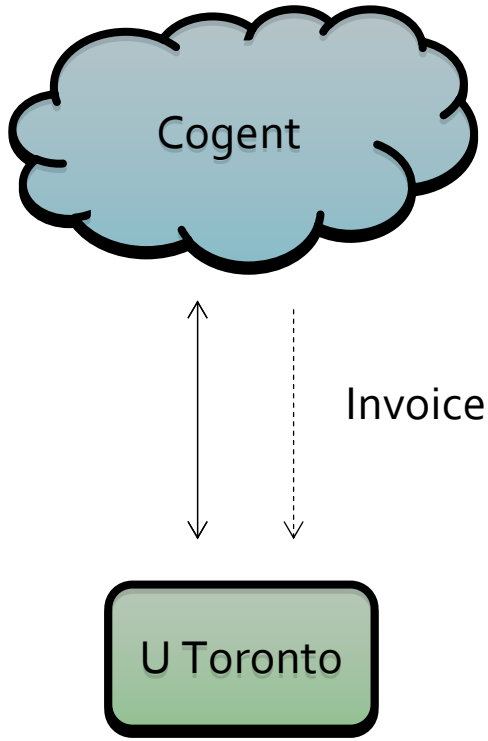
Vytautas Valancius, Cristian Lumezanu, Nick Feamster, Ramesh Johari, and Vijay V. Vazirani

How Many Tiers? Pricing in the Internet Transit Market

Internet Transit Market

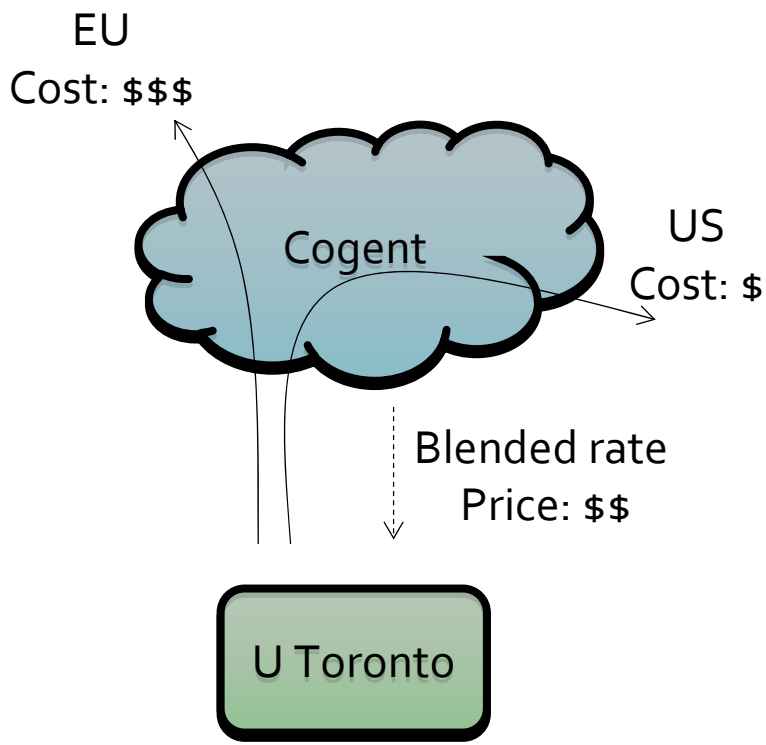
- Sellers
  - Large ISPs
  - National or international reach
- Buyers
  - Smaller ISPs
  - Enterprises
  - Content providers
  - Universities



Connectivity is sold at bulk using blended rates

What is Blended Rate Pricing?

