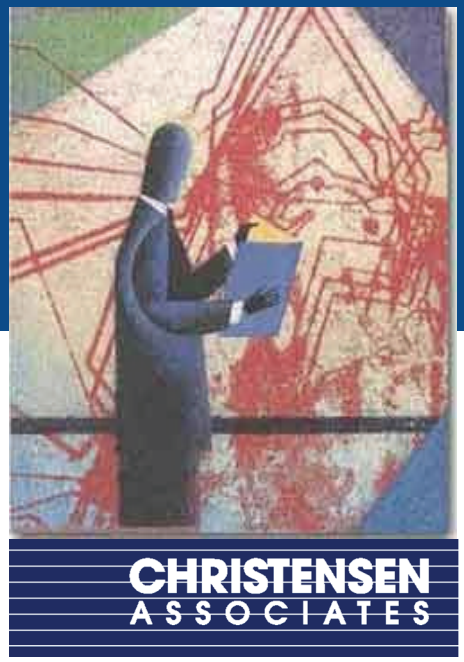


Total Factor Productivity in U.S. Class I Railroads 1987-2008

Kelly Eakin, Philip Schoech
Christensen Associates

Joseph A. Swanson
Jos. Swanson and Company

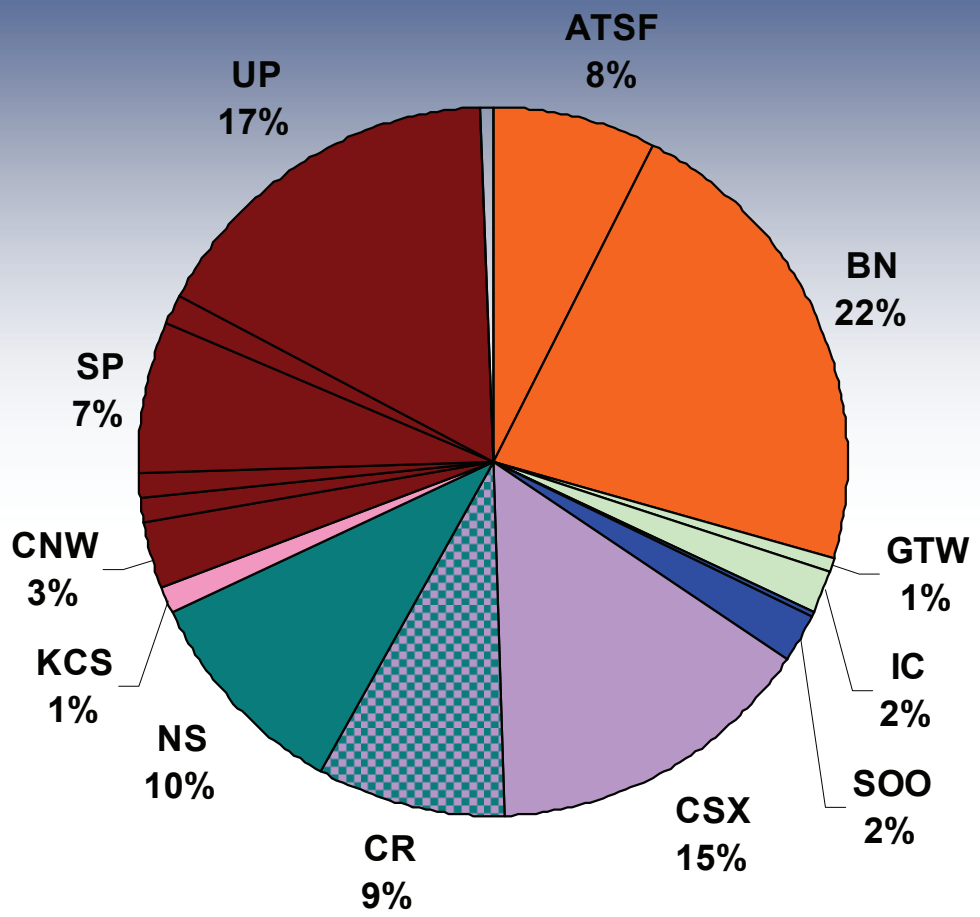
Presentation at the
North American Productivity Workshop VI
Rice University

