Nowcasting waterborne commerce: a Bayesian model averaging approach

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Upper Mississippi
Missouri
Illinois
Ohio
Arkansas
White
Cumberland
Tennessee
Black
Black Warrior
Red
Tombigee
Alabama
Atchafalaya
Mobile
Lower Mississippi
Gulf
Intracoastal
Waterway

Motivation

Nowcasting

- Use real-time data to predict contemporaneous values of a variable released with lag

Why do we care?

- Timely and accurate data helps market participants with operational decisions
- Network supports 600m tons of cargo per year

This paper

- Nowcast waterborne commerce (WBC) with coincident indicators
- Bayesian model averaging (BMA) averages nowcasts across models with different sets of predictors

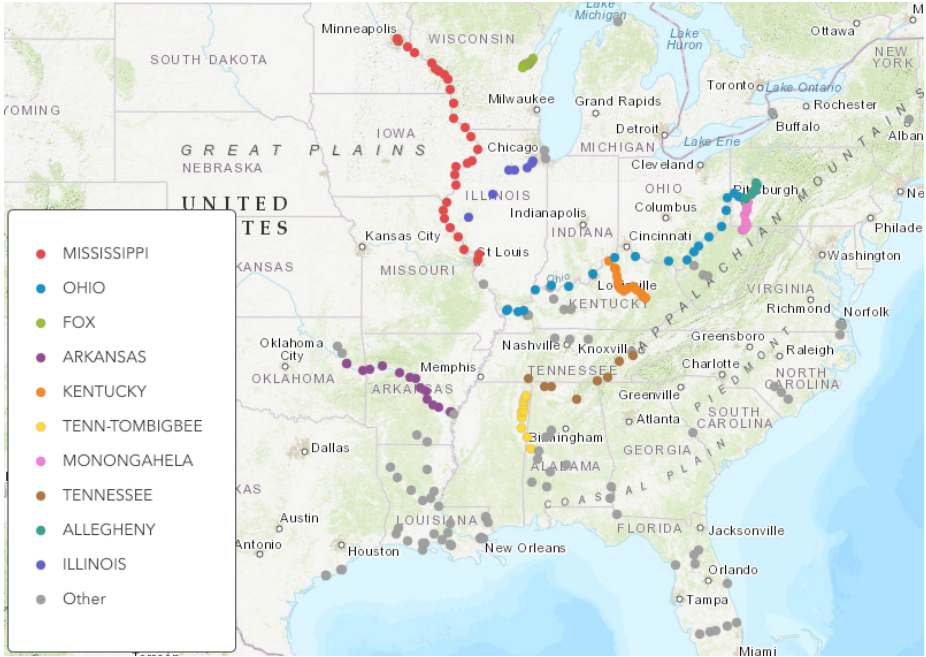
Waterborne commerce (WBC)

A lock is an elevator for ships

- Helps navigate uneven and inconsistent water levels

Lock Performance Monitoring System (LPMS)

- Measures cargo for each ship inside lock


MISSISSIPPI
OHIO
FOX
ARKANSAS
KENTUCKY
TENN-TOMBIGBEE
MONONGAHELA
TENNESSEE
ALLEGHENY
ILLINOIS
Other
Minneapolis
WISCONSIN
SOUTH DAKOTA
Milwaukee
Grand Rapids
Chicago
IOWA
GREAT PLAINS
NEBRASKA
MICHIGAN
Detroit
Cleveland
OHIO
ILLINOIS
Indianapolis
Columbus
Kansas City
INDIANA
Cincinnati
St Louis
MISSOURI
KANSAS
KENTUCKY
VIRGINIA
Richmond
Norfolk
Oklahoma City
Nashville
Knoxville
Greensboro
Raleigh
Memphis
TENNESSEE
Charlotte
NORTH CAROLINA
OKLAHOMA
ARKANSAS
Greenville
Atlanta
SOUTH CAROLINA
Dallas
Birmingham
GEORGIA
ALABAMA
Austin
LOUISIANA
FLORIDA
Jacksonville
Houston
New Orleans
Orlando
Tampa
Miami
Toronto
Lake Ontario
Rochester
Buffalo
Lake Erie
Ottawa
NEW YORK
Philadelphia
Washington
APPALACHIAN MOUNTAINS
PIEDMONT
COASTAL PLAIN

Data

WBC and LPMS example

Load 1 10 tons through locks L1, L2, L3

Load 2 20 tons through locks L2, L3, L4

Load 3 50 tons through locks L3, L4

$$WBC = 10 + 20 + 50 = \mathbf{80}$$

	L1	L2	L3	L4
Load 1	10	10	10	
Load 2		20	20	20
Load 3			50	50
LPMS	**10**	**30**	**80**	**70**

Data (2000-2013)

