Railroad Deregulation and Innovation in the Grain Supply Chain: Contrasting Shuttle and Non-Shuttle Grain Elevator Services

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INTRODUCTION

A.

Railroad Deregulation

1. 1973 Railroad Reorganization Act (3R Act)
2. 1976 Railroad Revitalization and Regulatory Reform (4R Act)
3. 1980 Staggers Act
4. Gave railroads operational freedom (**Meyer 1973)**

B.

Rail cost reducing strategies and Innovation

1. Sale, lease and abandonments (**Babcock and Bunch 2003**)
2. Productivity enhancing innovations (**Gallamore 1999**)
3. \$2-\$ 3 bil. productivity and caboose cost saving (**Bitzan and Keeler 2003**)
4. Significant productivity tended to diminish in the long term (**Wilson 1997**)

C.

Benefits to shippers

1. Falling rail rates as well as improved service quality (**Grimm and Smith 1986**)
2. Accrued benefits to grain producers and shippers (**Bitzan et al. 2003**)
3. Increased shipment size in grain supply chain (**Wilson and Dahl 2010**)
4. Proliferation of grain elevators capable of 100 plus railcar shipment(**shuttle**)

SHUTTLE GRAIN ELEVATORS

- **BURLINTON NORTHERN SANTA FE (BNSF):**
  - **Shuttle train:** 110 covered hopper cars, each with a capacity of 111 tons,
  - **shuttle elevator:** Enough track capacity to accept **110 cars** and load and unload them in **15 hours** up to three times per month without clogging the main line.

- **SOO Line (Canadian Pacific Railroad, CP)**
  - **Shuttle trains** (efficiency trains):100 cars and
  - **Efficiency elevators:** load **100 cars** within a **24-hour** period without disruption to the main line.

- **Perspective**
  - A 110-car train made up of 111-ton covered hopper cars will carry **400,000 bushels of wheat** (approx. 12,000 tons).
  - Volume requirements and loading and unloading makes **production** and **storage capacity** an important aspect of the shuttle program.

Grain Shippers' Perspective (elevator)

- **Construct or upgrade existing facilities to meet carrier standards**

- **Cost of constructing shuttle loader** (Kowalski, 2014)
  - In 1990 **$7 million** (1+ million bushel capacity)
  - Presently about **$25 million** (1.5 – 3 million bushel capacity)
  - Typical annual volume to justify building 17 – 20 million bushels

- **Question: Why build ?**
  - Lower shipping rates (contract)
  - Greater shipping capacity
  - Access to new markets (export bound)

BNSF Shuttle Elevators (Loaders)