June 2010

Background

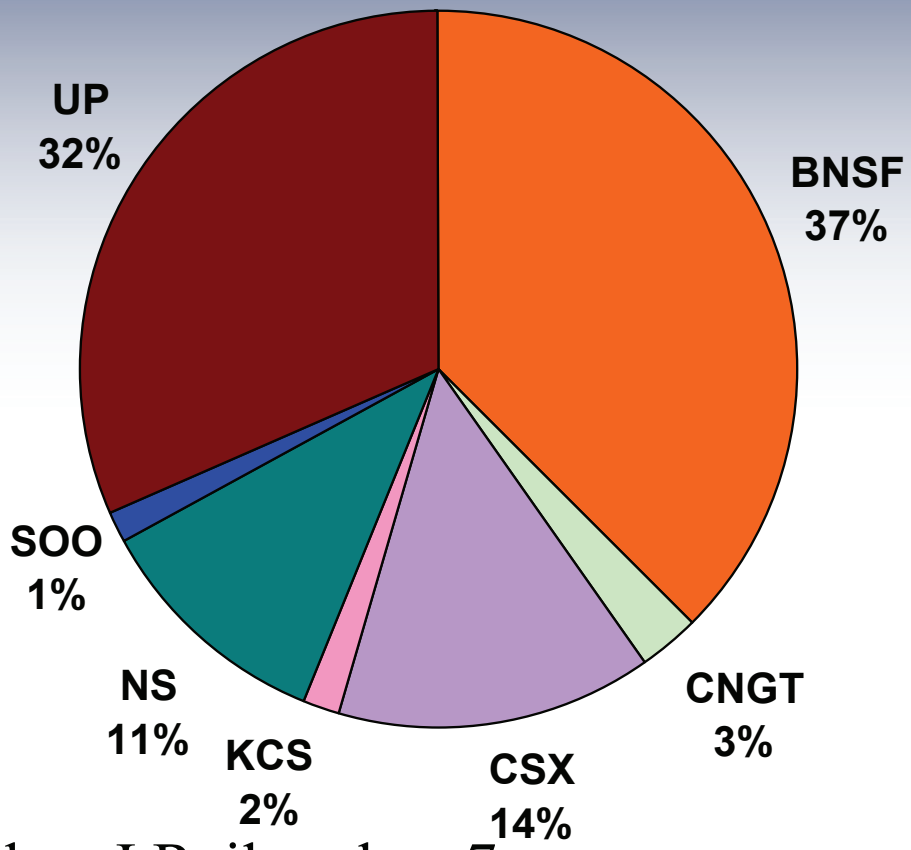
- *A Study of Competition in the U.S. Freight Railroad Industry and Analysis of Proposals that Might Enhance Competition*
  - Independent study by Christensen Associates for the Surface Transportation Board
  - Original report November 2008
  - Updated study January 2010
  - www.stb.dot.gov/stb/elibrary/CompetitionStudy.html and www.LRCA.com\railroadstudy
- TFP analysis presented here is a by-product of that study
  - Based on a dual variable cost function

Industry Structure 1987



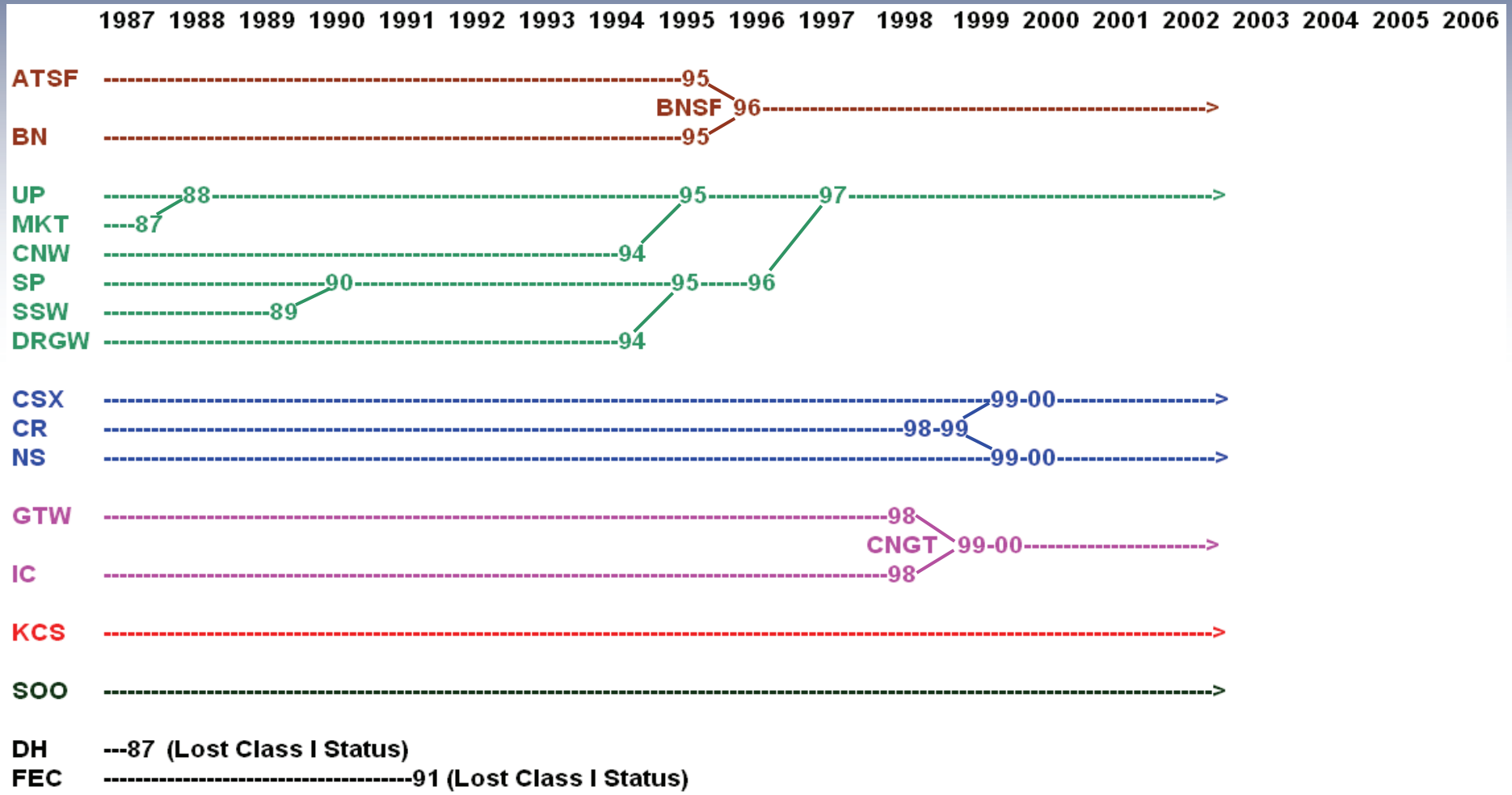
Number of Class I Railroads = 17
Revenue Ton-Mile HHI=1287