Monthly data for total tonnage and four primary commodities

- Coal
- Petroleum
- Food & farm
- Chemical

Waterborne commerce (WBC) data

- Point to point tonnages moved along the waterway
- Released with more than a year lag

Lock Performance Monitoring System (LPMS) data

- Real-time tonnages passing through particular locks

Conceptual framework

Bayesian model averaging (BMA)

Posterior probability that M_j is the true model

$$Pr(M_j|Y) = \frac{f(Y|M_j)\ Pr(M_j)}{\sum_{i=1}^{J} f(Y|M_i)\ Pr(M_i)} \qquad j = 1, ..., J$$

- Y observed data
- $Pr(M_j)$ prior probability that M_j is the true model
- $f(Y|M_j)$ marginal likelihood for model M_j

$$f(Y|M_j) = \int f(Y|\theta_j, M_j)\ p(\theta_j|M_j) d\theta_j$$

Bayesian model averaging (BMA)

BMA averages posterior inference across alternative models

$$\widehat{WBC}_t = \sum_{j=1}^{J} \widehat{WBC}_t^j \Pr(M_j|Y)$$

Posterior inclusion probability (PIP)

$$PIP_n = \sum_{j=1}^{J} \Pr(M_j|Y) I_j(X_n)$$

Empirically

- Markov-chain Monte Carlo Model Composition (MC^3)
- Rolling window techniques

Results

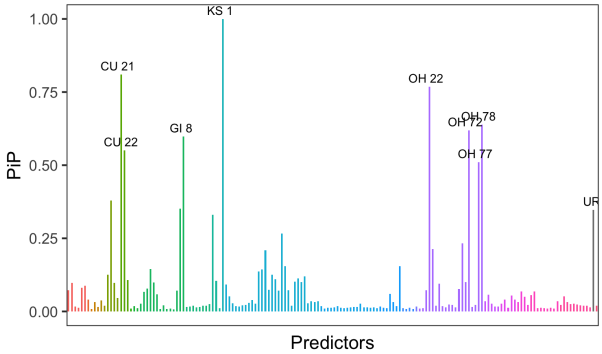
Top models

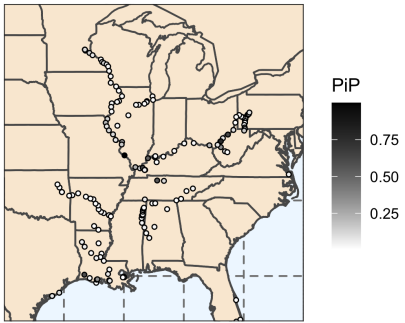
Posterior Model Probabilities for Top 10 Models: $\Pr(M_j|Y)$

	Total	Coal	Farm	Petro	Chem
1	1.47	1.72	1.31	1.61	1.57
2	1.42	1.28	1.20	1.49	1.28
3	1.12	1.17	1.17	1.23	1.17
4	1.11	0.96	1.15	1.09	1.01
5	0.95	0.95	0.99	1.05	0.98
6	0.82	0.82	0.93	0.96	0.94
7	0.81	0.83	0.92	0.73	0.86
8	0.80	0.80	0.86	0.65	0.82
9	0.77	0.70	0.75	0.63	0.69
10	0.75	0.67	0.72	0.58	0.68

Note: All table entries should be multiplied by 10^{-7}

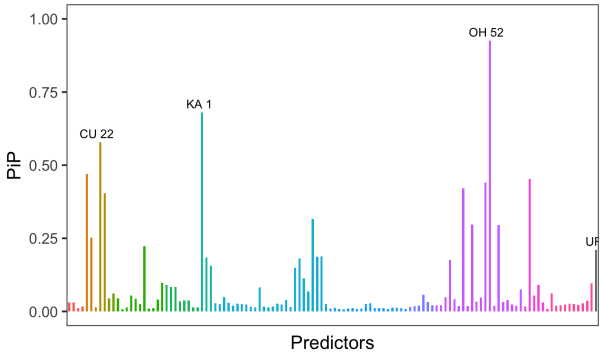
Total

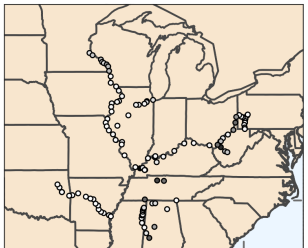




Predictor	PiP	River	State
Kaskaskia River Navigation Lock	0.999	Kaskaskia	IL
Barkley Lock	0.809	Cumberland	KY
Racine Lock and Dam	0.767	Ohio	OH
Smithland Lock and Dam	0.638	Ohio	KY
Willow Island Locks and Dam	0.618	Ohio	OH

