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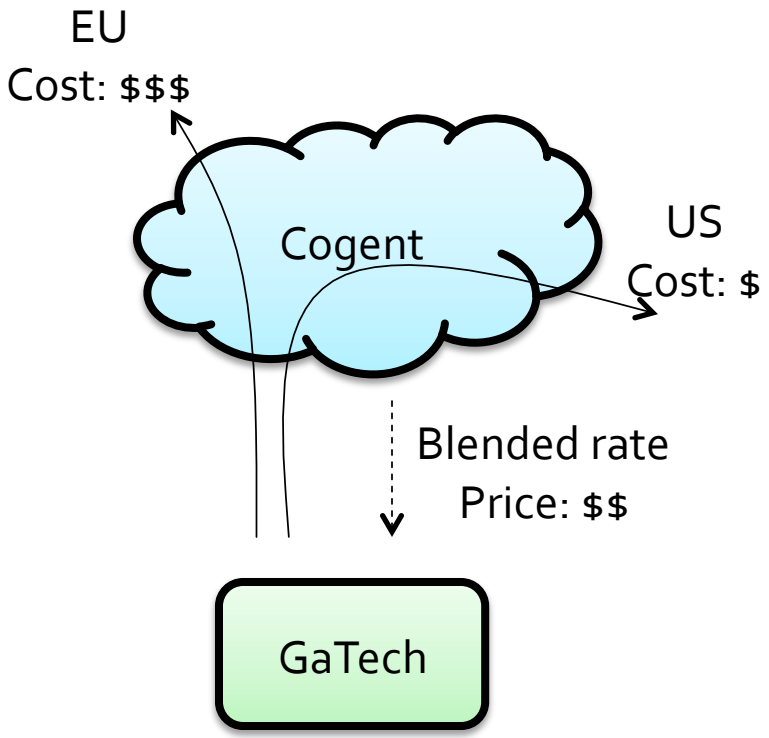
How Many Tiers? Pricing in the Internet Transit Market

Conventional Transit Pricing

- Blended rate:
  - Single price in $/Mbps/month
- Charged each month on aggregate throughput
  - Some flows are costly
  - Some are cheaper to serve
  - Price is set to recover total costs + margin
- Convenient for ISPs and clients



Can be inefficient!

Issues With Blended Rate Pricing

Uniform price yet diverse resource costs

Clients

Lack of incentives to conserve resources to costly destinations

ISPs

Lack of incentives to invest in resources to costly destinations

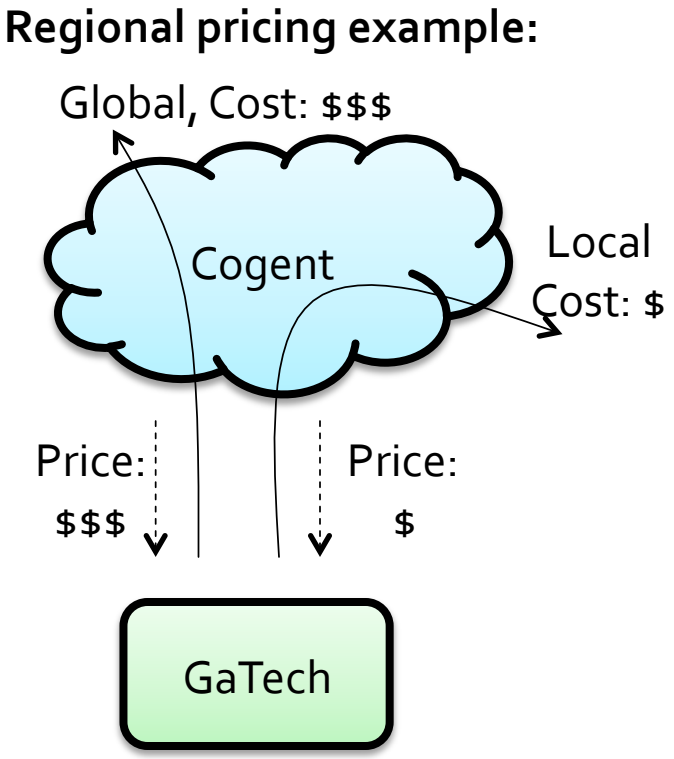
- **Pareto inefficient resource allocation**
  - A well studied concept in economics
- Potential loss to ISP profit and client surplus

Alternative: tiered pricing

Tiered Pricing

Price the flows based on cost and demand

- Some ISPs already use tiered pricing
  - Paid peering
  - Backplane peering
  - Regional pricing
  - **Limited number of tiers**



Question:

How efficient is such tiered pricing?