Industry Structure 2008



Number of Class I Railroads = 7
Revenue Ton-Mile HHI=2729

Class I Railroad Consolidation



TFP Analysis for the Big 4 Railroads

- "Industry TFP" analysis based on only the largest railroads
- Who are the "Big 4?"
  - Big 6 in 1987: ATSF, BN, CSX, NS,SP, UP
  - Big 5 in 1996: BNSF, CSX, NS, SP, UP
  - Big 4 since 1997: BNSF, CSX, NS, UP
- Why only the "Big 4?"
  - Although used in the cost function estimation, smaller firms have less credible elasticity estimates
  - We know who the survivors are and we are primarily interested in them

The "Big Four"
Revenue Ton Miles Shares

1987		1996		1997		1999		2008	
ATSF	8%	BNSF	30%	BNSF	31%	BNSF	35%	BNSF	37%
BN	22%	CSX	12%	CSX	12%	CSX	14%	CSX	14%
CSX	15%	NS	10%	NS	10%	NS	12%	NS	11%
NS	10%	SP	11%	UP	33%	UP	34%	UP	32%
SP	7%	UP	25%		**86%**		**95%**		**94%**
UP	17%		**88%**						
	79%								
HHI	**1287**	**HHI**	**1937**	**HHI**	**2426**	**HHI**	**2711**	**HHI**	**2729**
N	**17**	**N**	**10**	**N**	**9**	**N**	**8**	**N**	**7**

Summary of Cost Function Approach

- Variable Cost Function: $C^V(Y,W^V,K,N,ALH,t)$
  - Y=revenue ton miles
  - Four variable inputs: labor, equip, materials, fuel
  - K=capital stock; N=miles of road; ALH=average length of haul
- Translog Specification of Variable Cost Function
  - 21 firm dummies included (with mergers, 22 incarnations)
  - Share equations via Shephard's lemma
  - 4-equation system estimated via ITSUR
- Estimated Cost Elasticities Used in TFP Analysis

Total Factor Productivity

$TFP = \mathbf{Y}/\mathbf{X}$

$\mathbf{Y}$ is an output index

$\mathbf{X}$ is an input index

$\%\Delta TFP = \%\Delta \mathbf{Y} - \%\Delta \mathbf{X}$

$\approx \Delta \ln \mathbf{Y} - \Delta \ln \mathbf{X}$

Variable and Short Run Cost

Variable Cost: $C^V = C^V(Y,W^V,K,N,ALH,t)$

Short-Run Cost: $C^{SR} = C^V + W_K K$

Variable/Total Ratio: $S = C^V / C^{SR}$

Growth of Output

$$\%\Delta Y \approx \Delta \ln Y$$

$$\approx \Delta \ln C^{SR} - S(\partial \ln C^{V}/\partial \ln Y - 1/S)\, \Delta \ln Y$$

