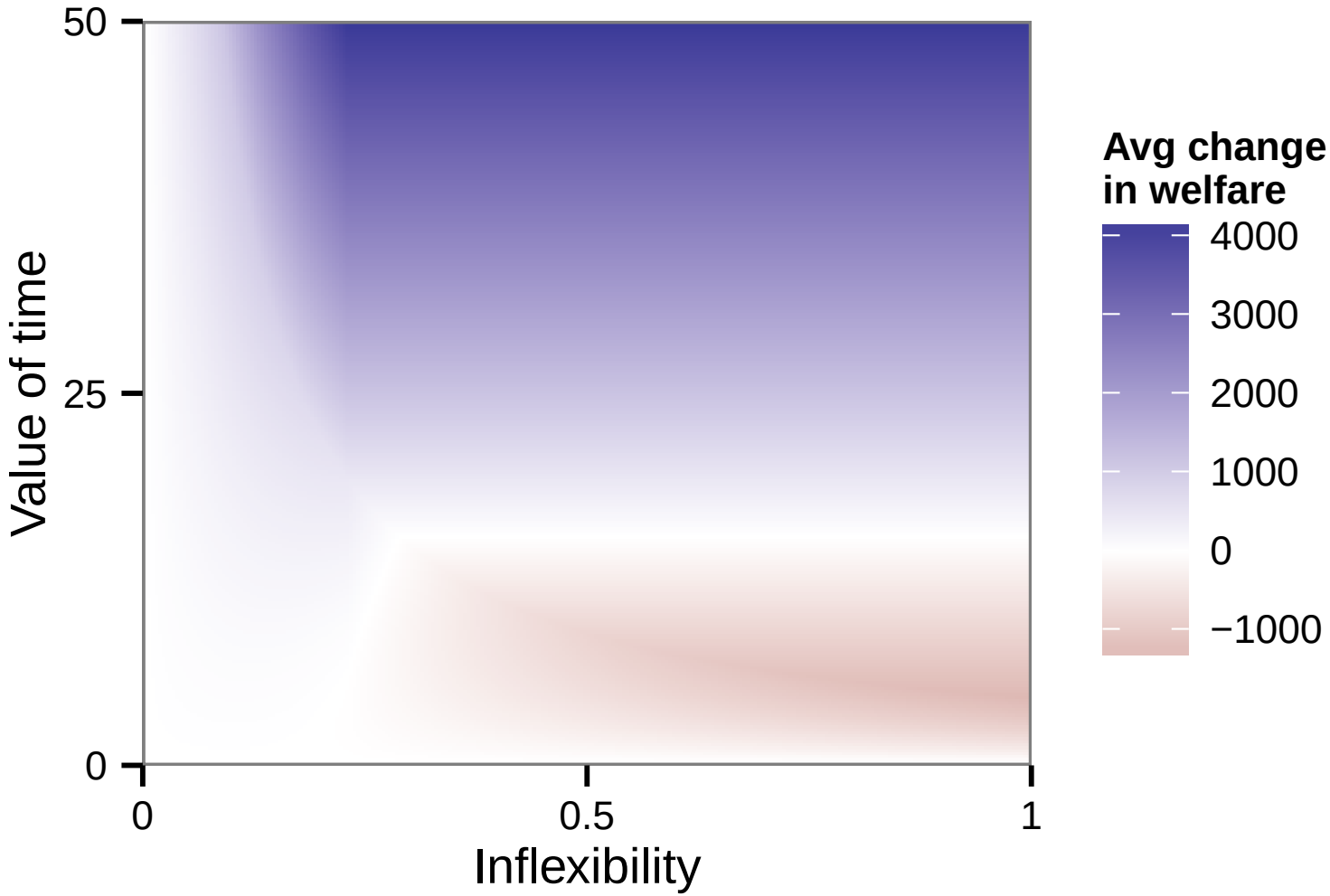

Figure: Change in trip price when pricing all lanes

Pricing 1/2 of lanes helps everyone

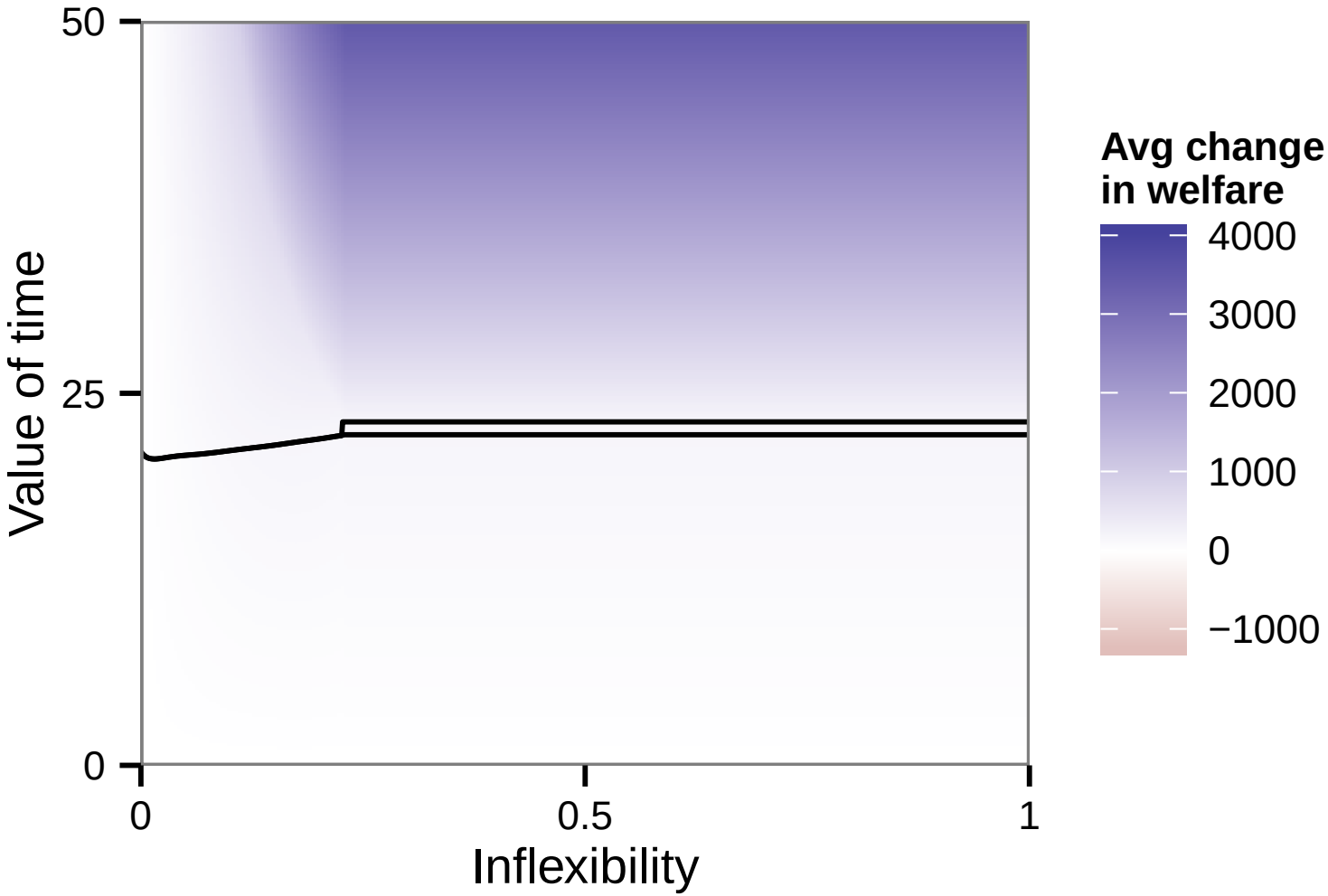

Figure: Change in trip price when pricing 1/2 of lanes

The welfare gains from pricing are large

Average annual welfare effects (dollars)

	Tolled	Pricing 1/2 of lanes
Largest welfare loss	2,390	0
Social welfare gains	2,400	1,740
Private welfare gains	1,080	760