Can ISPs benefit from more tiers?

Challenges

How can we test the effects of tiered pricing on ISP profits?

Modeling

1. Construct an ISP profit model that accounts for:
   - Traffic **demand** of different flows
   - **Servicing costs** of different traffic flows

Data mapping

3. Drive the model with **real data**
   - **Demand functions** from **real traffic data**
   - **Servicing costs** from **real topology data**

Number crunching

4. Test the effects of tiered pricing!

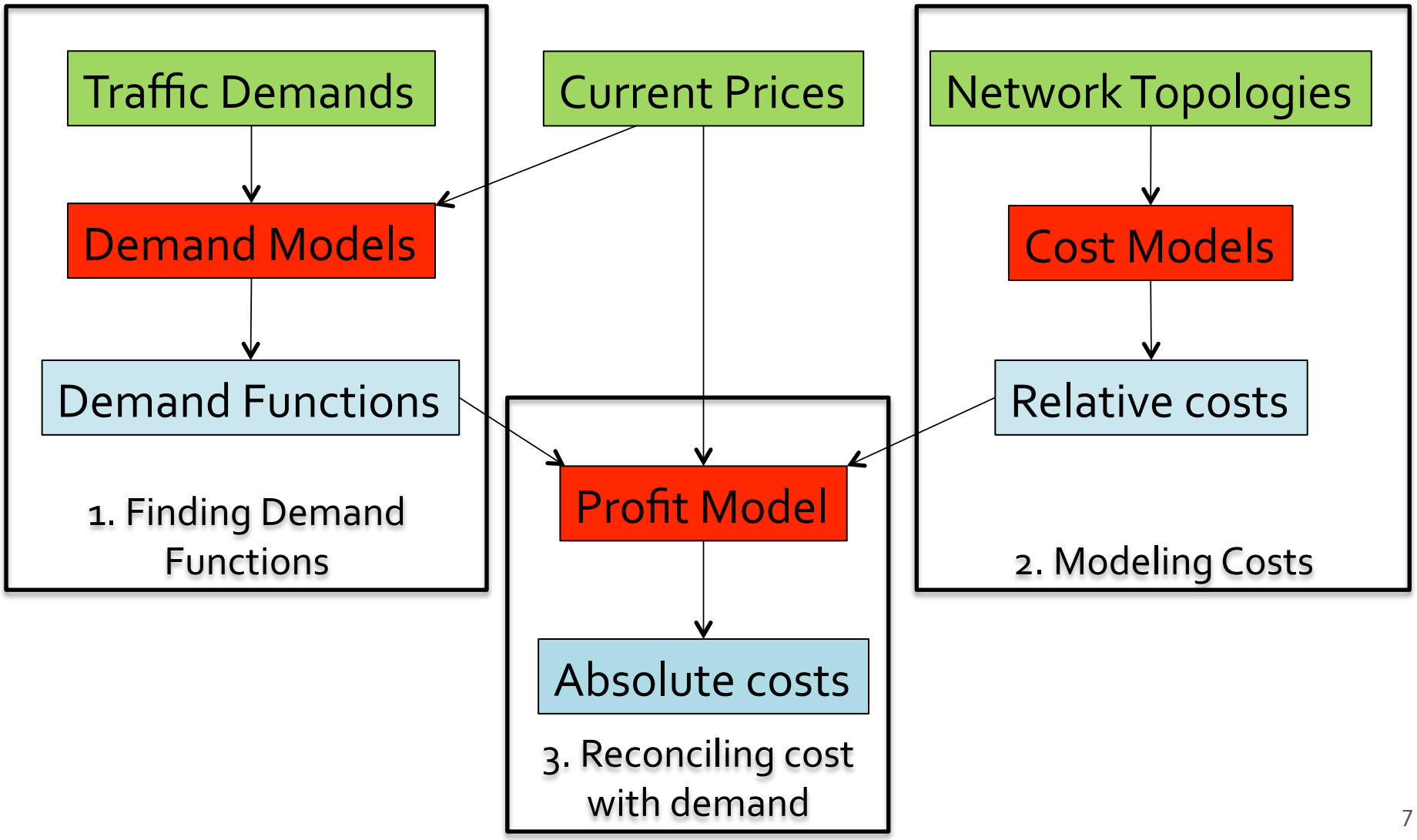
ISP Profit Model: Assumptions

Profit = Revenue – Costs
(for all flows)

- Flow revenue
  - **Price * Traffic Demand**
  - Traffic Demand is a function of price
  - How do we **model** and **discover** demand functions?