$$- S(\partial \ln C^{V}/\partial \ln N)\, \Delta \ln N$$

$$- S(\partial \ln C^{V}/\partial \ln ALH)\, \Delta \ln ALH$$

$$- S(\partial \ln C^{V}/\partial \ln K)\, \Delta \ln K$$

$$- S\sum^{K-1}(\partial \ln C^{V}/\partial \ln W_i)\, \Delta \ln W_i$$

$$- S\,(\partial \ln C^{V}/\partial t)\, \Delta t$$

$$-(1-S)\,[\Delta \ln W_K + \Delta \ln K]$$

Growth of Input

$$\%\Delta \mathbf{X} \approx \Delta \ln \mathbf{X}$$

$$\approx \Delta \ln C^{SR} - S[\sum^{K-1}\{(W_i X_i)/C^V\}\ \Delta \ln W_i]$$

$$+ (1\text{-}S)\ \Delta \ln W_K$$

Note: The above is derived from

a) $\Delta C^{SR} = \sum^K W_i \Delta X_i + \sum^K X_i \Delta W_i$ and

b) $\%\Delta \mathbf{X} = \sum^K \{(W_i X_i)/C^{SR}\}\ \Delta \ln X_i$

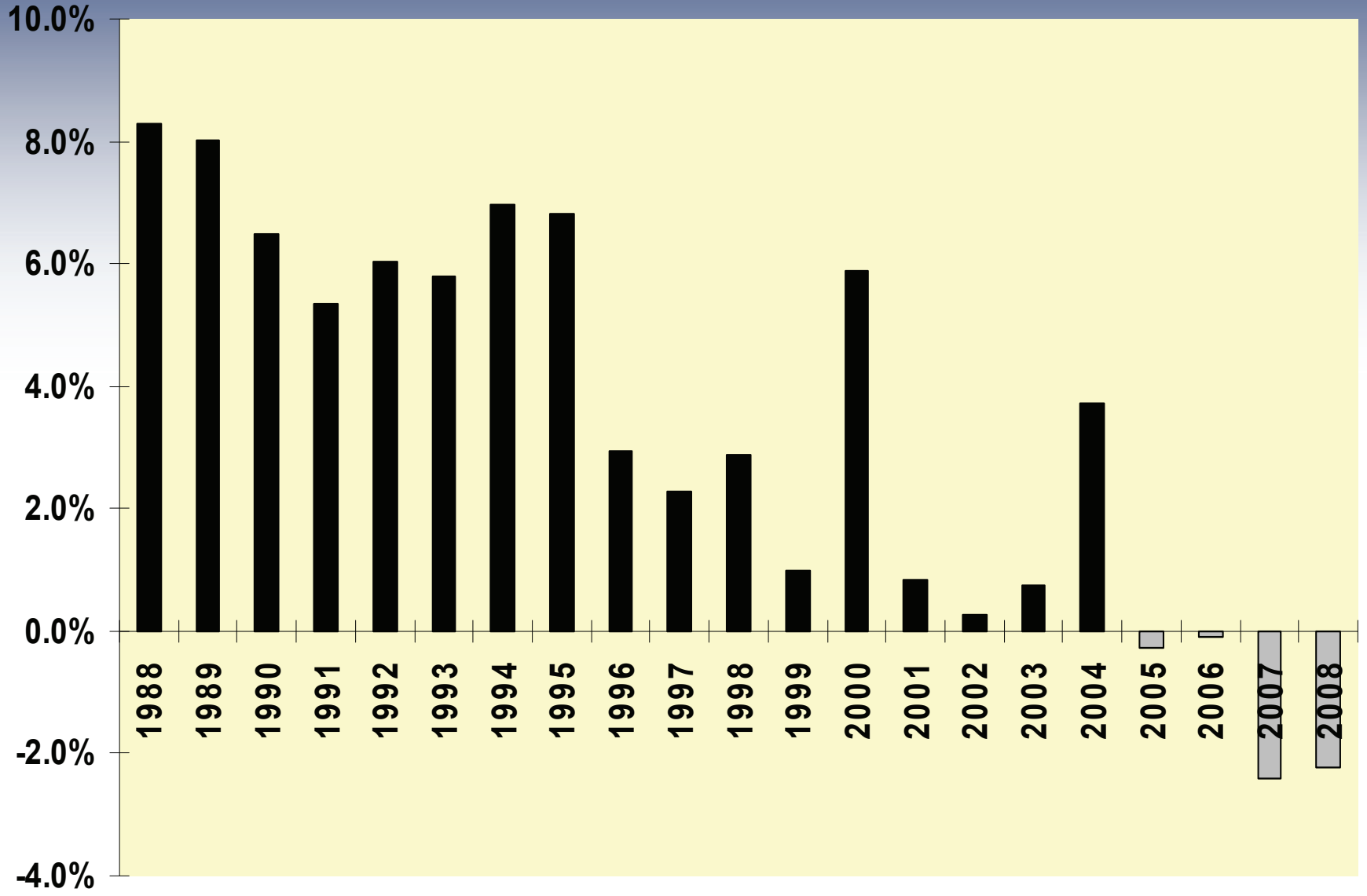
TFP Growth

$$
\begin{aligned}
\%\Delta TFP \quad & \approx \Delta \ln \mathbf{Y} - \Delta \ln \mathbf{X} \\
& \approx [1 - S(\partial \ln C^V / \partial \ln Y)] \, \Delta \ln Y \\
& - S(\partial \ln C^V / \partial \ln N) \, \Delta \ln N \\
& - S(\partial \ln C^V / \partial \ln ALH) \, \Delta \ln ALH \\
& - [S(\partial \ln C^V / \partial \ln K) + (1 - S)] \, \Delta \ln K \\
& - S \, (\partial \ln C^V / \partial t) \, \Delta t
\end{aligned}
$$

Implementation Notes

- "Industry elasticities" are the weighted averages of the individual firm elasticities
  - Weights are the firms' shares of "industry" variable cost
  - Only "Big 4/5/6" firms comprise the "industry"
- Midpoint values for elasticities and S used in year-to-year TFP analysis
  - $S = \frac{1}{2} [S_0 + S_1]$
  - $\partial \ln C^V / \partial \ln Y = \frac{1}{2} [\partial \ln C_0^V / \partial \ln Y) + \partial \ln C_1^V / \partial \ln Y)]$
  - Etc.