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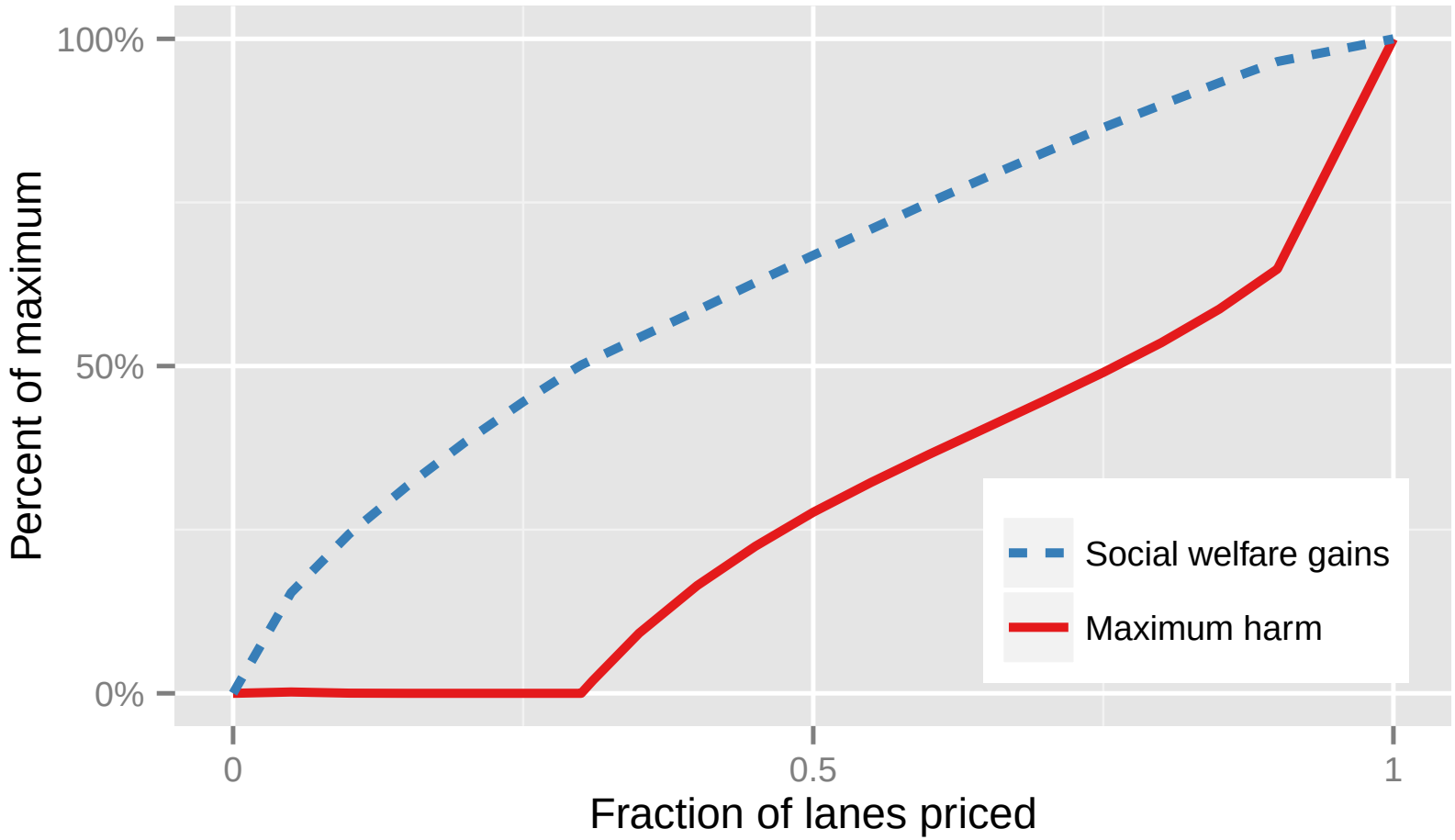
If willing to relax requirement that pricing hurt no one, then can obtain a larger share of welfare gains



We can improve the welfare effects of congestion pricing

Things could add to analysis to help tolling help everyone

- Use of revenue
- Ways to let inflexible poor to pay with time to travel at peak
- Shocks to preferences–everyone has days they are inflexible