- Flow cost
  - **Servicing Cost * Traffic Demand**
  - Servicing Cost is a function of distance
  - How do we **model** and **discover** servicing costs?

Approach to Modeling

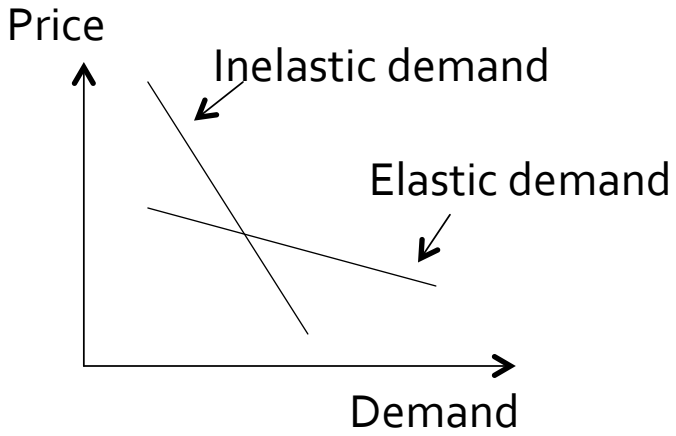


Finding Demand Functions

Canonical commodity demand function:

Demand = F(Price, Valuation, Elasticity)

Valuation – how valuable flow is
Elasticity – how fast demand changes with price



How to find the demand function parameters?