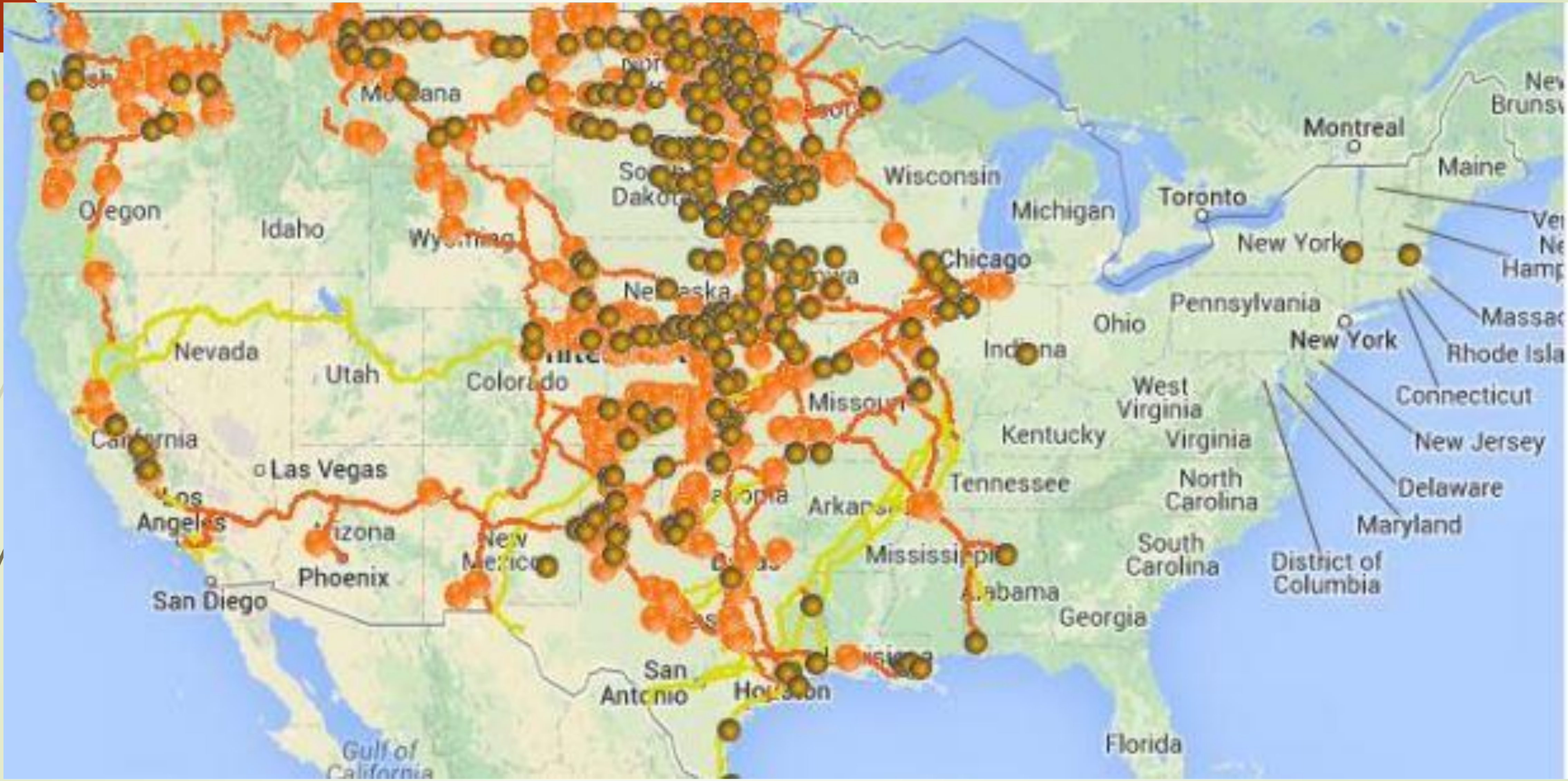


FIGURE 1
Source: BNSF

SHUTTLE AND NON-SHUTTLE (COUNTRY) ELEVATOR