Network Benefits From Increased Network Size

How postal network characteristics frame the Universal Service Obligation

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Disclaimer

This presentation and any views expressed herein are my personal opinions and do not necessarily represent the views of either the Postal Regulatory Commission or Commissioner Ruth Goldway.

Introduction

Examining the postal service from a network theory perspective helps explain:

- certain implications of the Universal Service Obligation, and
- aspects of postal costs, service, performance and operations.

Overview

- Postal networks exhibit similarities to classical networks, but differ in certain key ways.

- Network scaling laws are a useful way to assess the externality advantages of the postal service.

- The mail flow is evolving toward greater asymmetry.

- The law requiring a geographically-uniform rate is a key driver of the Universal Service Obligation.

- New delivery points are a benefit, not a burden.

A Network Approach

Postal economics usually takes a component-level approach, and tends to marginalize network effects.

The purpose of this paper is not to select or specify USO elements. Instead, it reviews system-level drivers for universal service.
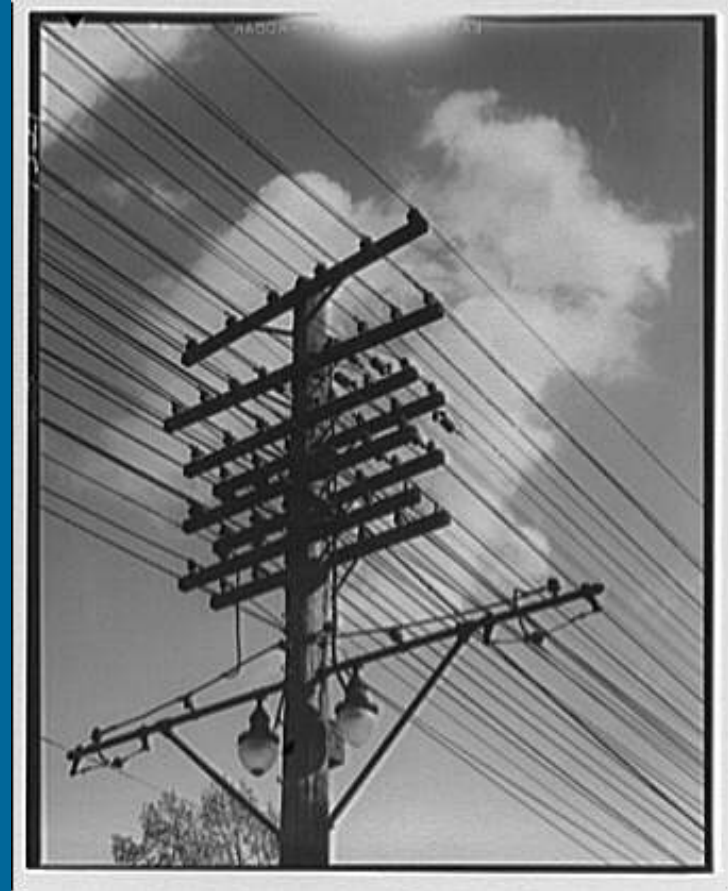
Network Industries

- Utilization of a network or infrastructure to deliver retail services
- Large capital investment and high sunk costs
- Economies of scale and scope
- Market concentration
- May inhibit competition

Two-way Network Industries

- Telecommunications
- Cable TV / Satellite
- Postal service
- Airports / seaports / waterways
- Bus / Truck / Train Transport

One-way Network Industries

- Electricity
- Natural gas
- Oil Pipelines
- Water Pipelines
- Sewage

Other Network Industries

- Airline reservation computer systems

- Real estate multiple listing services

- Credit / debit card systems

- Check clearing services

Postal Service: A Hybrid Network

Postal Service combines a transportation/sorting network with a last-mile delivery network.

Postal Network Turning Asymmetric

Postal Service is a network shifting from a peer-to-peer (two-way) role toward a predominantly broadcast (one-way) function.

In contrast, other communication/transportation networks tend to evolve toward symmetry.