$Valuation = F^{-1}(Price, Demand, Elasticity)$

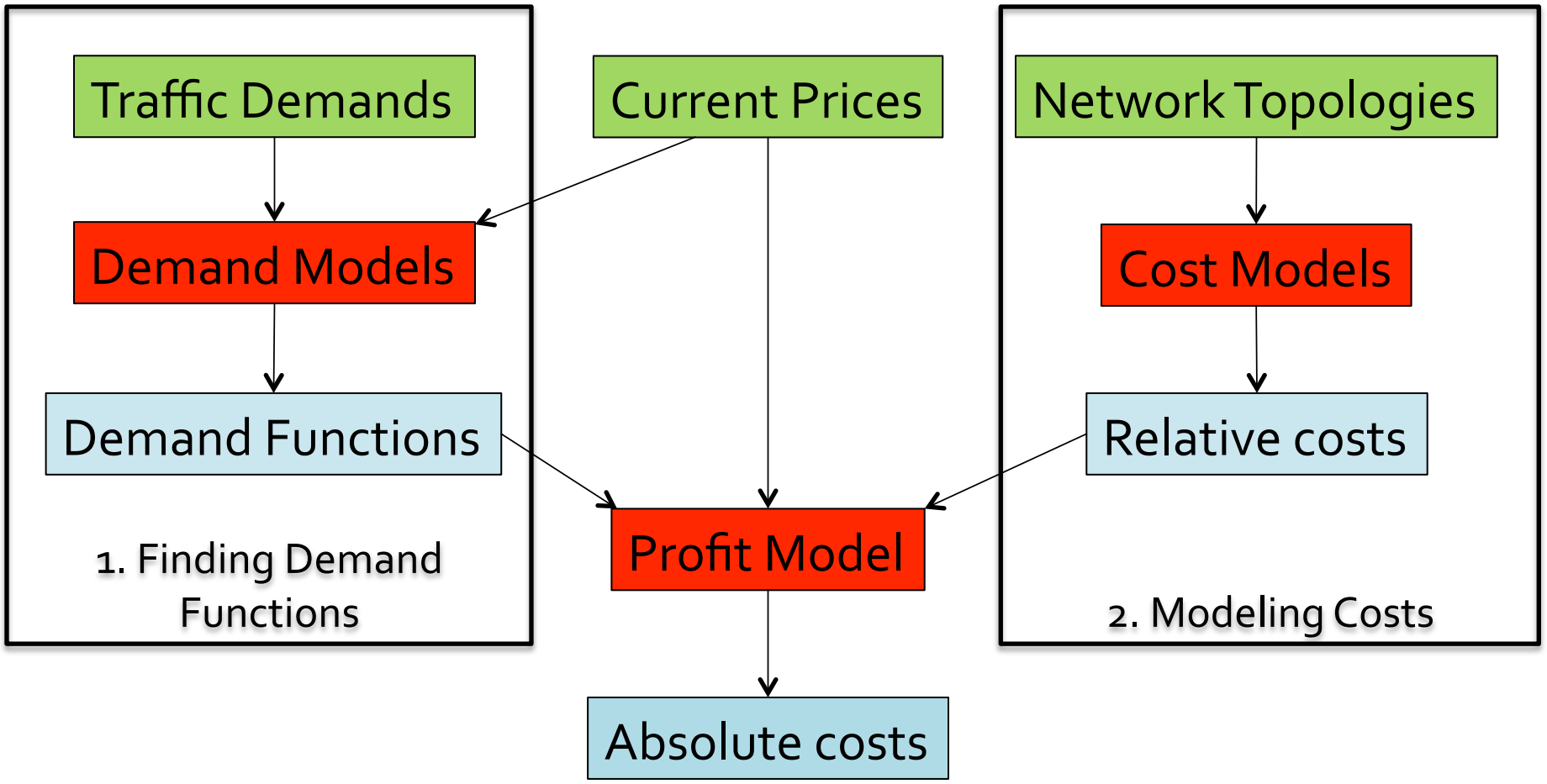
Current price

Current flow demand

Assumed range of elasticities

We mapped traffic data to demand functions!

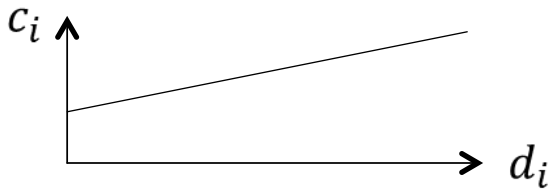
Approach to Modeling



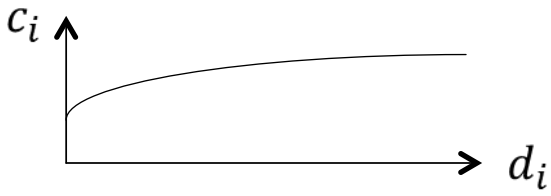
Modeling Costs

How can we model flow costs?

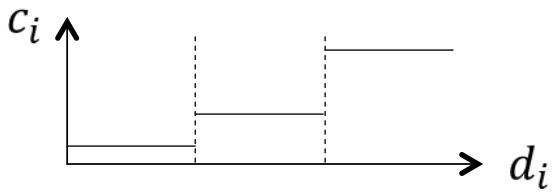
Linear:



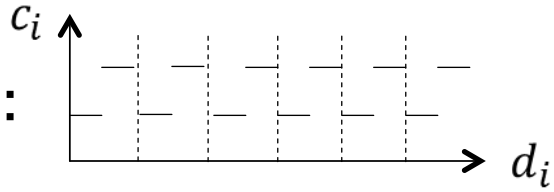
Concave:



Region:



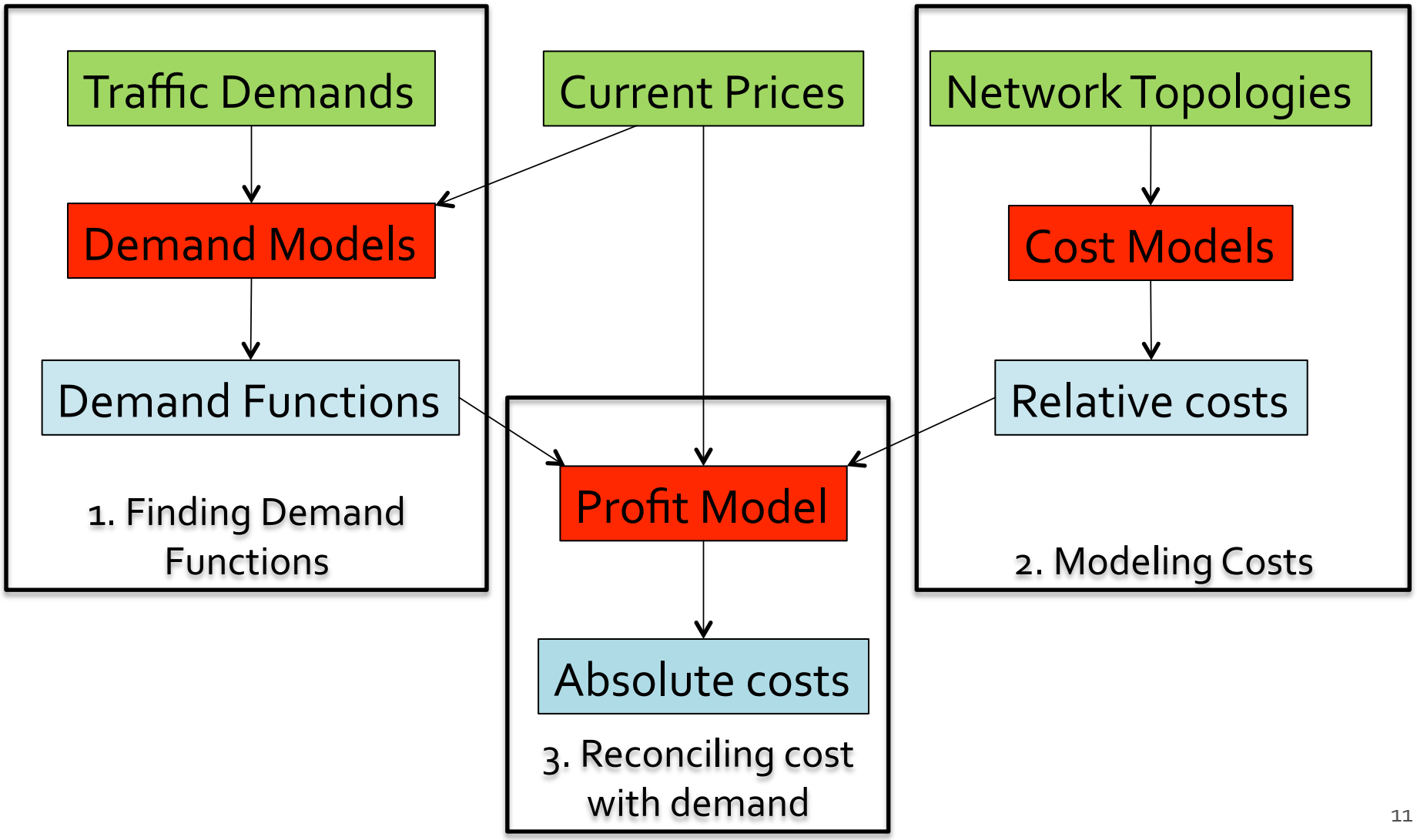
Dest. type:



ISP topologies and peering information alone
can only provide us with **relative flow servicing costs**.

real_costs = γ * relative_costs

Approach to Modeling



Normalizing Costs and Demands

Assuming ISP is rational and profit maximizing:

Profit = Revenue – Costs = F(**price**, **valuations**, **elasticities**, **real_costs**)

F′(**price***, **valuations**, **elasticities**, **real_costs**) = 0

F′ (**price***, **valuations**, **elasticities**, **γ * relative_costs**) = 0

γ = F′$^{-1}$(price*, valuations, elasticities, relative_costs)

Data mapping is complete: we know demands and costs!

Subject to the noise that is inherent in any structural estimation.