LOGISTICS

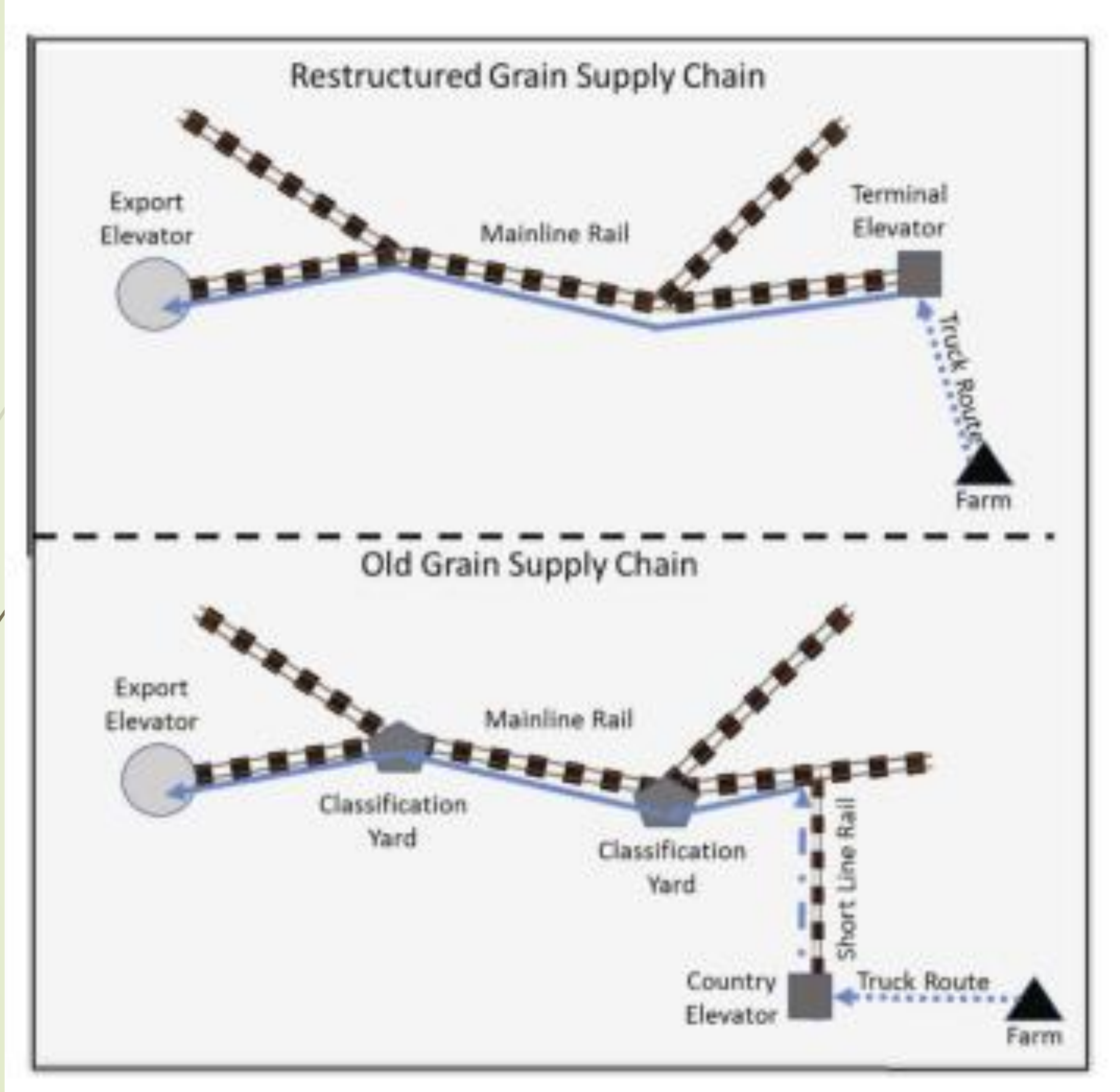
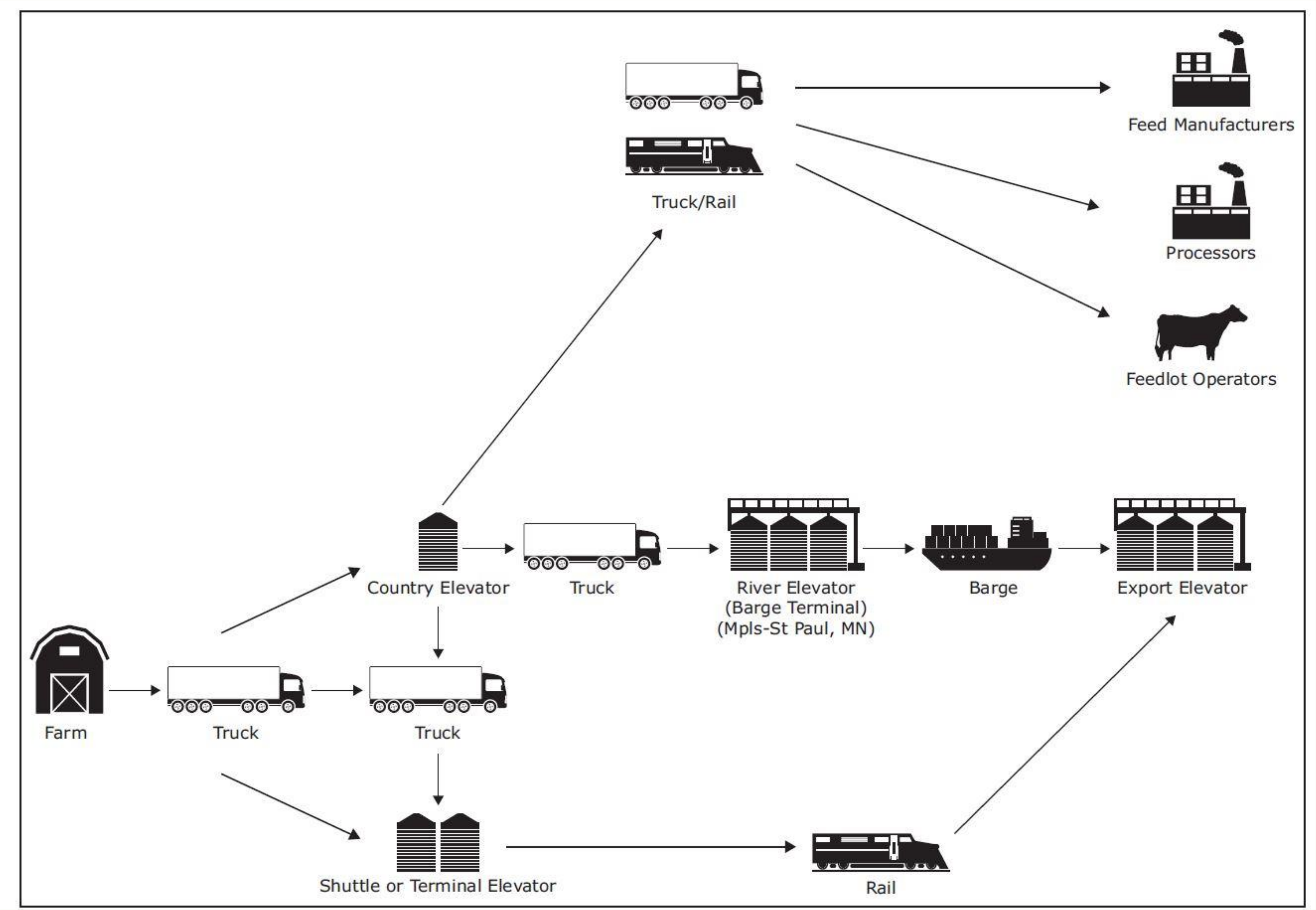