Mail Volume: More One-Way

- Household to Household: 3%
- Household to Nonhousehold: 6%
- Nonhousehold to Nonhousehold: 21%
- Nonhousehold to Household: 70%

(USPS Household Diary Study - 2006)

Selected Network Attributes

- Topology
- Externality Effects
- Sunk costs
- Essential Facilities
- Connectivity
- Congestion
- Compatibility & Standards

The Externality Effect - Two-way networks

- Rohlfs (1974) - Adding new members increases value to incumbent members (provided there is no congestion or interference)

- Reciprocity (reverse traffic) "Calls Beget Calls"

- Reiterativity (multiplier effect)

Externalities Promote Expansion

- White (1999) Significant externalities result in a smaller network than socially optimal

- A tax and subsidy combination at the margin could be Pareto-improving and thus worthwhile (the incumbents are still better off)

- This occurs in the postal network

Postal Sunk Costs

Postal Service is labor-intensive (80+%), but:

⊠ Postal processing/handling facilities

⊠ High tech mail sorting equipment

⊠ Long-term labor obligations

Postal Has Some "Essential Facilities"

- ⊠ The national addressing scheme
- ⊠ Software to update/correct addresses
- ⊠ Access to mail entry points
- ⊠ Last-mile delivery services
- ⊠ Intelligent Mail bar coding and tracking data
- ⊠ Forwarding, return (ancillary services)

Connectivity & Potential Connectivity

- Expected net present value (NPV) of the stream of transactions between a pair of nodes, summed over all the node pairs

- <u>Optional</u> transactions value afforded
  – example: Phones that dial only 911

Delivering to Everyone is Valuable

- Potential Connectivity: "The postal service reaches everyone, everywhere, every day."

- In postal service, delivering to "everyone" achieves an incremental stepwise result better than reaching "less than everyone".

Congestion (and Accessibility)

- network quality impairment

- holiday capacity constraints

- delayed transportation or deliveries

- network congestion theory could potentially model accessibility issues to evaluate USO

Compatibility

- Nodes and links must be compatible with each other.

- Postal examples include:

  - the zip code system
  - addressing scheme
  - address certification
  - readability certification
  - envelope shapes
  - critical entry times

Network Scaling Theories

- Sarnoff's Law - (linear)

- Metcalfe's Law - (square)

- Reed's Law - (exponential)

- Odlyzko's Analysis - (exponential)

- Hybrid S-Curve (with saturation effects)

- Kilkki-Kalervo Law - (group size weighted)

- Gupta Buyer-Seller Diffusion Law

Sarnoff's Law

- Broadcasting model – Sarnoff (1915-1919)
- Linear growth
- One way communications
- Few sources, many sinks
- Marginal value of each new connection is constant
- $V = c_1 N$

Metcalfe's Law

- Metcalfe (1980)

- Network value grows proportionately with the number of other users you can call

- Overstates network value for very large N

- $V = c \ [(N * (N-1)] / 2) \rightarrow cN^2$

Reed's Law

- Reed (1999)

- Group forming networks are valuable

- Subscription lists, mail lists, chat rooms, buddy lists

- $2^N - N - 1$ subsets of N members

- $\longrightarrow 2^N$

- $V = c_1 N + c_2 N^2 + c_3 2^N$

Odlyzko's Approach

- Odlyzko, Briscoe, Tilly & Weinman (2006-7)

- "Gravity Law" (spatial/social relationships)

- Zipf's Law (power law distribution)

- We talk with some more often than with others

- Harmonic distribution: 1, ½, 1/3, ¼ …

- Total connectivity value ⟶ c [n log (n)]

Kilkki-Kalervo Law

- Kilkki, Kalervo (2004)

- Reed's Law is flawed (groups vary in value)

- The 2^N coefficient must decrease at large N

- $V = [pm_1 + p^2m_2 + p^3*m_3/(r-2-(r-3)p] \, K$

Hybrid S-Curve with Saturation

- Linear + Exponential + Log + saturation effects

- Saturation caused by limited customer resources

- Gottinger (2003) suggests using econometric methods to empirically determine the shape of the network externality benefit curves

Buyer-Seller Diffusion Law

- Gupta , Mela, Vidal-Sanz (2006)
- Buyer-seller interaction determines Customer Lifetime Valuation and thus network value
- Related to two-sided matching markets
- E.g.: Job agencies, realtors, auction houses

- Appears germane to modeling postal service

Mail Recipients are Valuable

Buyers (mail recipients) don't pay the firm, but they attract fee-paying sellers (mailers)

Recipient must receive some minimum amount of valued mail to maintain mail channel utility