Testing ISP Pricing Strategies

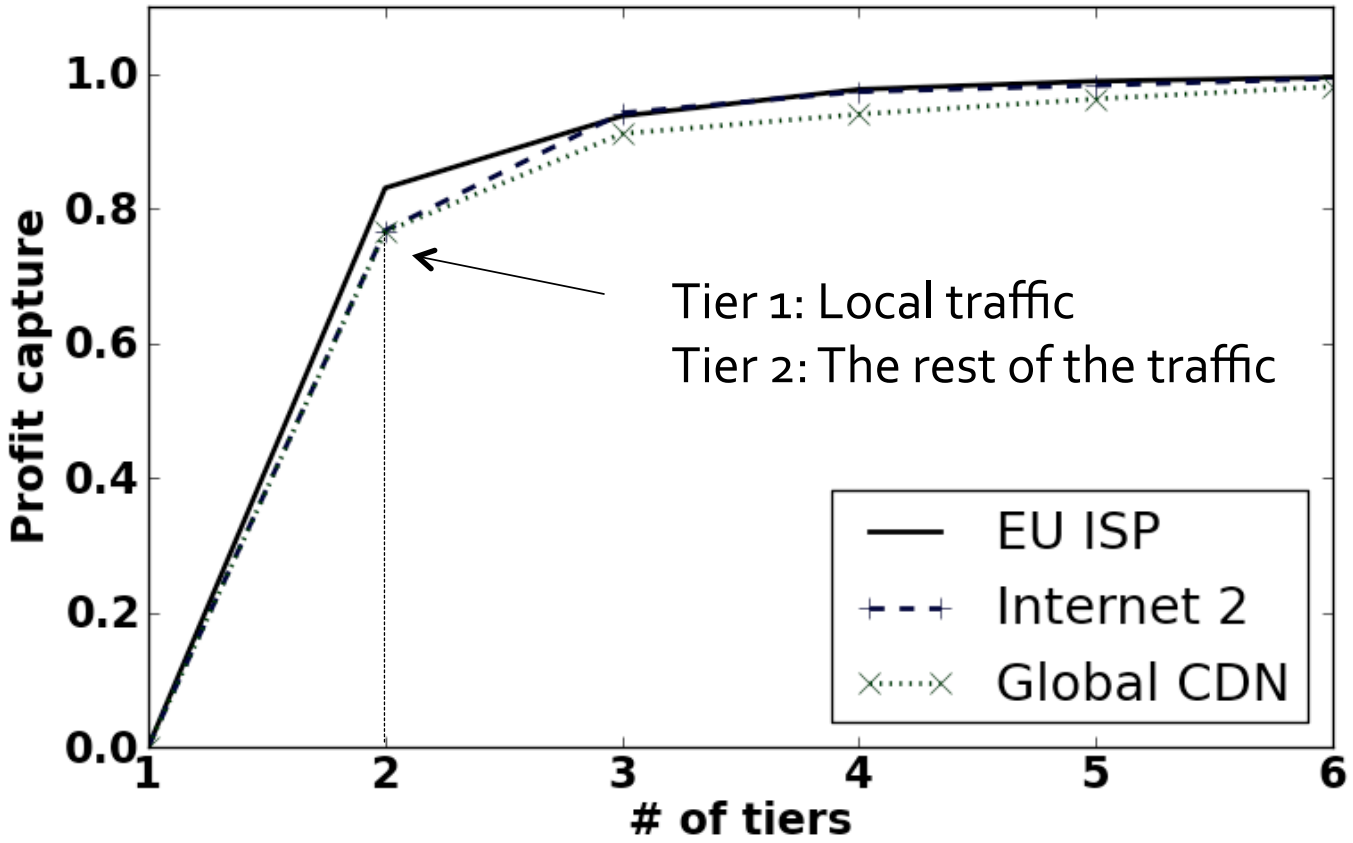
1. Select a number of pricing tiers to test
   - 1, 2, 3, etc.
2. Map flows into pricing tiers
   - Optimal mapping and mapping heuristics
3. Find profit maximizing price for each pricing tier and compute the profit

Repeat above for:

- 2x demand models
- 4x cost models
- 3x network topologies and traffic matrices

Results: Profit Capture

Constant elasticity demand with **linear cost model**



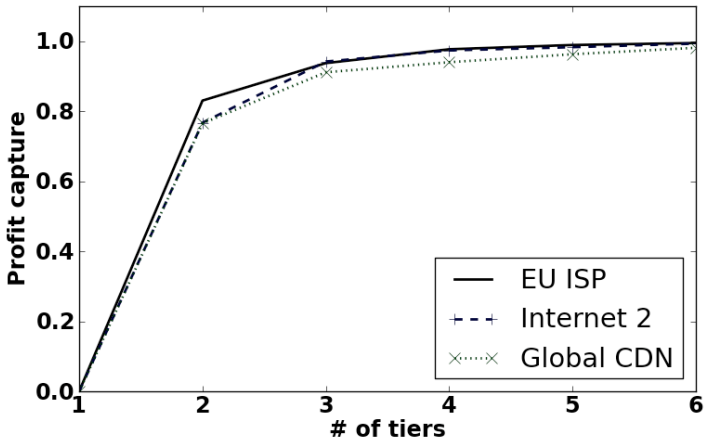
*Elasticity – 1.1, base cost – 20%, seed price - $20