- 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

SPs

Lack of incentives to conserve resources to costly destinations

Lack of incentives to invest in resources to costly destinations

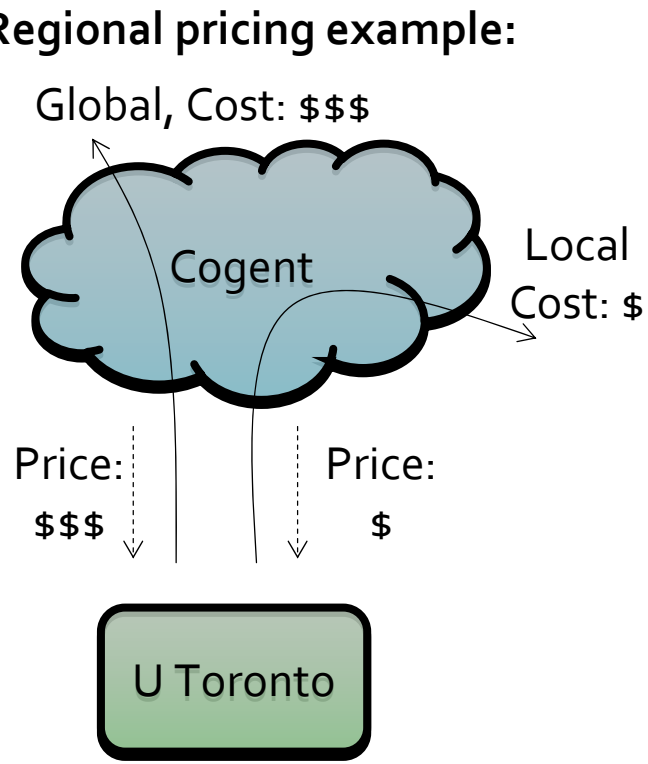
- Potential loss to ISP profit and client surplus

tiered pricing

Tiered Pricing

Price flows based on cost and demand

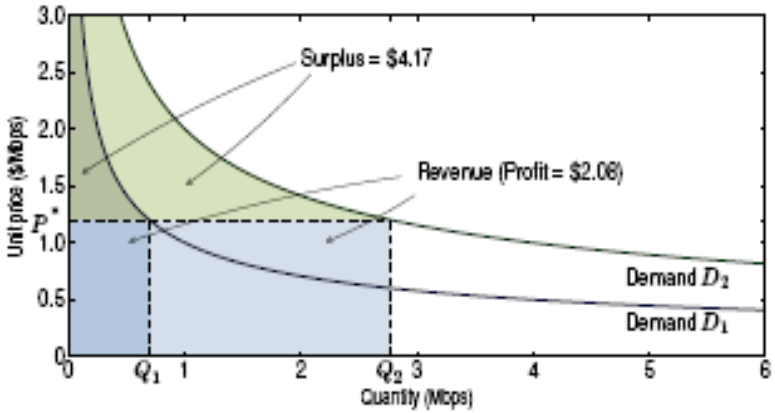
- Some ISPs already use tiered pricing
  - Regional pricing
  - Paid peering
  - Backplane peering
  - Limited number of tiers



Tiered Pricing

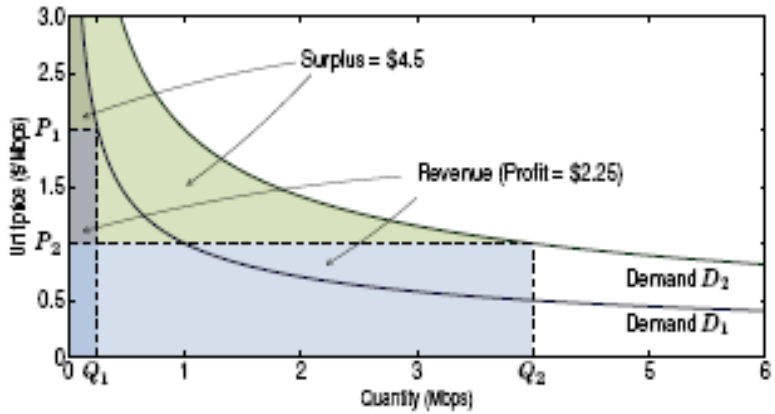
An Example: Tiered Pricing

- Tiered Pricing increases ISP profit and consumer surplus.



(a) **Blended-rate pricing.** ISP charges a single blended rate P_0.

Question:
How efficient is such tiered pricing?
Can ISPs benefit from more tiers?



(b) **Tiered pricing.** ISP charges rates P_1 and P_2 for flows.