FIGURE 2
Source: Hyland et al. (2016)

Grain Supply Chain



RATIONALE

1. **Long run effects of innovation with adoption of the shuttle technology with likely regional effects**

- If the rationale for the introduction of shuttle services was to improve efficiency in grain transportation, then we expect **shuttle elevators** to differ from **non-shuttle** (country) elevators.

- A good way to determine likely differences is to access how shippers (disaggregate) view both services (shuttle and non-shuttle) using **elasticities** calculated from a **derived demand model.**

RATIONALE CONTD

2. Potential policy concerns stemming from increasing use of shuttle services.

- Boyer (2016) noted that in the long-run railroad **shipper investments** in rail dependent facilities can alter the demand elasticities for a specific railroad service or an entire transportation corridor.
- Whether these investments play a role in determining demand elasticities or relative modal usage (e.g. rail, truck) is an empirical question.
- This potential can be gauged by comparing shuttle and non-shuttle grain elevators **demand for transportation (derived).**

OBJECTIVE

- To assess likely difference between shuttle and non-shuttle elevators demand for transportation using elasticities calculated from shippers' link specific cost function.

  - **Case Study**: North Dakota Hard Red spring wheat shipment between 2006 and 2013.

  - Application of a **derived demand** approach facilitates calculation of elasticities and comparing rail and truck services for shuttle and non-shuttle elevators.

THEORETICAL MODEL

- Similar to Oum (1979), North Dakota grain shippers' transport cost function can be specified as:

$$TC = f(W_R, W_T, Q, D, SHUT) \quad (1)$$

Where,

TC = total transportation cost
W_R = price of rail transportation
W_T = price of truck transportation
Q = quantity shipped (tons)
D = distance
$SHUT$ = shuttle elevator dummy

- Following Shephard's Lemma (1973), modal input demand functions can be derived from shippers' total transportation cost as follows:

$$\frac{\partial TC}{\partial W_i} = X_i, \qquad i = T, R \quad (2)$$

Where,

$X_i = quantity\ of\ rail\ or\ truck\ transportation$

- North Dakota Shippers' link specific transport cost function used in analysis is given as:

$$TC_l = f(W_{il}, Q, D_l, T, SHUT) \qquad (3)$$

Where,

TC_l = total rail and truck transportation cost on link l;
W_{il} = i × l vector of prices of i modes on link l;
Q = total output on link l (tonmiles);
D_l = distance of link
T = time trend
$SHUT$ = shuttle elevator dummy
$l = 1, 2, \ldots l$

- Links involve **individual elevators** in state and four major destinations for ND grain
  - Destinations:
    - Duluth and Minneapolis St Paul, MN,
    - PNW (Portland, OR)
    - Gulf (New Orleans, LA)