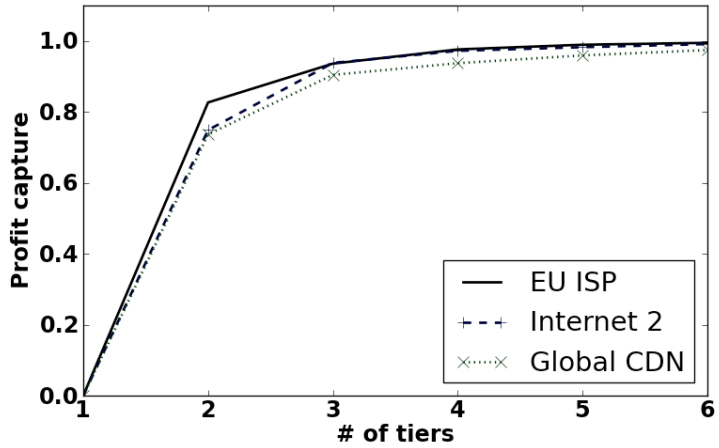
Results: Big Picture

Linear Cost Model

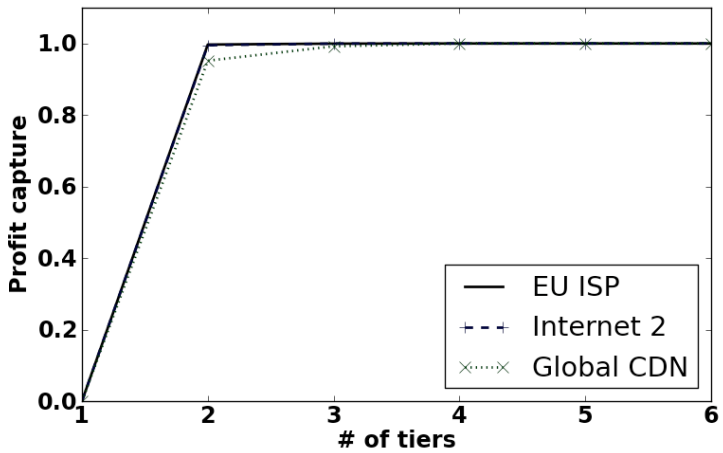
Concave Cost Model

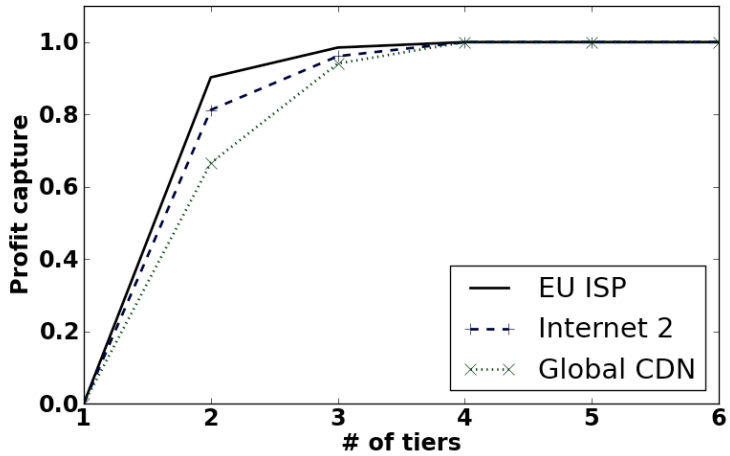
Constant Elasticity Demand





Logit Demand





Conclusion

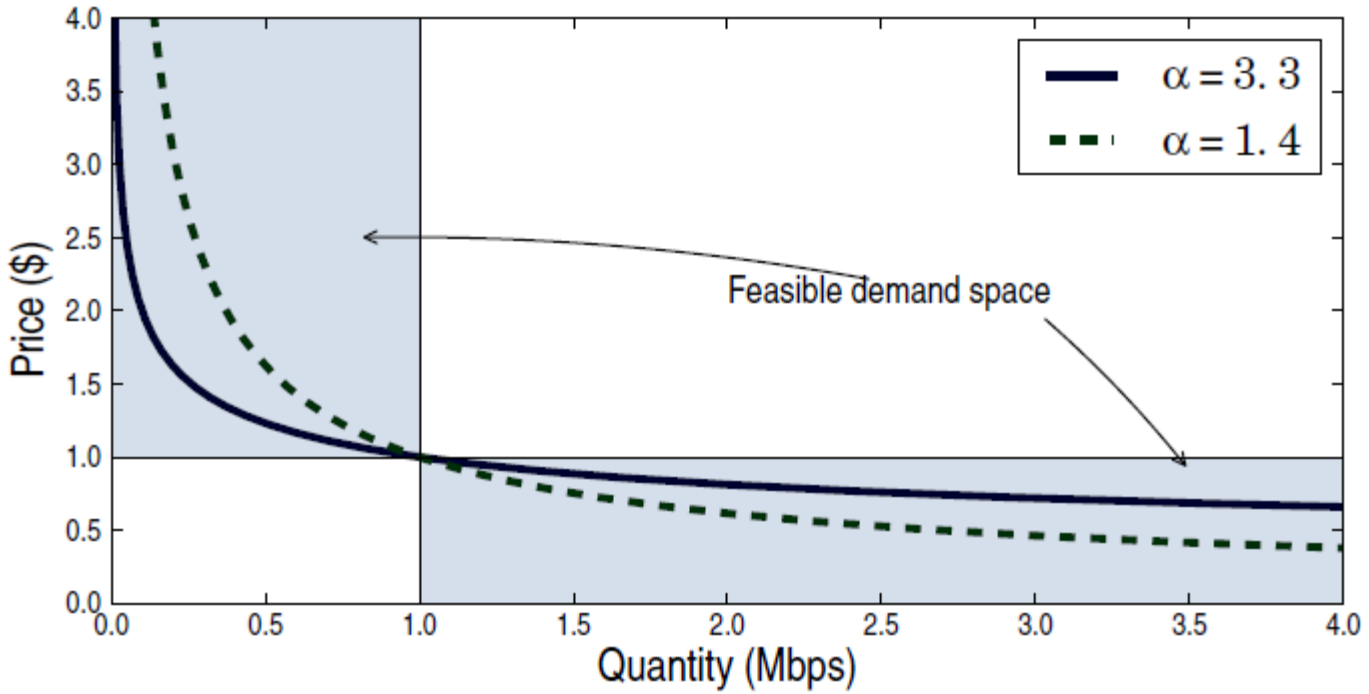
- Having more than 2-3 pricing tiers adds only marginal benefit to the ISP
- The results hold for wide range of scenarios
  - Different demand and cost models
  - Different network topologies and demands
  - Large range of input parameters
- Current transit pricing strategies are close to optimal!

Questions?

http://valas.gtnoise.net

What About Competition?

- Very hard to model!
- Perhaps requires game-theoretic approach and more data (such as where the topologies overlap, etc.)
- It is possible to model some effects of competition by treating demand functions as representing **residual** instead of **inherent** demand. See Perloff's "Microeconomics" pages 243-246 for discussion about **residual** demand.


4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Price ($)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Quantity (Mbps)
α = 3. 3
α = 1. 4
Feasible demand space

What About Costs of Implementing Tiered Pricing?

1. Past 4-5 tiers the costs are marginal in practice (Section 5.)

2. Higher costs with more tiers reinforce our findings: more tiers will add even less benefit to ISP.

How can ISPs use this?

- ISPs can perfect these models to estimate how much different flows add to their cost structure.
- ISPs can use the pricing methods we developed.
- ISPs can verify if, given their topology and demand, they might benefit form more tiers.

Tiered Pricing

Price flows based on cost and demand

- Some ISPs already use tiered pricing
  - Backplane peering
    - Charge less for traffic you can offload to peers in the same PoP
  - Paid peering and on-net/off-net pricing
    - Charge less for on-net traffic
  - Regional pricing
    - Charge less for local traffic

How is such pricing implemented?

- Detail how tiered pricing done
- Explain that paper is not about this
- Paper is about how many tiers is wise to have

- Explain implications to operators:
  - If few tiers are enough then we're all set
  - If many tiers are good, then look forward at implementing them. Perhaps also look forward to some granular bandwidth market (think enron)

Implications Slide

- Here is why we see the result

Implication 2

- If demand is concentrated, a few tiers will add a lot of benefit.

- For the rest of demand, depends on cost. Marginal cost differences -> marginal gain in profit with many tiers
- Large cost differences -> tangible gain in profit with many tiers

Caveats

- We don't know elasticities, so we test large range of them.
- The data might be biased already for the traffic because of congestion signalling (maybe demand is more than we see).
- We can't model competition long term (no one can)