Causes of Postal Network Complexity

- ✓ critical handoff timing

- ✓ a discrete (quantized) delivery periodicity

- ✓ first class mail must be expedited

- ✓ different types/priorities of mail must merge

- ✓ substantial labor considerations

- ✓ contingency planning

- ✓ accommodating contractors and customers

Additional Causes of Postal Network Complexity

- ✓ Local autonomy
- ✓ "On the fly" re-routing
- ✓ Congruent networks
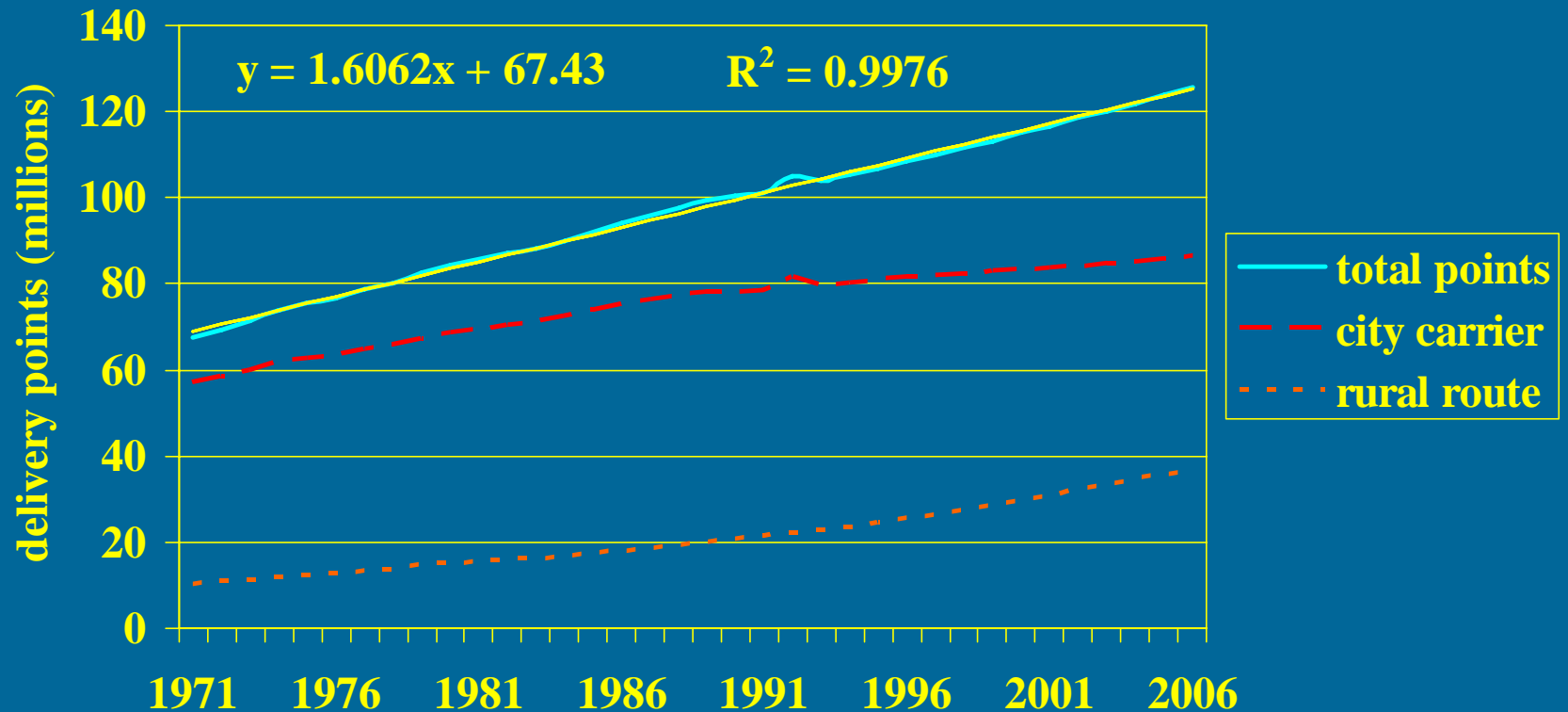- ✓ Access to competitor networks

Postal Network Service Advantages

✓ Sharing of system resources

✓ Facilitated error correction and expedition

✓ Graceful degradation of service

✓ Excess capacity with surge capability

Reaching Everyone is Challenging

Postal Delivery Points Increasing

$y = 1.6062x + 67.43$ $R^2 = 0.9976$

delivery points (millions)

140
120
100
80
60
40
20
0

1971   1976   1981   1986   1991   1996   2001   2006

total points
city carrier
rural route

MJR - 11/16/07

New Delivery Points

- Adding postal delivery points is a natural outcome of household formation and population growth.

- New delivery points attract new mail.

- Studying the profile of mail to and from new delivery points would be worthwhile.

