Modernizing U.S. Waterway Logistics:
A Strategic Barge Forecasting & Optimization Project

AI for Supply Chain & Logistics Management

Jul 7, 2025

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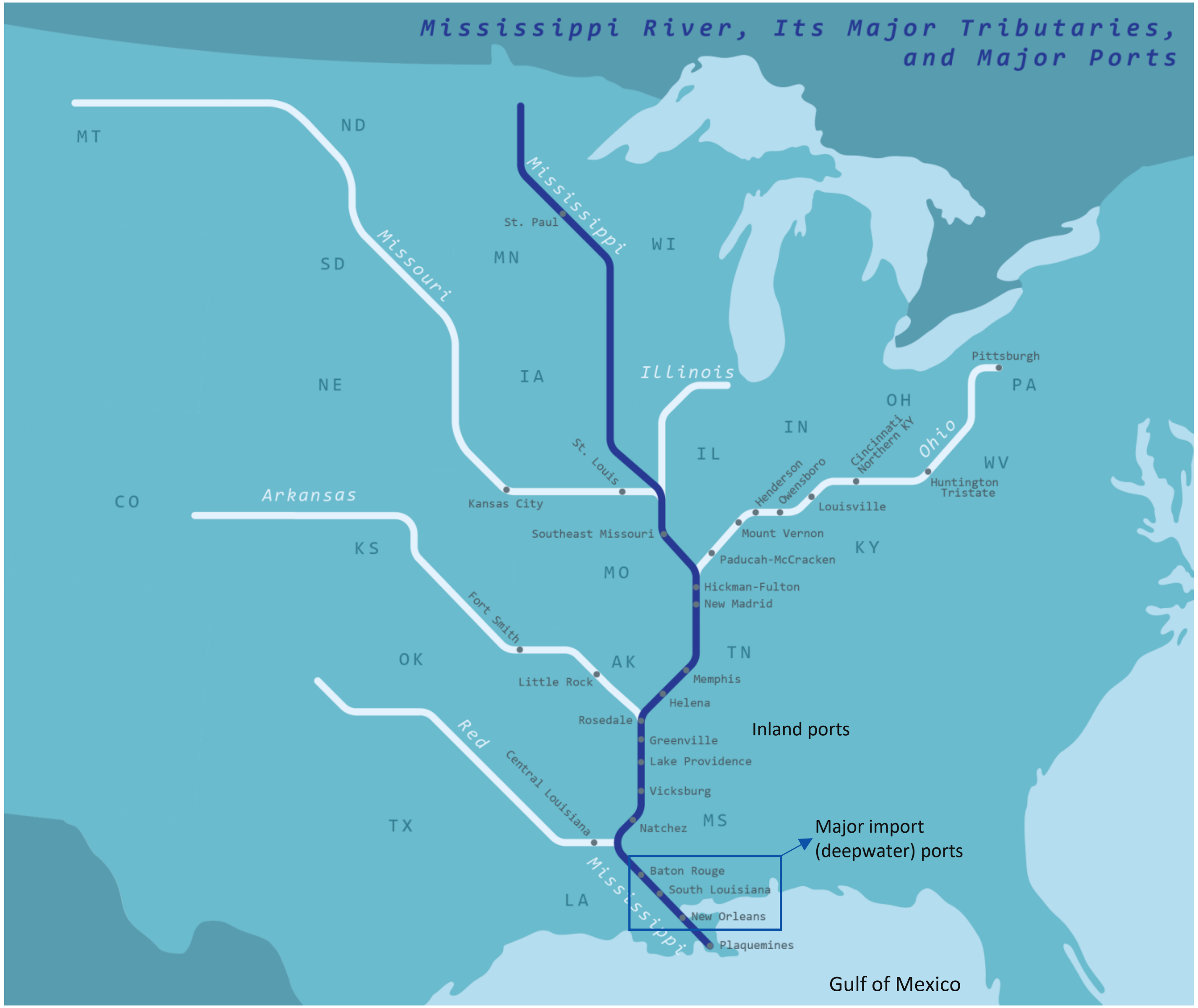
Mississippi Waterway



- The Mississippi River system alone spans 12,350 miles, connecting 31 states.
- In 2019, inland waterways moved 514.9 million tons of domestic commerce.
- The Mississippi River accounts for 60% of all grain exported from the US.
- Annually, the river transports over 175 million tons of freight, valued at over $70 billion.