Challenges

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

1. Construct an ISP profit model that accounts for:
   - **Demand** of different flows
   - **Servicing costs** of different flows
2. Drive the model with **real data**
   - **Demand functions** from **real traffic** data
   - **Servicing costs** from **real topology** data
3. Test the effects of tiered pricing!

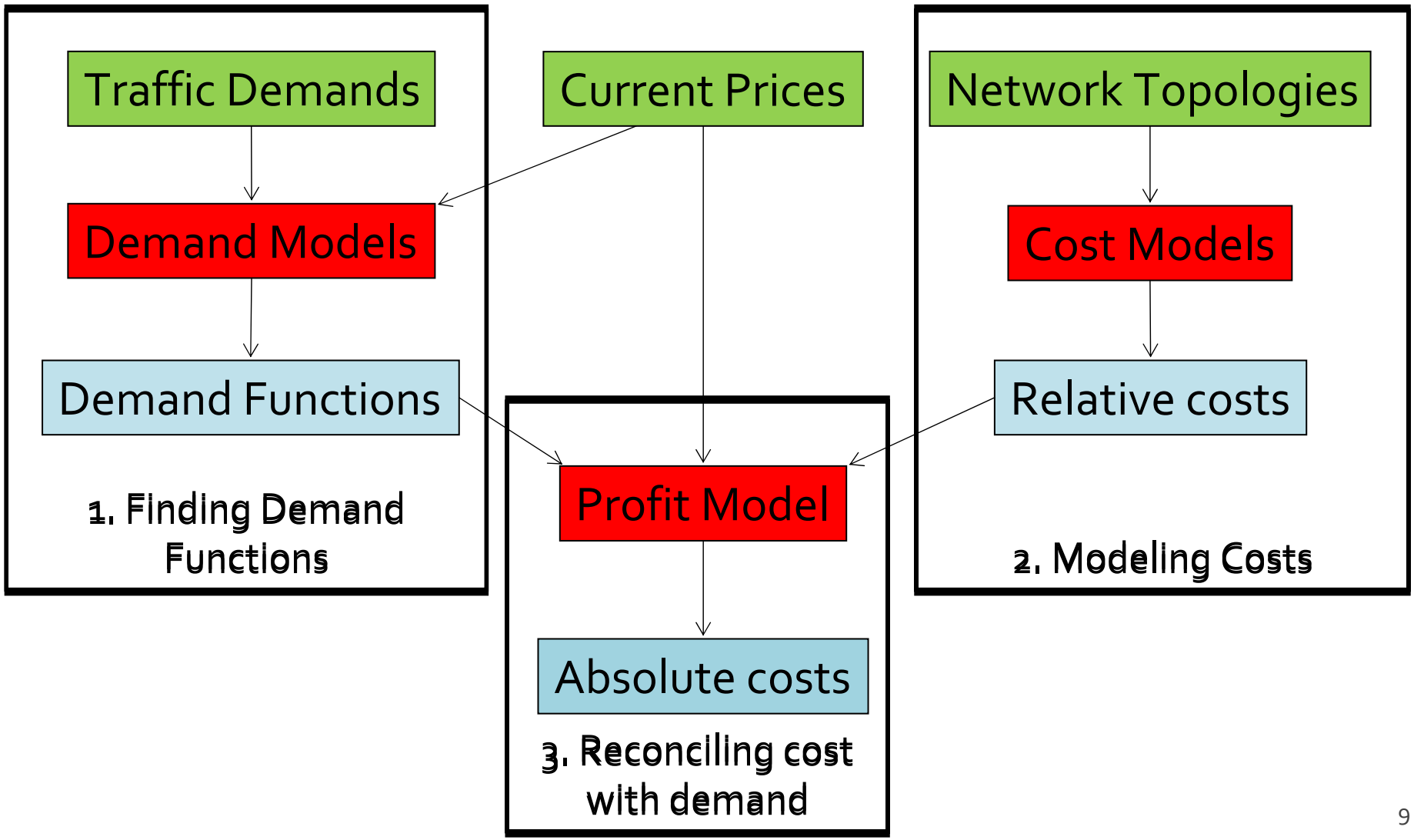
ISP Profit Model: Assumptions

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

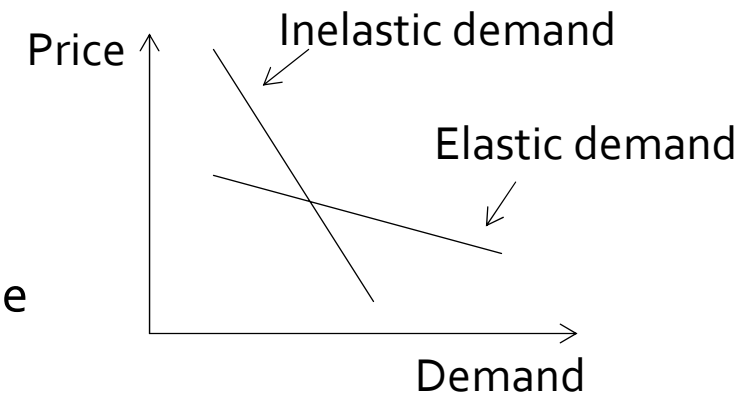


Finding Demand Functions

Canonical flow 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)