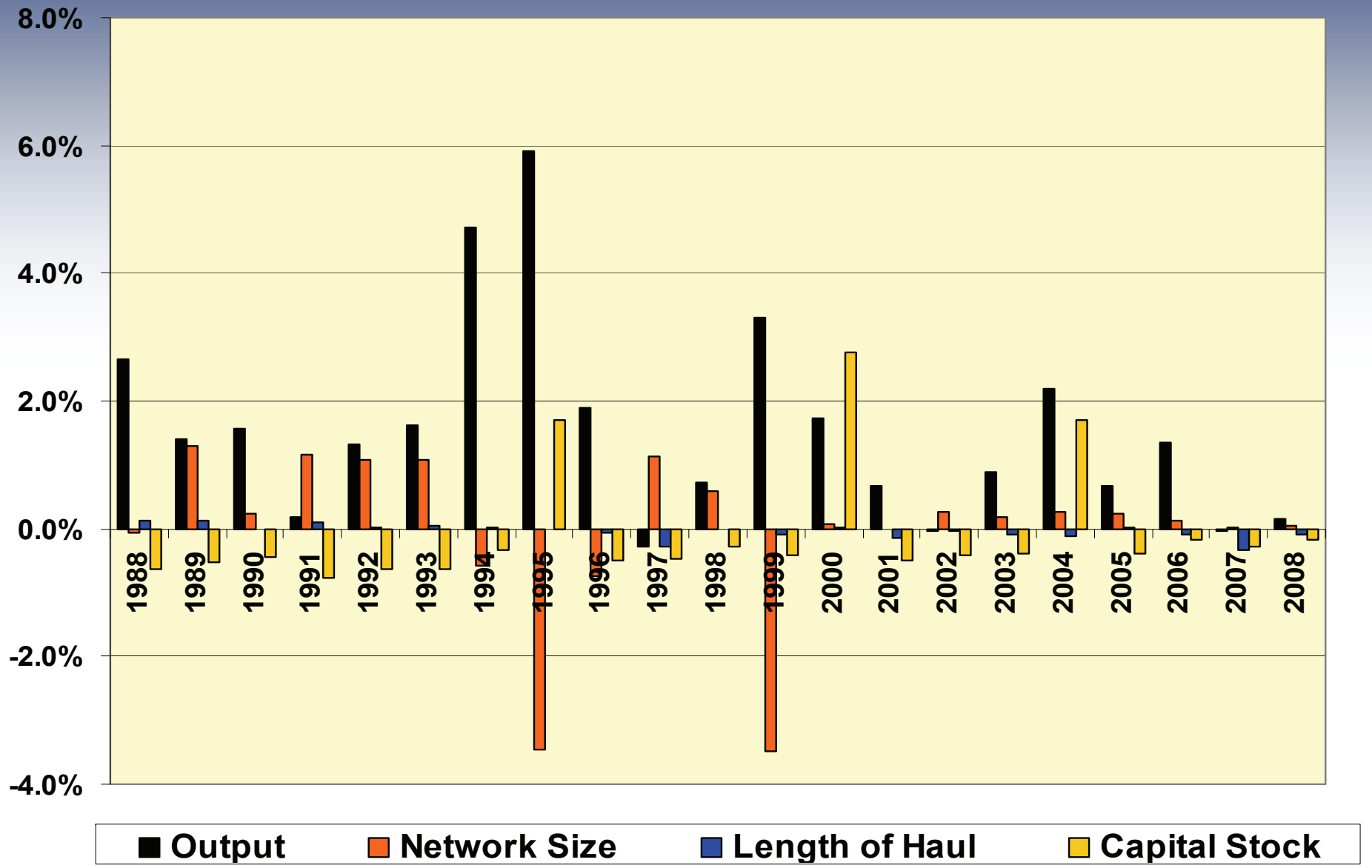
Big 4 TFP Growth



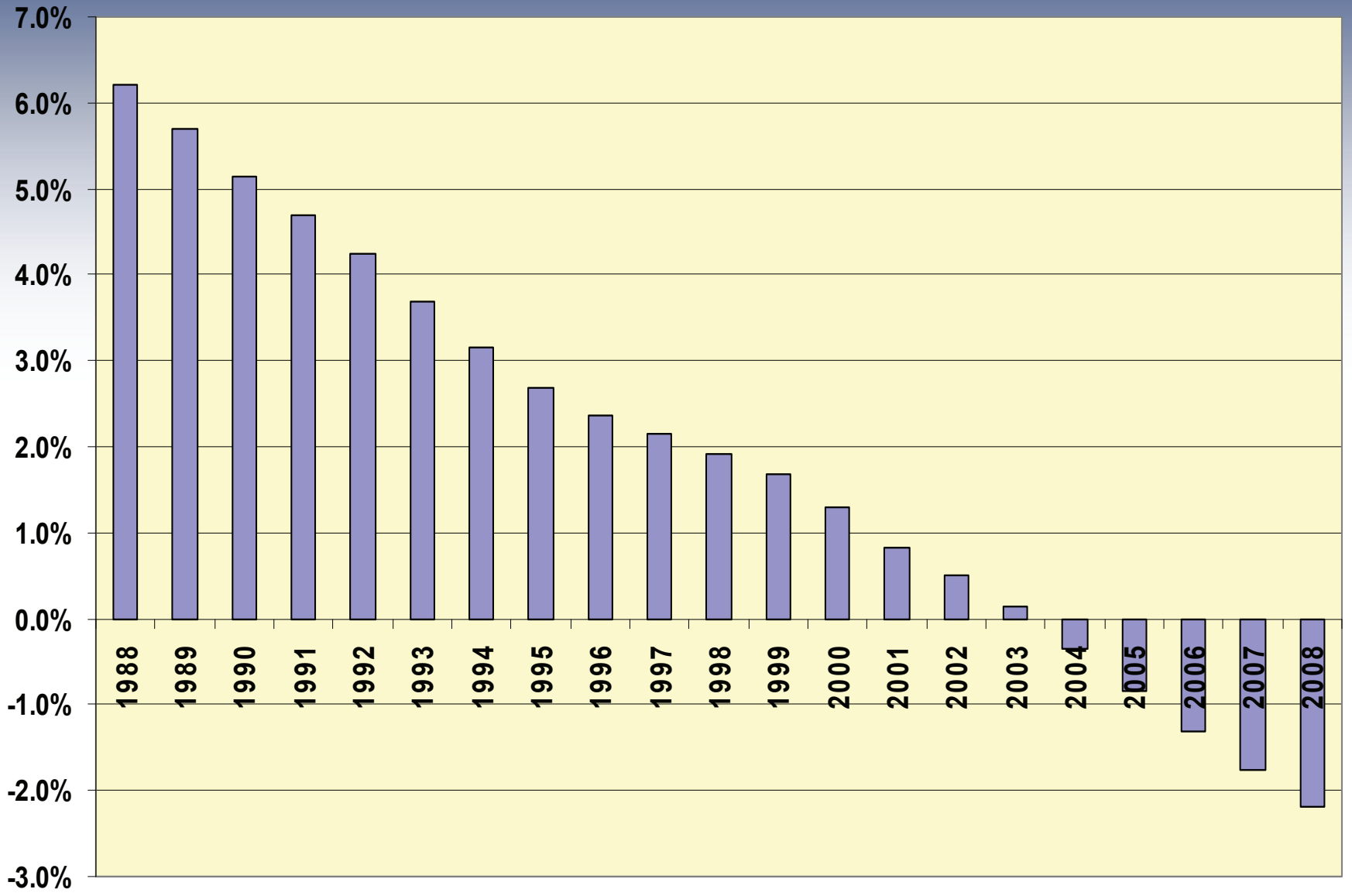
Changes in TFP Factors

	1987-1995	1995-2002	2002-2008	1987-2008
Revenue Ton Miles	54%	24%	18%	126%
Miles of Road	-2%	7%	-4%	1%
Miles of Track* (not a factor *per se*)	-7%	4%	-7%	-10%
Capital Stock	-12%	1%	2%	-10%
Average Length of Haul	11%	22%	8%	47%