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Things could add to analysis to help tolling help everyone

- Use of revenue
  - Negative tolls off peak
  - Cut sales tax
  - Expand highway
  - Subsidize public transit
- Ways to let inflexible poor to pay with time to travel at peak
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  - Expand highway
  - Subsidize public transit
- Ways to let inflexible poor to pay with time to travel at peak
  - Public transit
  - Carpooling
- Shocks to preferences–everyone has days they are inflexible

Conclusion

- Traffic congestion is a major problem
- We have too much traffic because drivers don't face full cost
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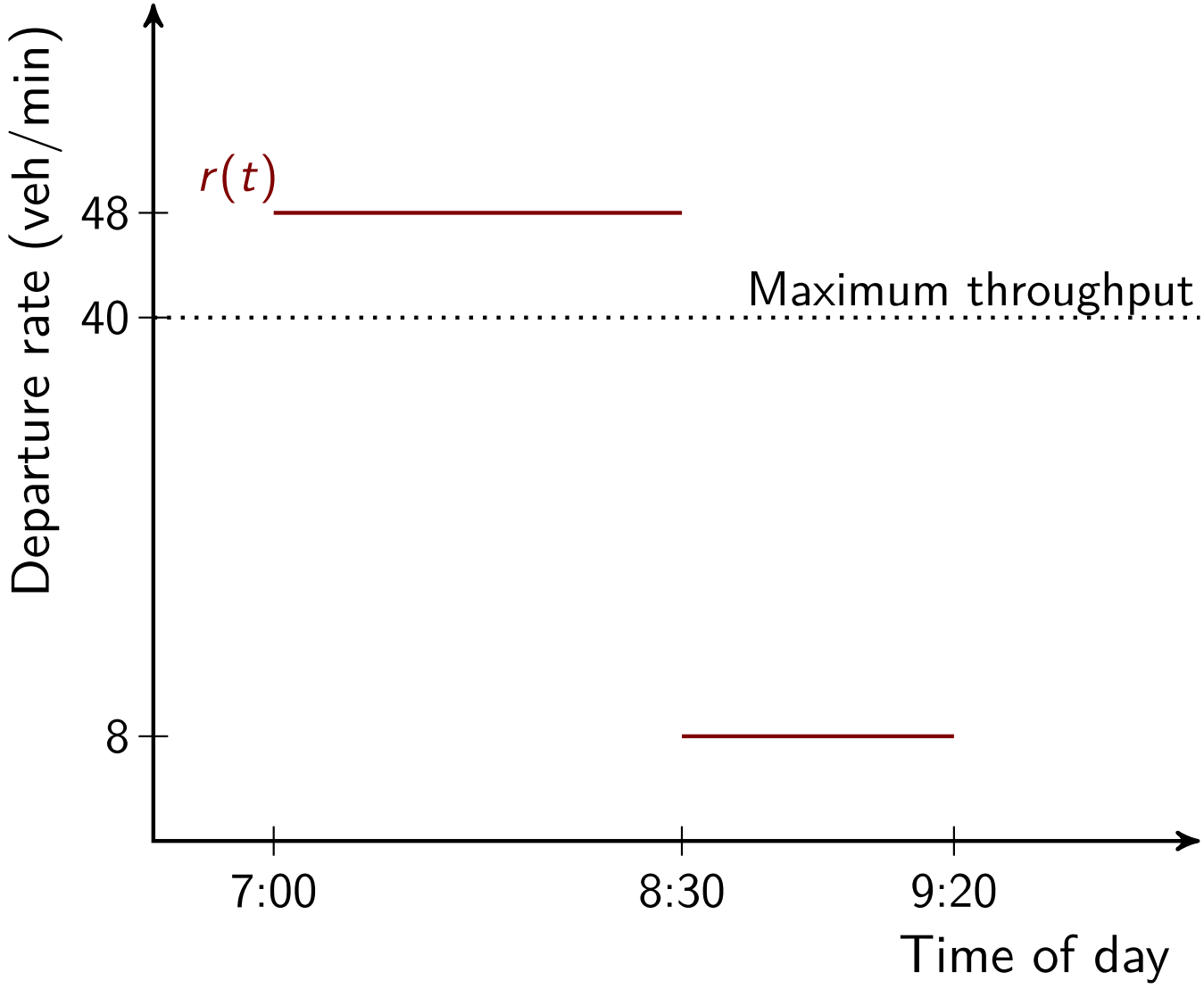
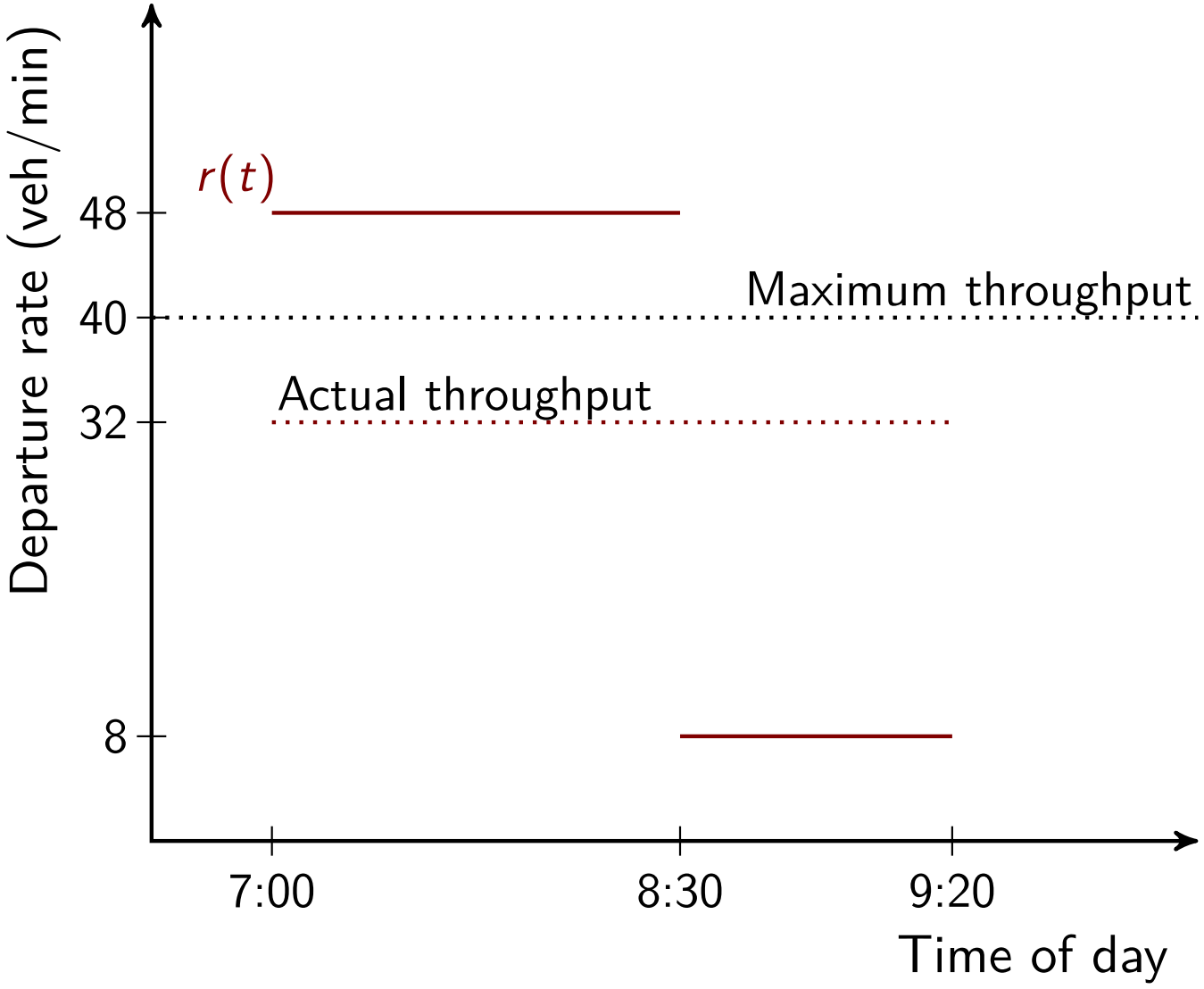
- Tolls should be able to increase highway throughput
- Theoretically, pricing a portion of the lanes can help all road users, even before we use the revenue
- Empirically, pricing 1/2 of lanes on SR-91 will help all road users, with welfare gains of 3.5% median income