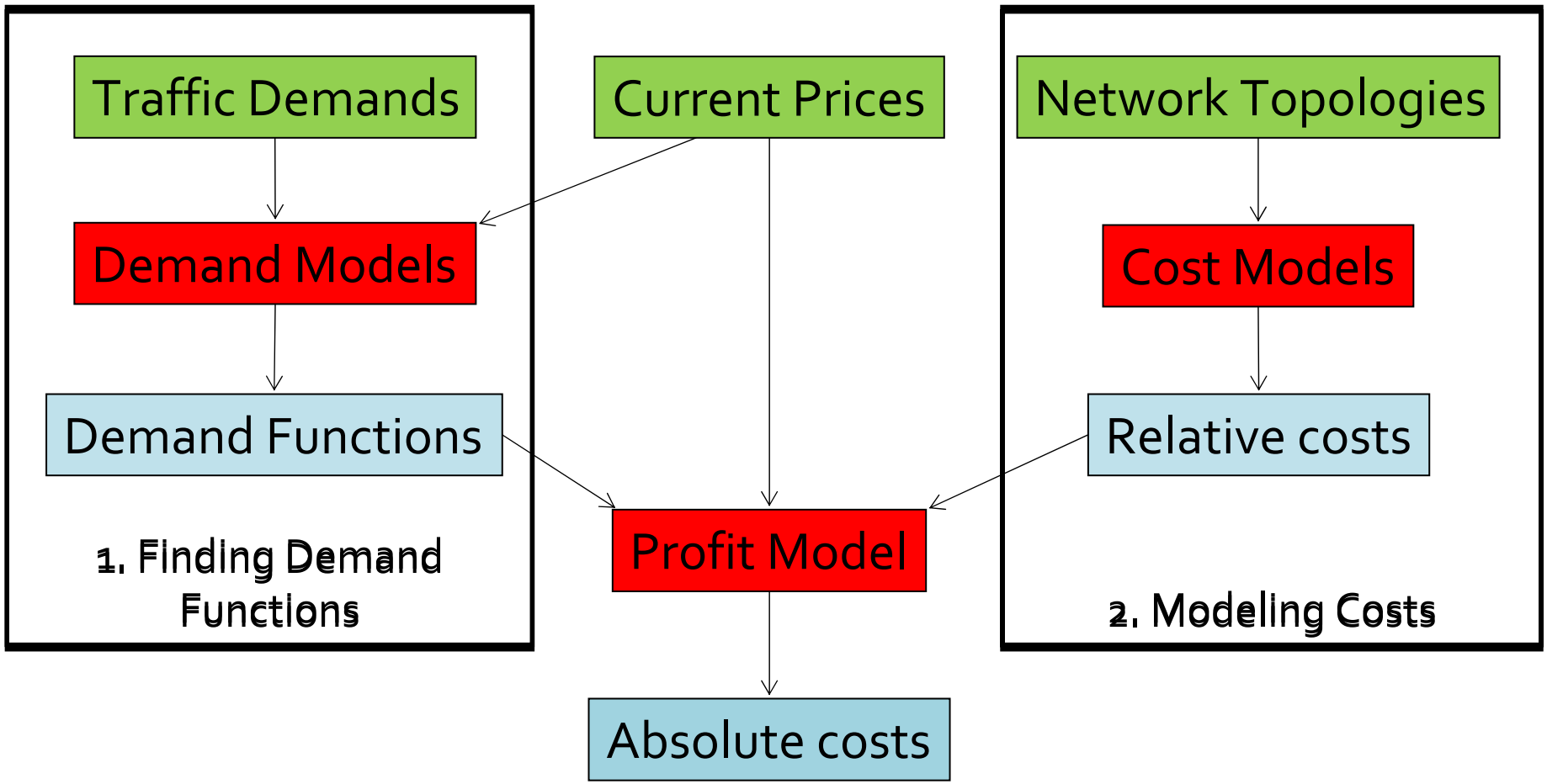
Current price

Current flow demand

Assumed range of elasticities

We mapped traffic data to demand functions!

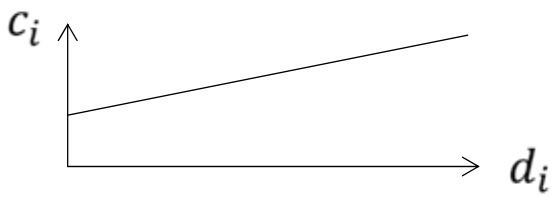
Approach to Modeling



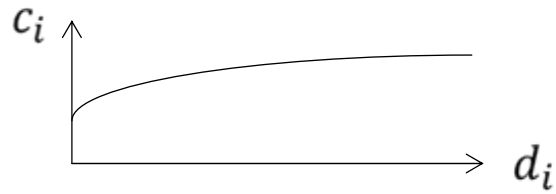
Modeling Costs

How can we model flow costs?

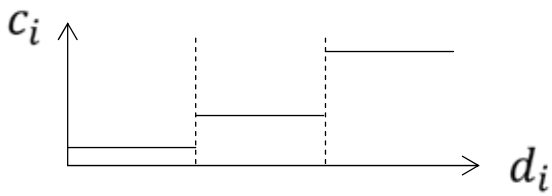
Linear:



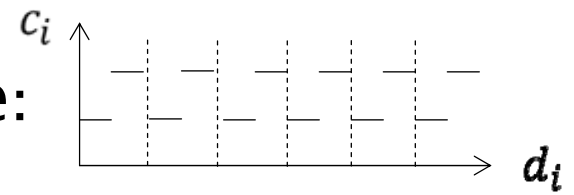
Concave:



Region:



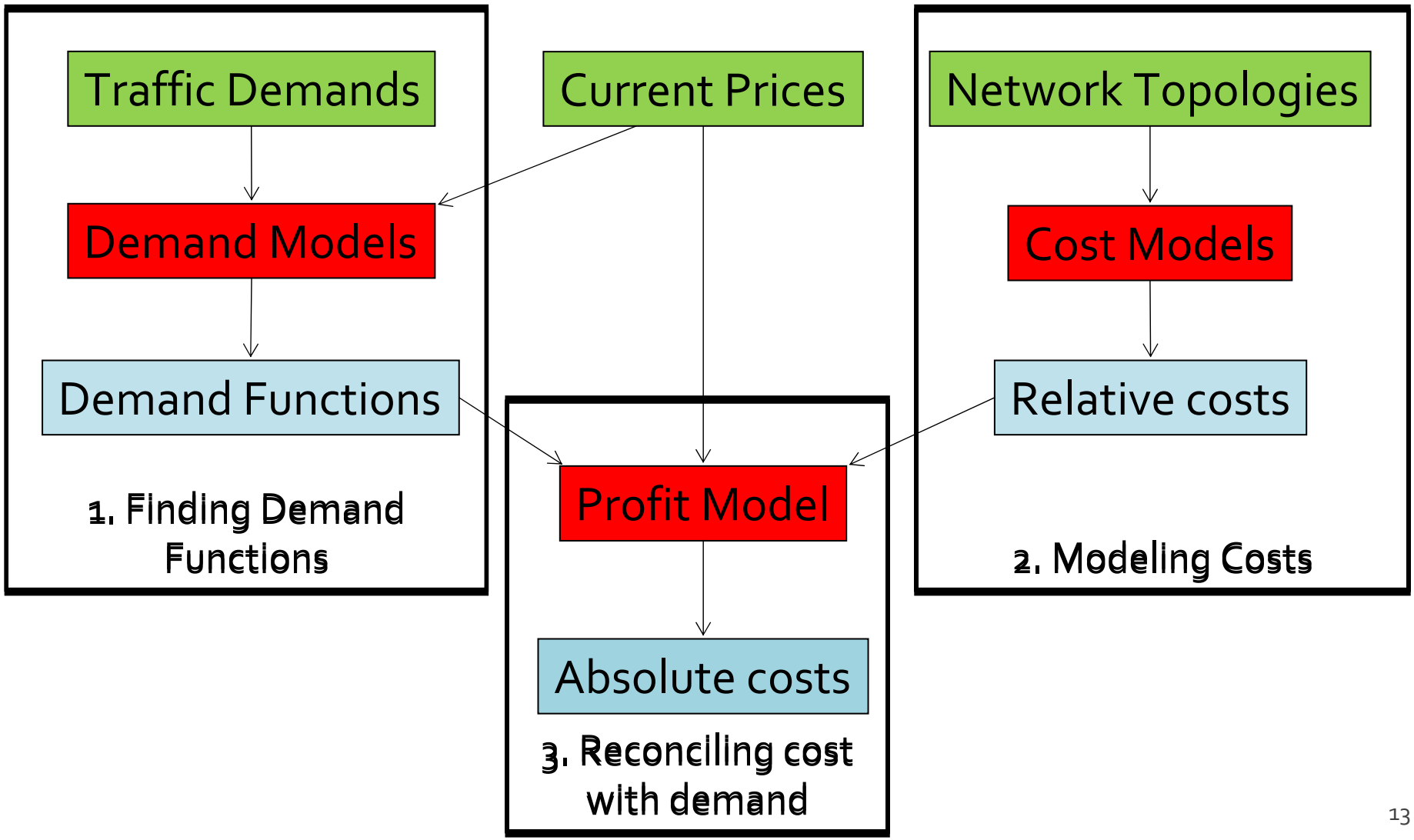
Dest. type:



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

= 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

= 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

Traffic flow bundling strategies

- Optimal: exhaustively search all possible combinations.
- Demand-weighted: balanced traffic demand among different bundles. E.g., divide 4 flows with demands 30, 10, 10, 10 into two bundles: bundle 1: 30; bundle 2: 10, 10, 10.
- Cost -weighted: separate bundles for local flows and shared bundles for flows traversing longer distances. E.g., regional pricing.
- Profit-weighted: use potential profit metric accounting for cost and demand together. The same weighting algorithm as in cost and demand-weighted bundling.