❑ The Transcendental Logarithmic (translog) form of the link specific cost function is given as:

$$InTC_l = \alpha_0 + \sum_i \alpha_i In(W_{il}) + \rho_q In(Q) + \beta_t In(D_l) + \psi_\phi T + \varrho_s SHUT + \frac{1}{2}\sum_{ij} \tau_{ij} In\,(W_{il}) In\big(W_{jl}\big) + \sum_i \tau_{iq} In(W_{il}) In(Q_l) + \sum_i \tau_{it} In(W_{il}) In(D_l) + \sum_i \tau_{i\phi} In(W_{il}) T + \sum_i \tau_{i\varrho} In(W_{il}) SHUT + \frac{1}{2}\tau_{qq}(InQ_{il})^2 + \tau_{qt} InQ_{il} InD_l + \frac{1}{2}\tau_{tt}(InD_l)^2 + \frac{1}{2}\tau_{\phi\phi}(T)^2 + \tau_{q\phi} InQ_{il} T + \tau_{q\varrho} InQ_{il} SHUT + \tau_{t\varrho} In(D_l) SHUT + \tau_{t\phi} In(D_l) T + \tau_{\phi\varrho} TSHUT \qquad (4)$$

❑ Homogeneity and symmetry conditions:

$\sum_i \alpha_i = 1,$

$\sum_i \tau_{ij} = \sum_j \tau_{ij} = 0,$

$\sum_i \tau_{iq} = \sum_i \tau_{it} = \sum_i \tau_{i\phi} = \sum_i \tau_{i\varrho} = 0, \qquad \tau_{ij} = \tau_{ji}$

❑ Input demand function given as:

$$\frac{\partial InTC_l}{\partial In(w_{il})} = x_{il}\frac{w_{il}}{C} = S_{il}$$

SUR ESTIMATION

Parameter	Name	Parameter Estimate	P-Value
α_0	Intercept	13.8206*	0.0001
α_1	ln (Rail Rate)	0.8479*	0.0001
α_2	ln (Truck Rate)	0.1521*	0.0001
ρ_1	ln (Ton-Miles)	0.9752*	0.0001
ρ_2	ln (Link Distance)	0.0053	0.7260
ρ_3	Time	-0.0047	0.3629
ρ_4	Shuttle Dummy	-0.1136*	0.0001
τ_{11}	1/2 $(\ln \text{Rail Rate})^2$	-0.0192	0.5581
τ_{22}	1/2$(\ln \text{Truck Rate})^2$	-0.0192	0.5581
β_{11}	1/2 ln $(\text{Ton-Miles})^2$	0.0041*	0.0033
β_{22}	1/2$(\ln \text{Link Distance})^2$	-0.0384	0.1305
β_{33}	1/2$(\text{Time})^2$	-0.0008	0.5821
τ_{12}	ln (Rail Rate)*ln (Truck Rate)	0.0192	0.5581
χ_{11}	ln (Rail Rate)*ln (Ton-Miles)	0.0620*	0.0001
χ_{12}	ln (Rail Rate)*ln (Link Distance)	-0.0446**	0.0175
χ_{13}	ln (Rail Rate)*Time	0.0068**	0.0455
χ_{14}	ln (Rail Rate)* Shuttle Dummy	0.1275*	0.0001
χ_{21}	ln (Truck Rate)*ln (Ton-Miles)	-0.0620*	0.0001
χ_{22}	ln (Truck Rate)* ln (Link Distance)	0.0446**	0.0175
χ_{23}	ln (Truck Rate)*Time	-0.0068**	0.0455
χ_{24}	ln (Truck Rate)*Shuttle Dummy	-0.1275*	0.0001
β_{12}	ln (Ton-Miles)*ln (Link Distance)	-0.0034	0.3327
β_{13}	ln (Ton-Miles)*Time	0.0009	0.2408
β_{14}	ln (Ton-Miles)*Shuttle Dummy	-0.0057	0.1697
β_{23}	ln (Link Distance)*Time	0.0005	0.8472
β_{24}	ln (Link Distance)*Shuttle Dummy	-0.0025	0.8427
β_{34}	Time*Shuttle Dummy	0.0060***	0.0562