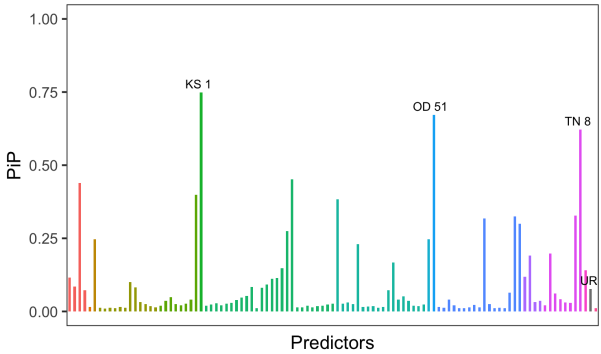
Coal

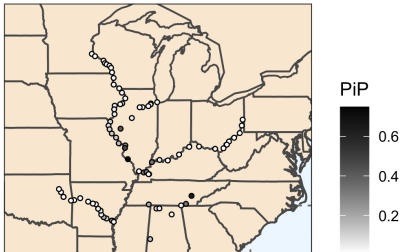




Predictor	PiP	River	State
Lock and Dam 52	0.926	Ohio	IL
Winfield Locks and Dam Main 1	0.680	Kanawha	WV
Cheatham Lock	0.578	Cumberland	TN

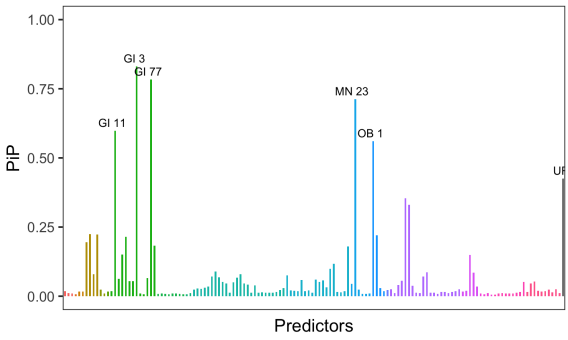
Food & farm

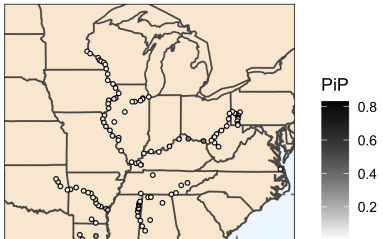




Predictor	PiP	River	State
Kaskaskia River Navigation Lock	0.748	Kaskaskia	IL
Old River Lock	0.672	Old	LA
Watts Bar Lock	0.622	Tennessee	TN