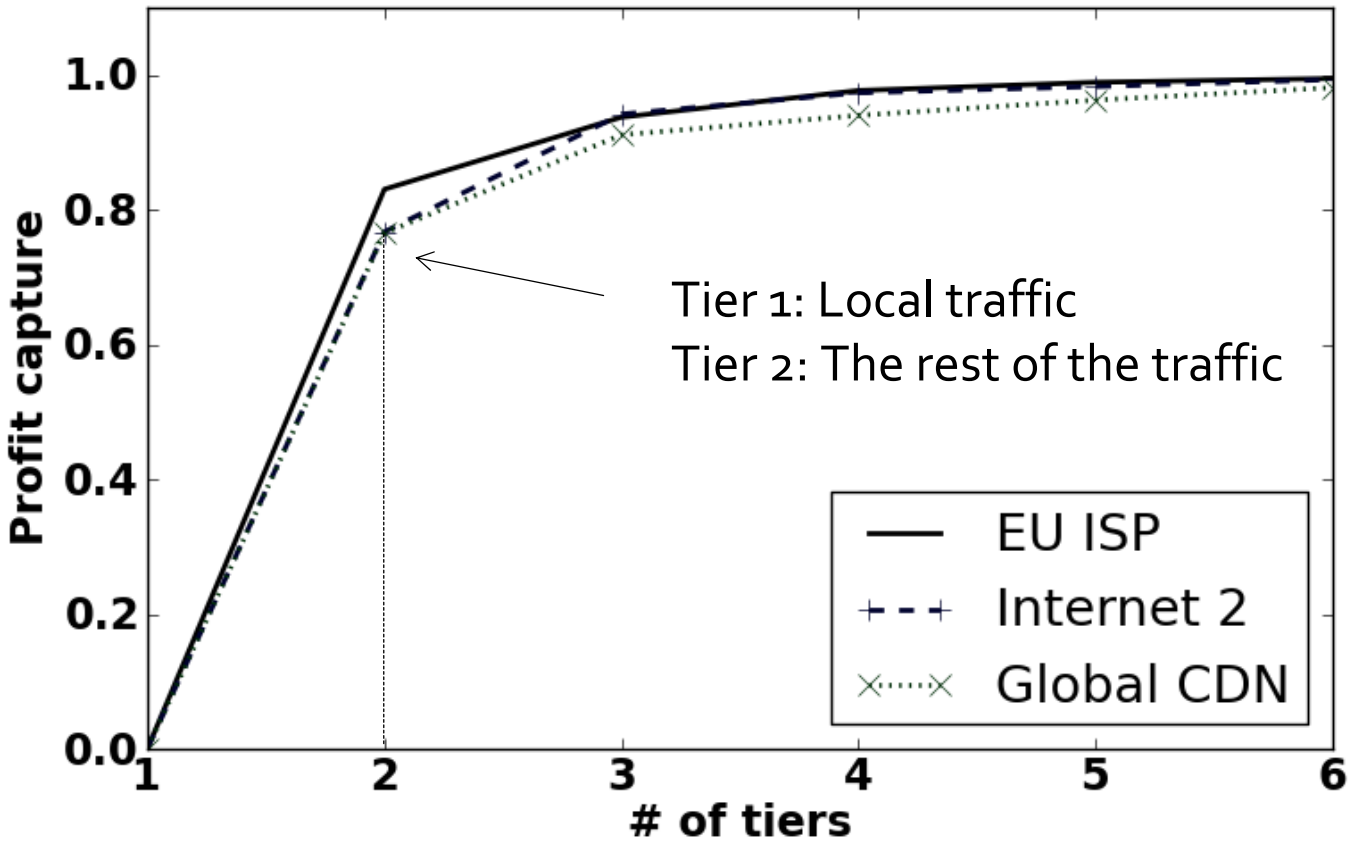
Testing ISP Pricing Strategies

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 maximum profit

Repeat above for:
-2x demand models: constant elasticity demand; logit demand
-4x cost models: linear; concave; region; dest. type.
-3x network topologies and traffic matrices: EU ISP; CDN;Internet 2

Results: Profit Capture

Constant elasticity demand with **linear cost model**



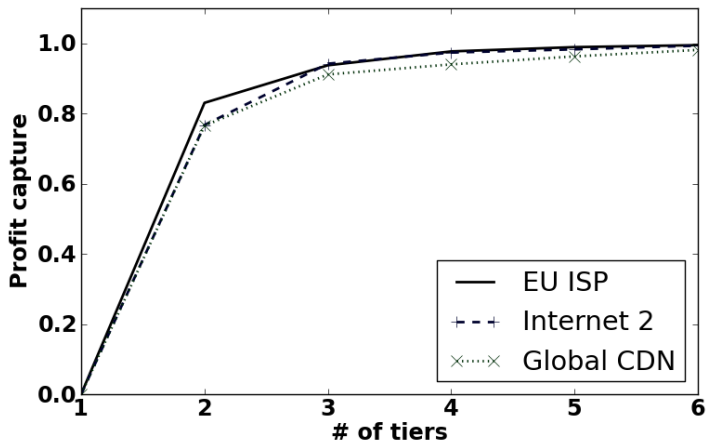
*Elasticity – 1.1, base cost – 20%, seed price - $20