Appendix

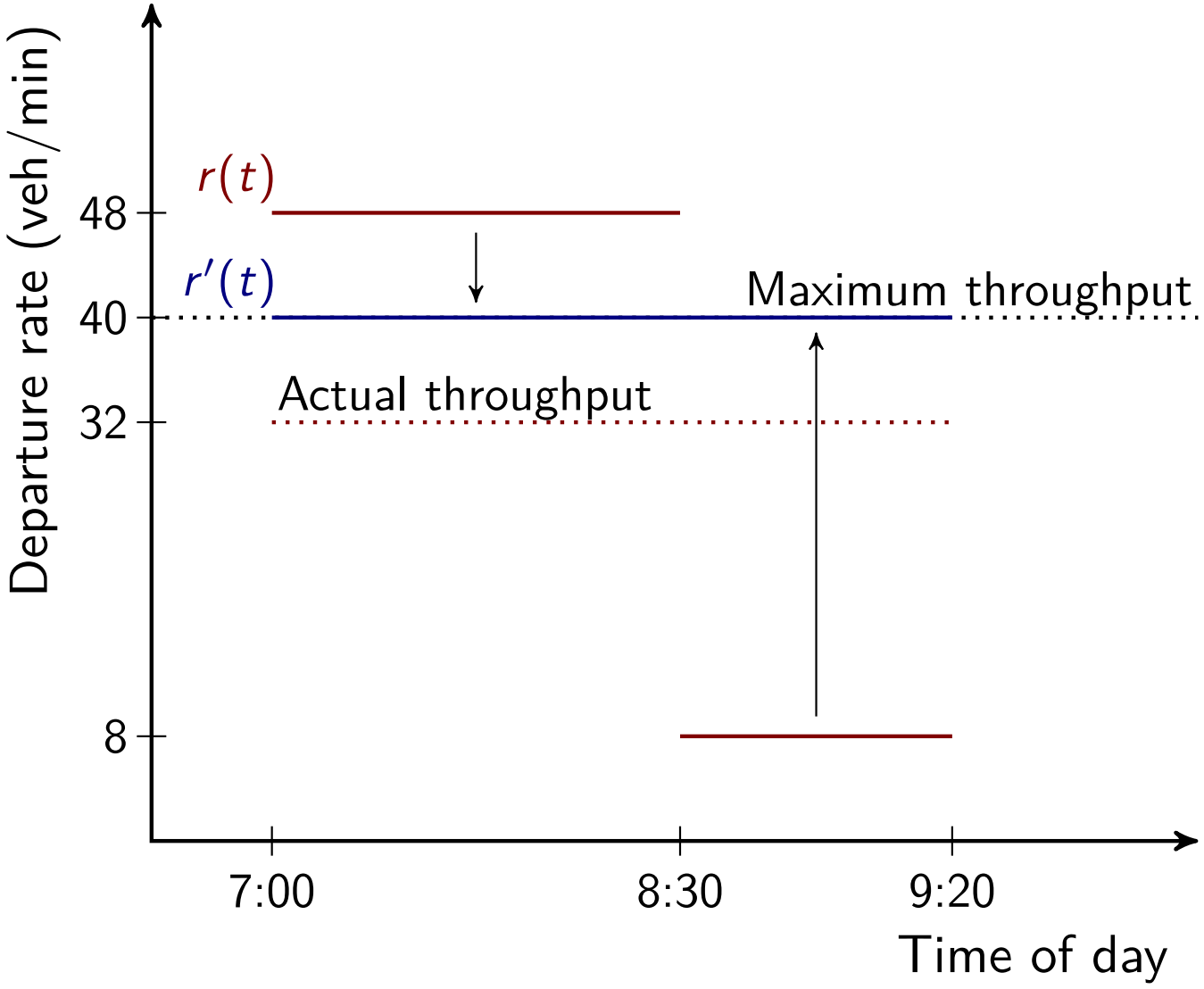
Queues form because too many drivers depart at once