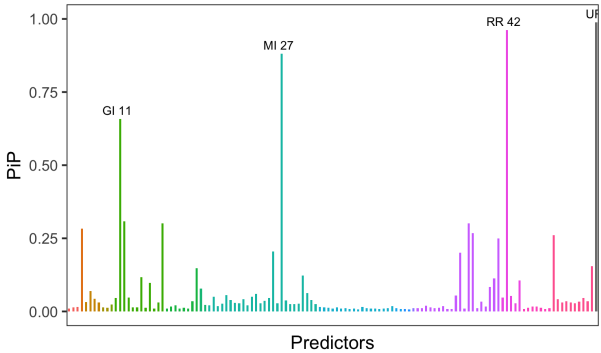
Petroleum

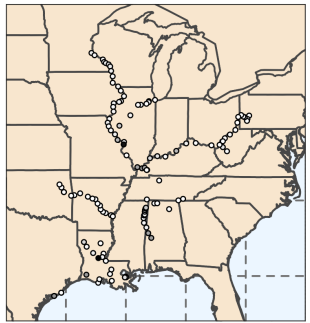




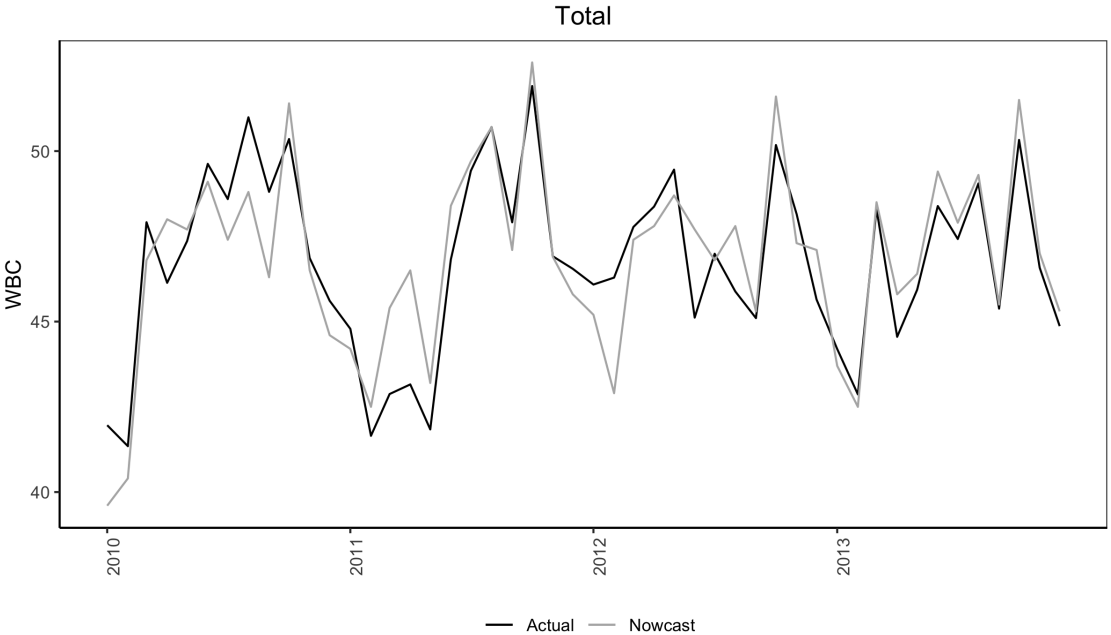
Predictor	PiP	River	State
Inner Harbor Navigation Canal Lock	0.831	Gulf	LA
Leland Bowman Lock	0.783	Gulf	LA
Lock and Dam 3	0.712	Monongahela	PA
Colorado River East Lock	0.598	Gulf	TX
Jonesville Lock and Dam	0.560	Ouachita	LA

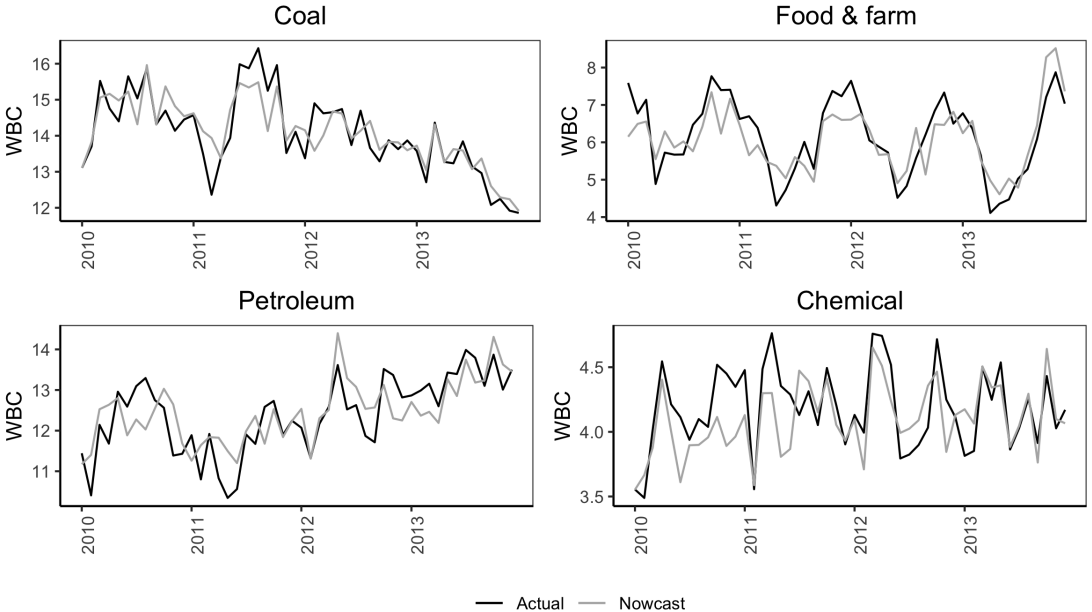
Chemical





Predictor	PiP	River	State
Unemployment rate (two-month lag)	0.988		
John H. Overton	0.961	Red	LA
Chain of Rocks Lock and Dam 27	0.881	Mississippi	MO
Colorado River East Lock	0.658	Gulf	TX


Total
WBC
50
45
40
2010
2011
2012
2013
Actual
Nowcast


Coal
Food & farm
Petroleum
Chemical
WBC
2010
2011
2012
2013
Actual
Nowcast

Nowcast evaluation metrics

Average Percentage Nowcast Error

Year	Total	Coal	Farm	Petroleum	Chemical
2010	1.98	-0.65	3.23	-0.94	4.75
2011	-2.31	-0.27	2.29	-2.13	2.95
2012	-0.34	0.28	1.08	-1.44	1.02
2013	-0.96	-1.23	-5.69	1.45	-1.27

Summary

Summary

Bayesian model averaging (BMA) incorporates model uncertainty into nowcasts

- Average nowcasts across models with different sets of predictors

Results can be operationalized

- Help firms make decisions
- Negotiate rates
- Gauge equipment needs

Thank you