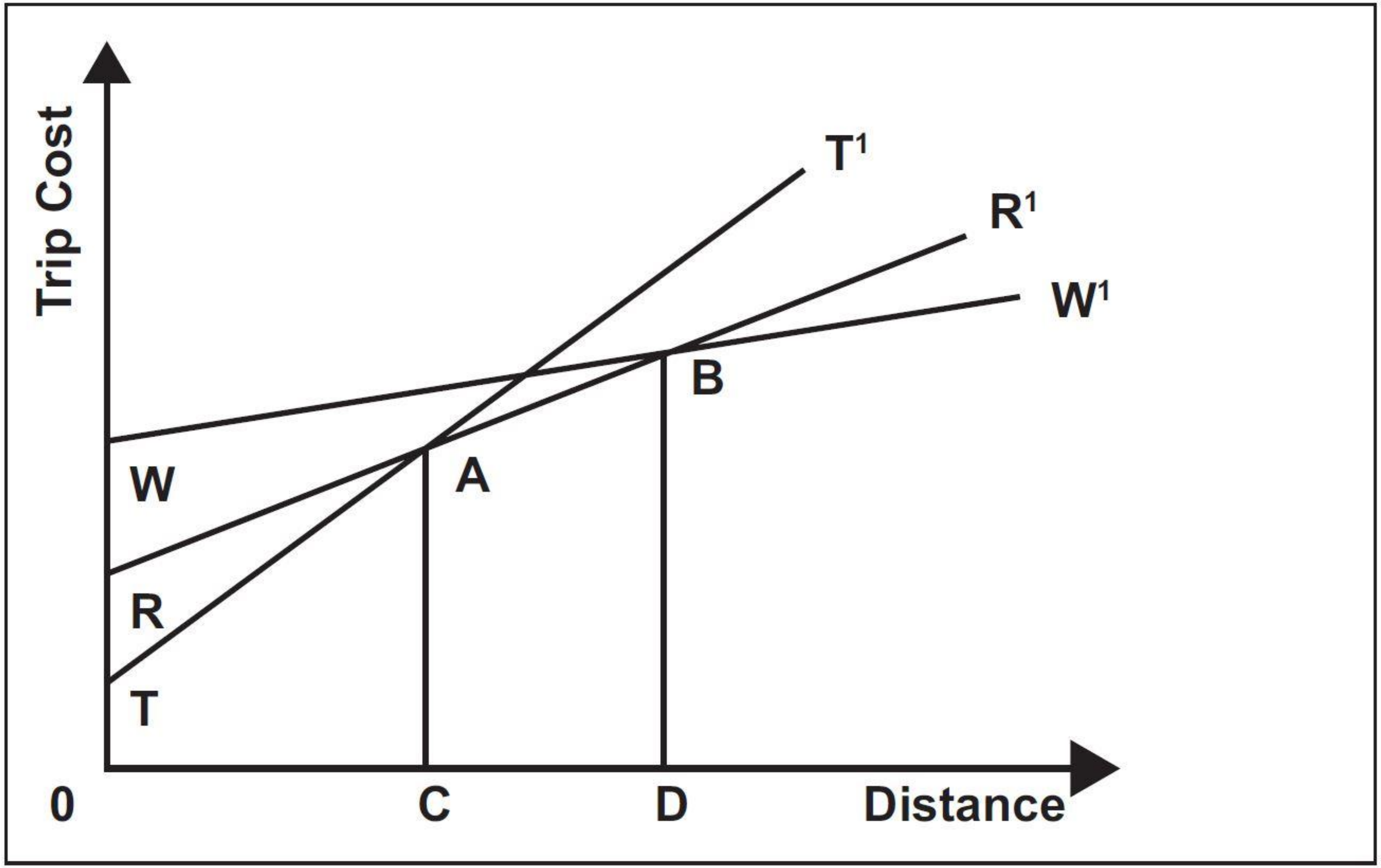
*, **, *** Significance at the 1%, 5% and 10% respectively
Observation = 2002
System Weighted R^2 = .9417
System Weighted MSE = 9915.

*Estimated Modal Elasticities Shuttle and Non-Shuttle Elevator

	Elevator Type	
	Shuttle	Non-Shuttle
Rail Factor share (S_{1l})	0.98	0.85
Truck Factor Share (S_{2l})	0.02	0.15
Elasticity of Substitution σ_{12}	1.79	1.15
Rail price elasticity $\varepsilon_{11} = -\varepsilon_{12}$	-0.04	-0.17
Truck price elasticity $\varepsilon_{22} = -\varepsilon_{21}$	-1.75	-0.98