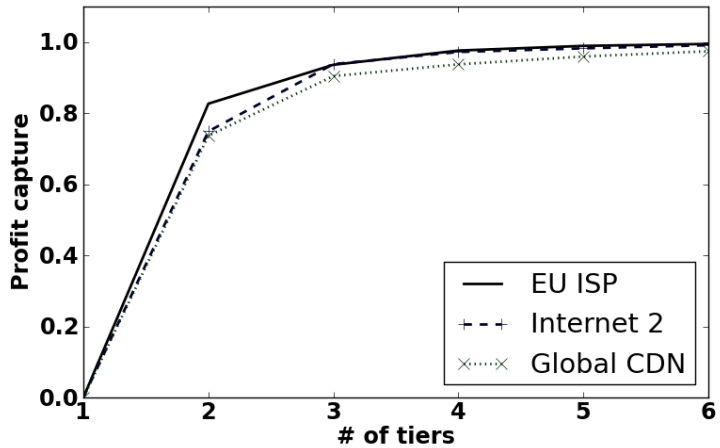
Results: Big Picture

Linear Cost Model

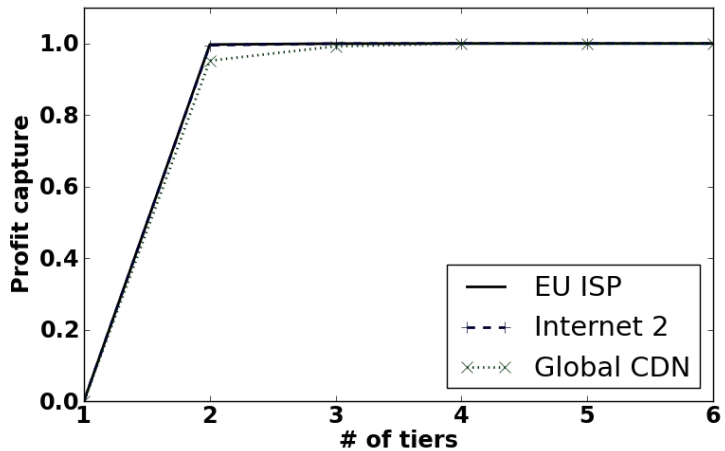
Concave Cost Model

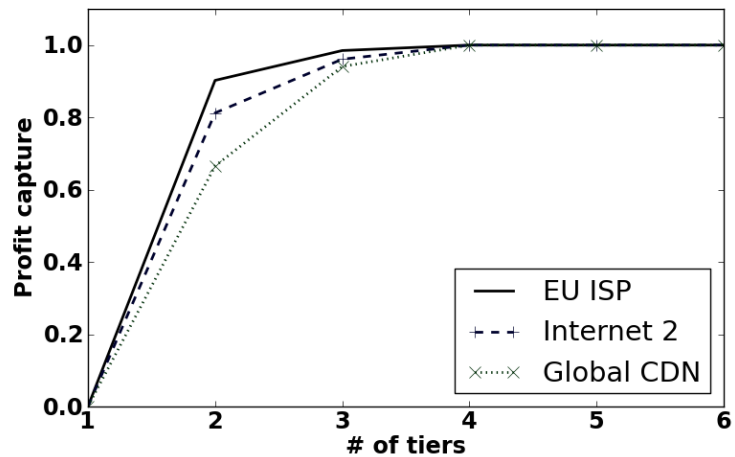
Constant Elasticity Demand





Logit Demand





Conclusion

- Current transit pricing strategies are close to optimal!
- Competition between ISPs are not considered. It is very hard to model. Perhaps Requires game-theoretic approach and more data (e.g. where topologies overlap.)

Questions?

Thanks for your attention!☺