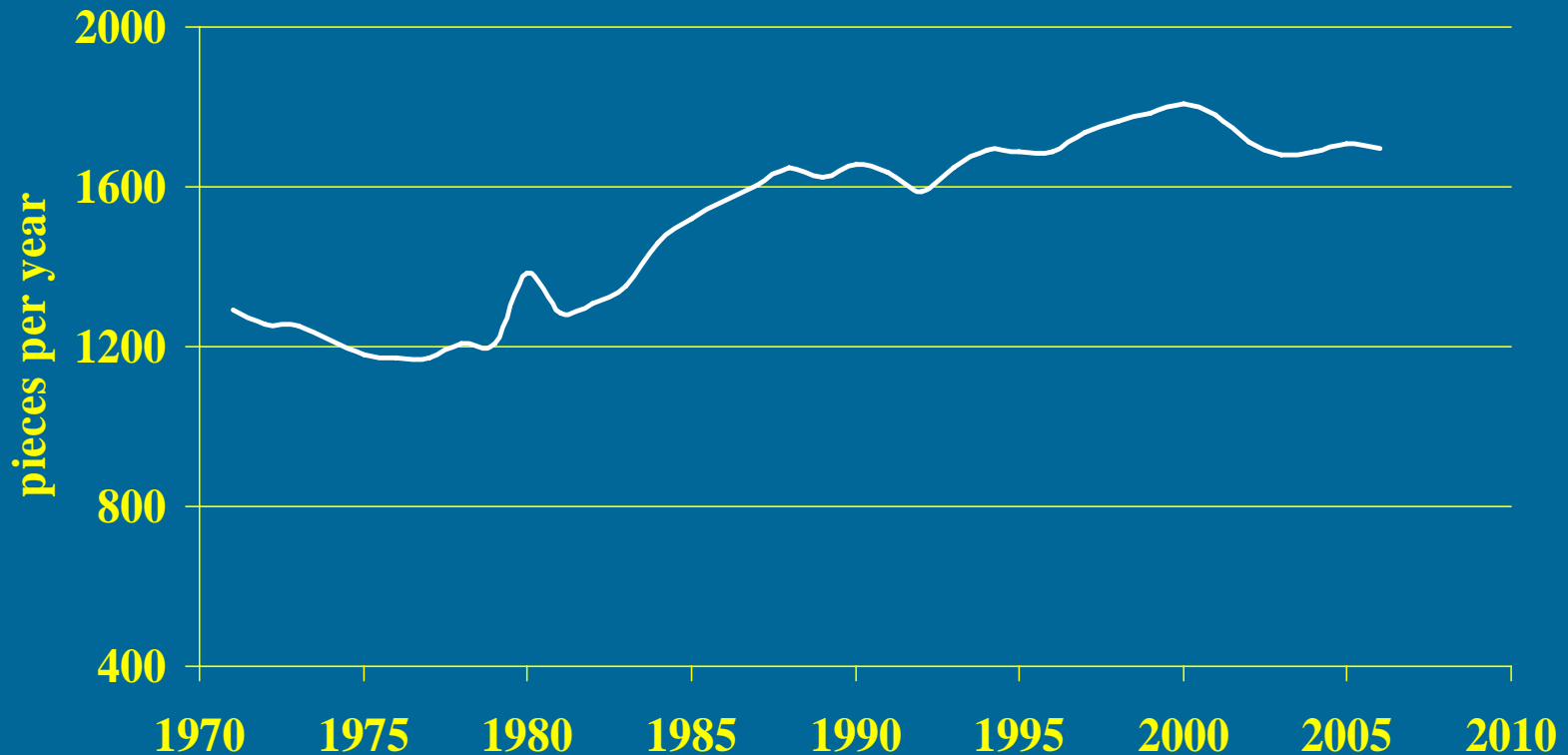# New Delivery Points Are Beneficial

MORE MAIL VOLUME

- New residences
- New businesses

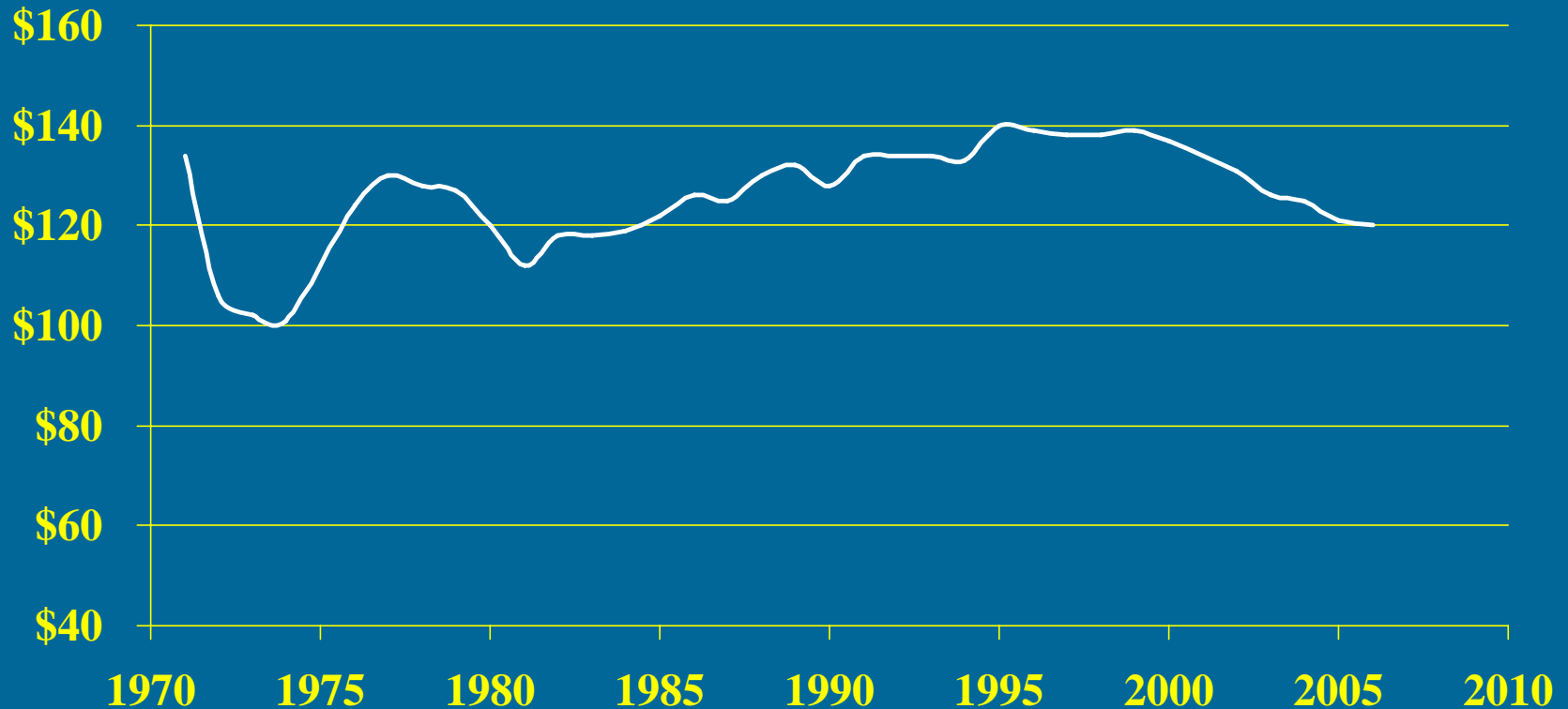(See Schuyler, IRET Advisory # 219 (2007))

LOWER UNIT COST

- Clustered Boxes
- Apartment Buildings
- Rural Routes
- Highway Routes
- Infill
- Increased route density

Average Mail per Delivery Point

Average Revenue Per Delivery Point (1972 constant dollars)

Legal Basis for Universal Service

- 39 U.S.C. § 101(a) – "provide prompt, reliable, and efficient services to patrons in all areas and shall render postal services to all communities"

- § 101(b) – "provide a maximum degree of effective and regular postal services to **rural areas, communities and small towns where post offices are not self-sustaining**"

Other Universal Service Obligations

- to offer to all locations a uniform rate for sealed letter mail - 39 U.S.C. § 404(c)

- to serve as nearly as practicable the entire population of the United States - § 403(a)

Other Congressional Instructions

Annual Congressional appropriation directs:

➢   Maintain six day a week delivery service

➢   Maintain Rural Free Delivery

Postal Policy Choices Steer USO

- Affordable widespread service; home delivery
- Pay per piece of mail sent (metered service)
- Sender pays the postage
- Non-discriminatory rates
- Uniform distance-invariant rate (letters/books)
- Content-based rates (<u>not</u> "net neutrality")
- Confidentiality / integrity of the mail

Demand Propels Universal Service

➢ Sufficient mail volume (industrialized nations)

➢ Uniform letter rates

➢ Demand from mailers to reach everyone

➢ Mailers find new delivery points attractive

Conclusions

- Network analysis has emerged as a potential tool for evaluating postal services

- Policy decisions requiring certain uniform rates drive the Universal Service Obligation

- Delivery point revenue profiles can help assess the cost of providing universal service

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