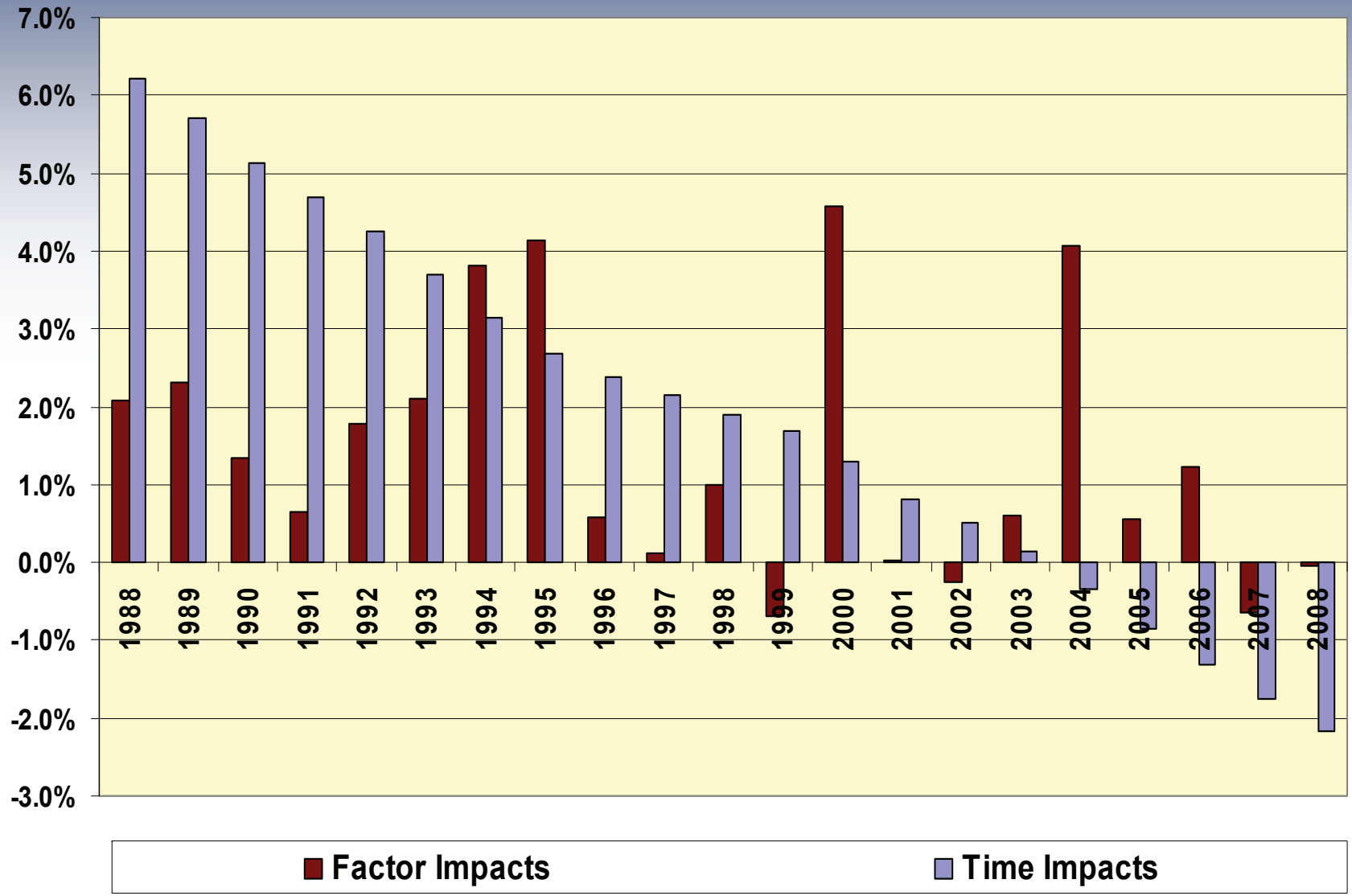
Factor Impacts on TFP



Time Impacts on TFP



Factor vs. Time Impacts



TFP Factor Multipliers

- The impact on TFP of a 1% change in a factor

- From the TFP growth equation:

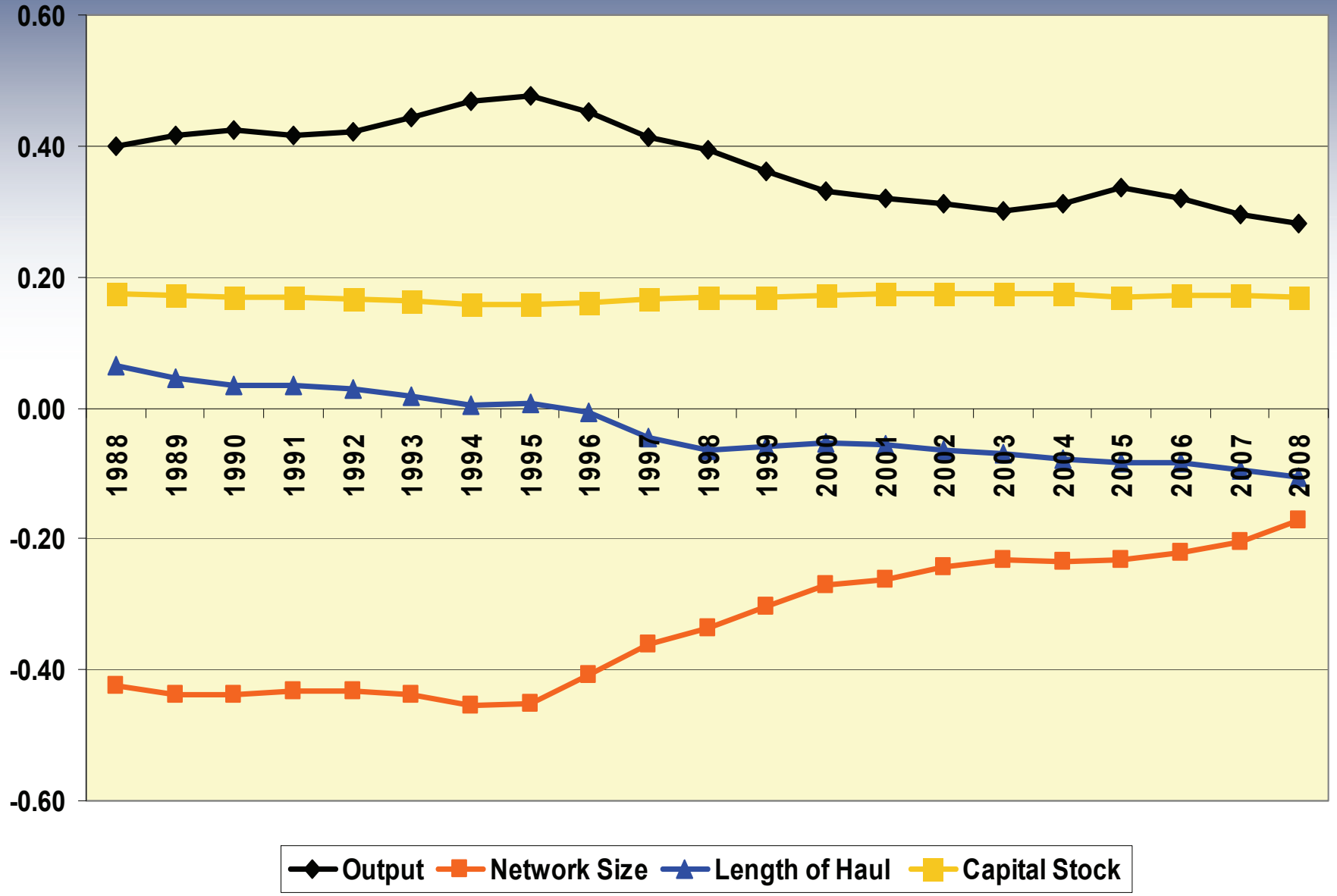
  Output Multiplier: $[1-S(\partial \ln C^V/\partial \ln Y)]$