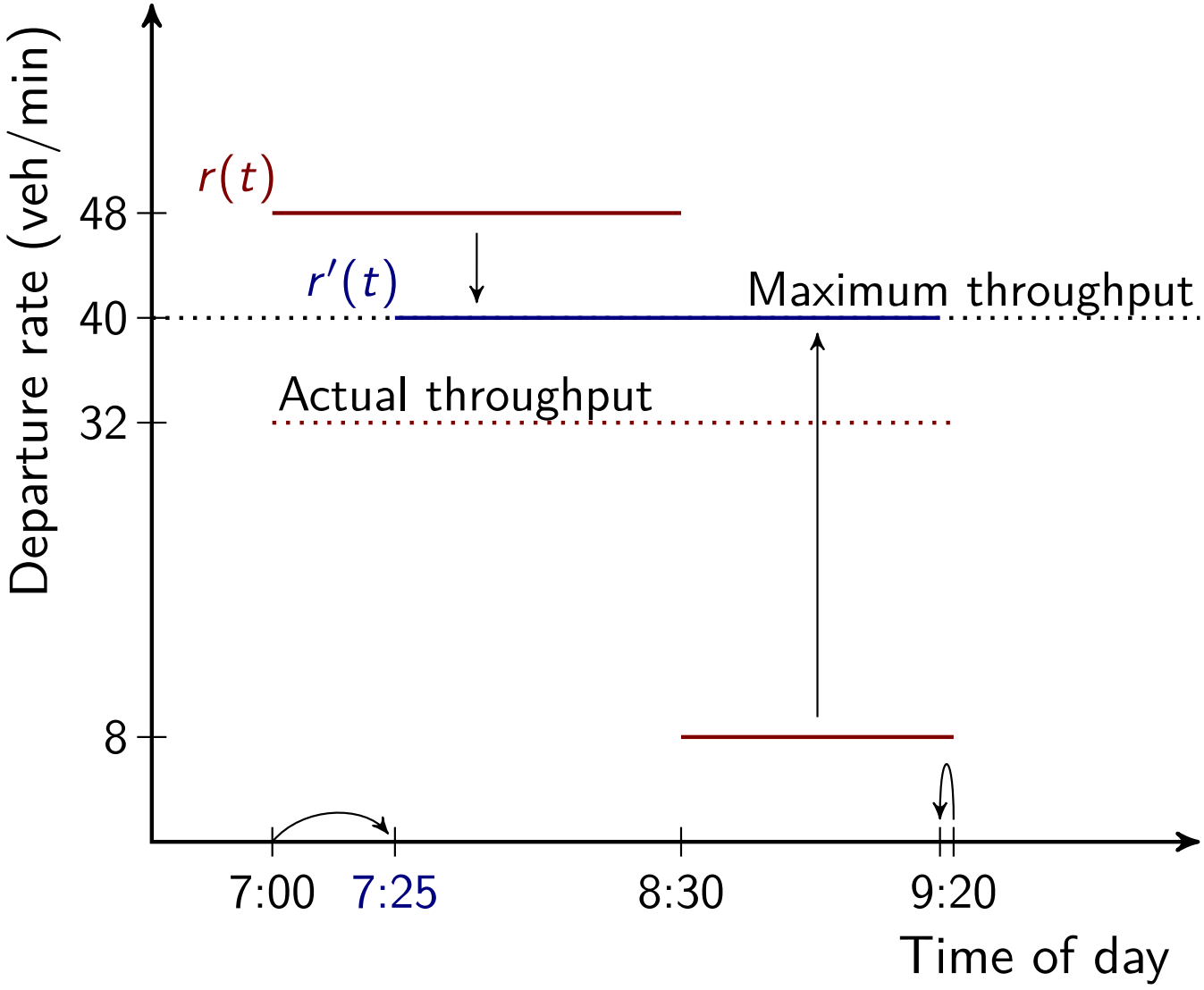
Throughput falls because of queuing



Use tolls to affect rate at which drivers depart



No queuing means higher throughput and shorter rush hour