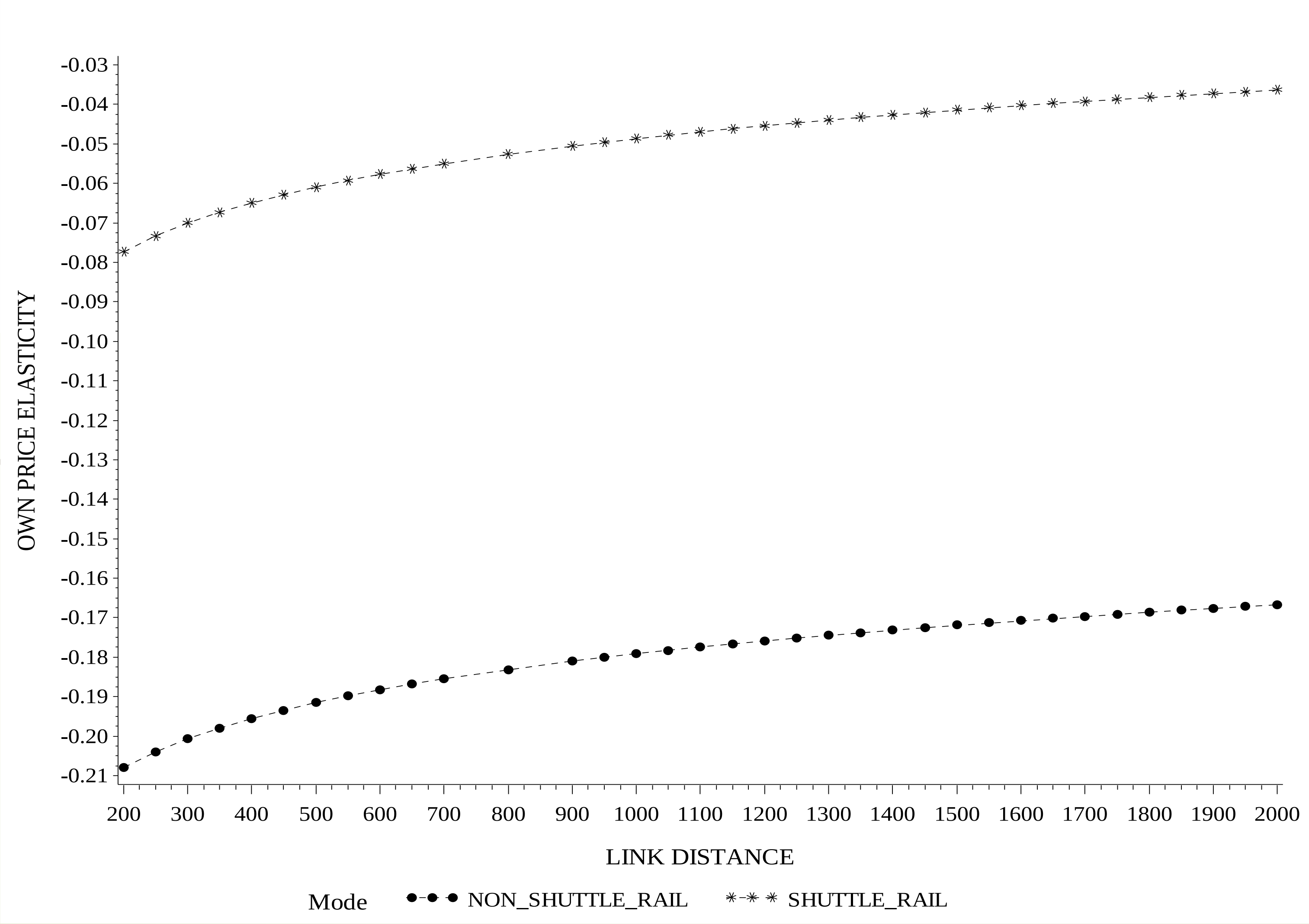
*Compensated demand elasticities

Trip Cost and Intermodal Competition



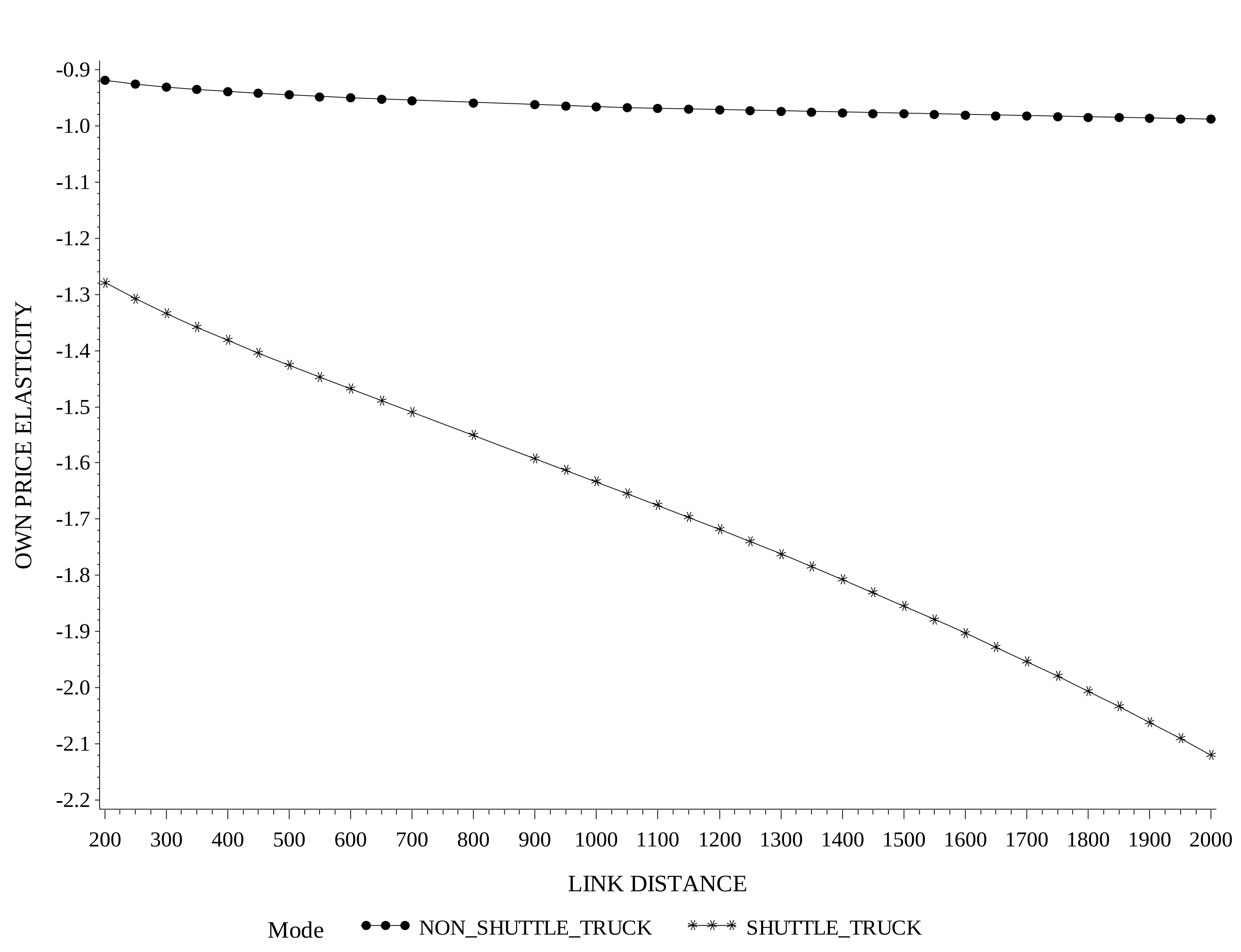
❑ *Rail Modal Elasticities Shuttle vs Non-Shuttle Elevators

Link Distance	Shuttle Elevator Rail $\lvert\varepsilon_{11-shut}\rvert$	Non-Shuttle Elevator Rail $\lvert\varepsilon_{11-non\_shut}\rvert$
250	0.073	0.204



❑ *Truck Modal Elasticities Shuttle vs Non-Shuttle Elevators

Link Distance	Shuttle Elevator Truck $\lvert \varepsilon_{22-shut} \rvert$	Non-Shuttle Elevator Truck $\lvert \varepsilon_{22-non\ shut} \rvert$



CONCLUSION, IMPLICATION, AND LIMITATION

- Shuttle elevator role significant
  - Shipper investment might alter rail service elasticities
- Shuttle elevator more rail intensive than non-shuttle
- Rail shuttle shippers view truck as less of substitute relative to country elevator rail shippers
  - Likely incentive for carriers to expand track related investment to increase shuttle use
- Limitations
  - Estimated rates
  - Compensated demand
  - Lack of relative short distant movements
    - No local origin-destination grain movement