  Network Size Multiplier: $- S(\partial \ln C^V/\partial \ln N)$

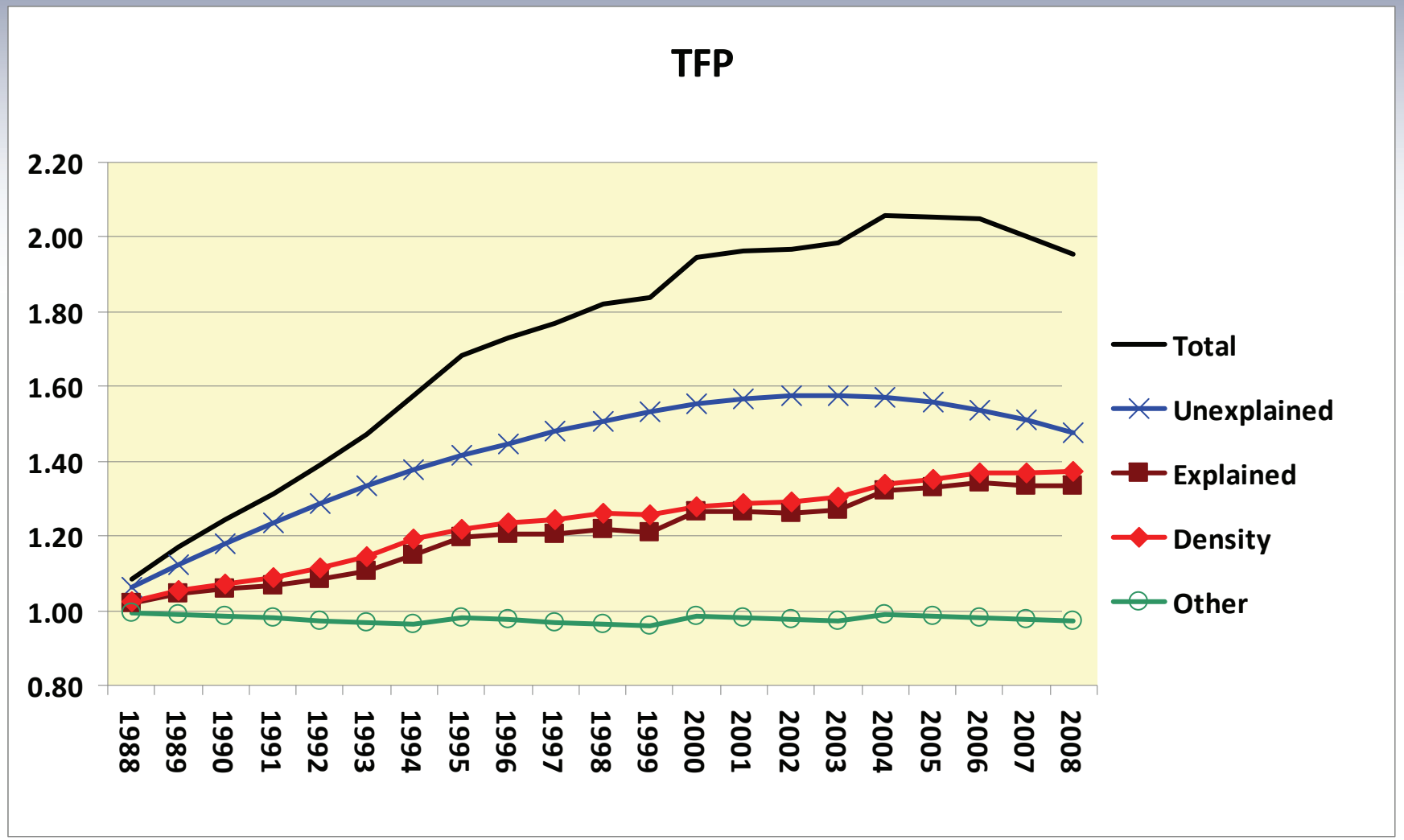
  Length of Haul Multiplier: $- S(\partial \ln C^V/\partial \ln ALH)$

  Capital Multiplier: $-[S(\partial \ln C^V/\partial \ln K) + (1-S)]$

TFP Factor Multipliers



Reality Check: It's About Density



Conclusions

- Railroad consolidation coincides with strong productivity gains
- Consolidation resulted in increased density
- Increased density contributed substantially to TFP growth
- The marginal impact on TFP of increasing density is about half what it was in 1987

Conclusions

- Unexplained technical change was the leading source of TFP growth early on, but has diminished substantially in recent years
- Analysis did not take into account change in shipping mix (e.g., increased importance of intermodal)
- Completely parallel analysis has been done for the railroads individually