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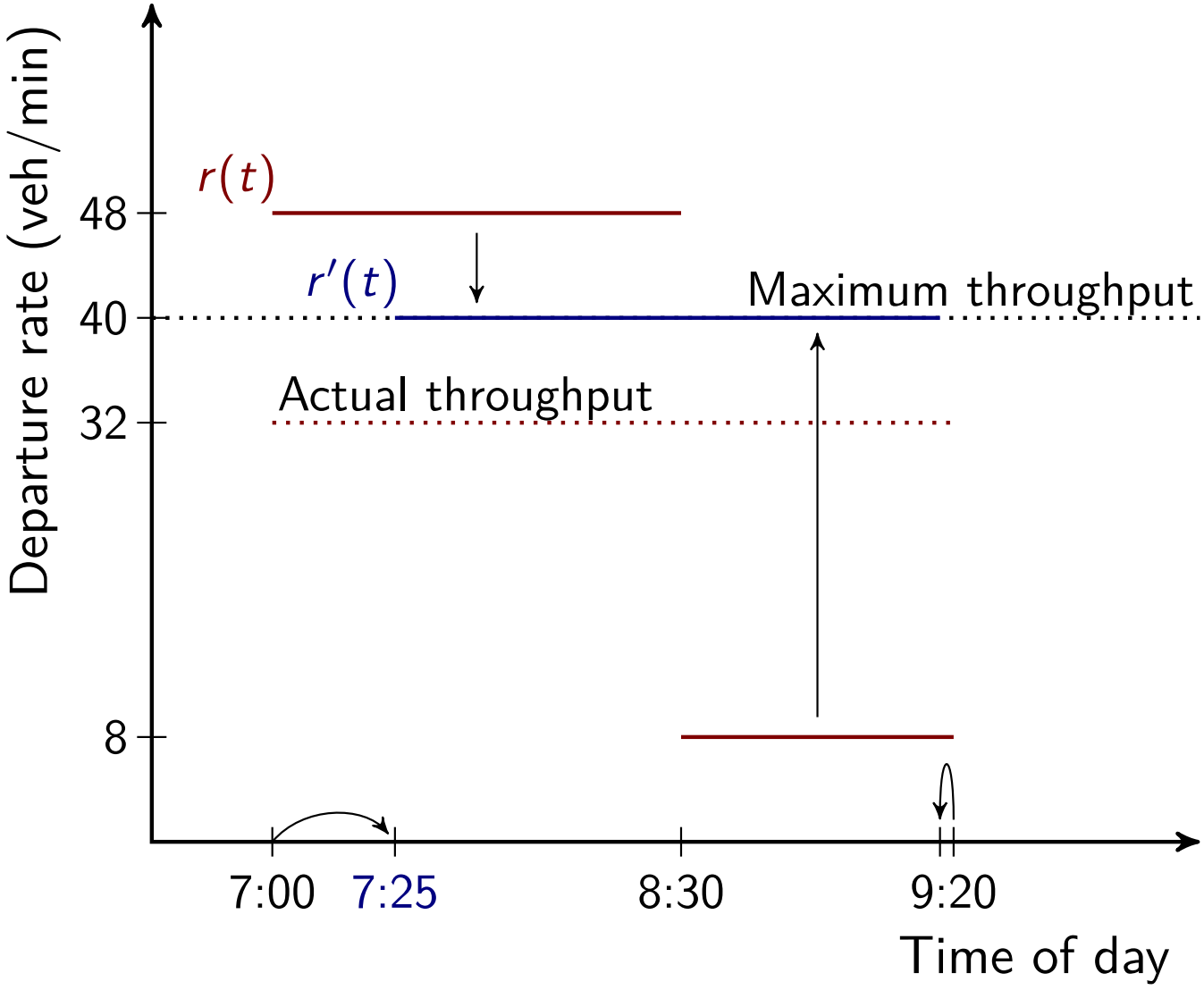

$\Rightarrow$ when drivers are the same, pricing helps everyone

Return