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Intermodal Transportation

Cargo arrives by ship at a port and is then transferred often in the same container onto rail or trucks or inland water for onward delivery inland, combining different transport modes into a single, efficient logistics chain.

Rail

New Orleans is the only U.S. city where deep-draft shipping aligns with the rail gateway to make a truly intermodal freight source.

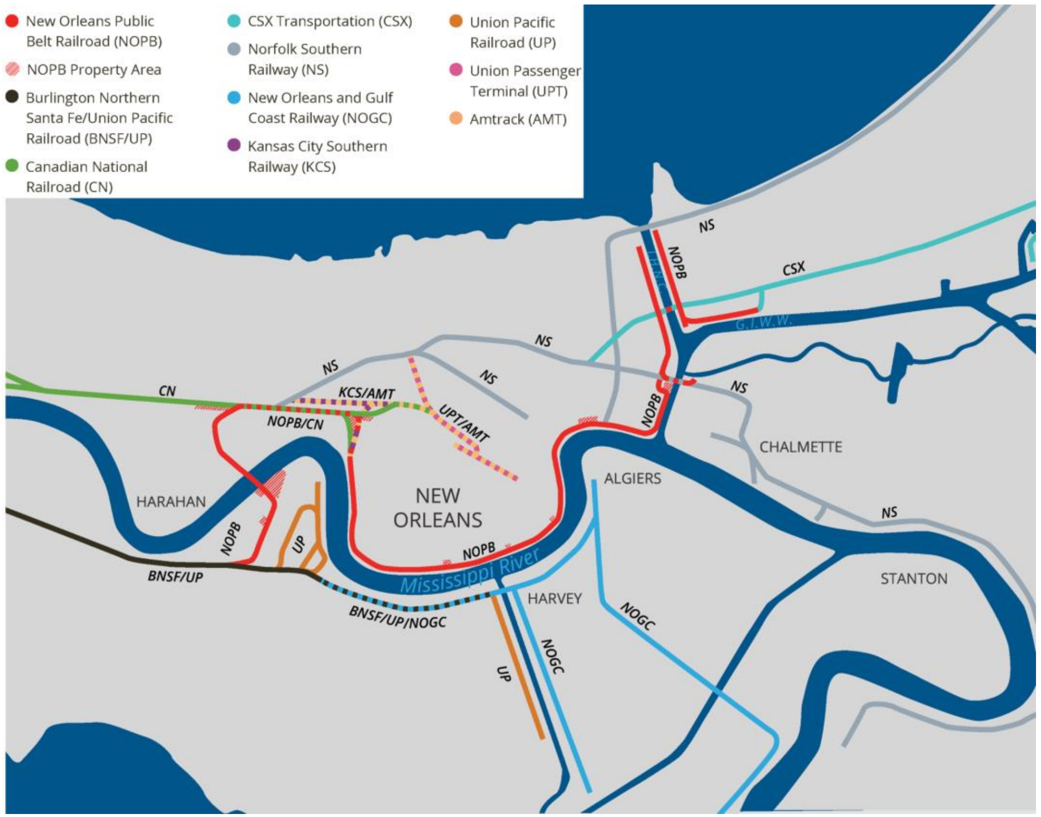
River

The Port of New Orleans is connected to 14,500 miles of waterways through the Mississippi River and its tributaries. Additionally, the Gulf Intracoastal Waterway provides direct access along the Gulf Coast.

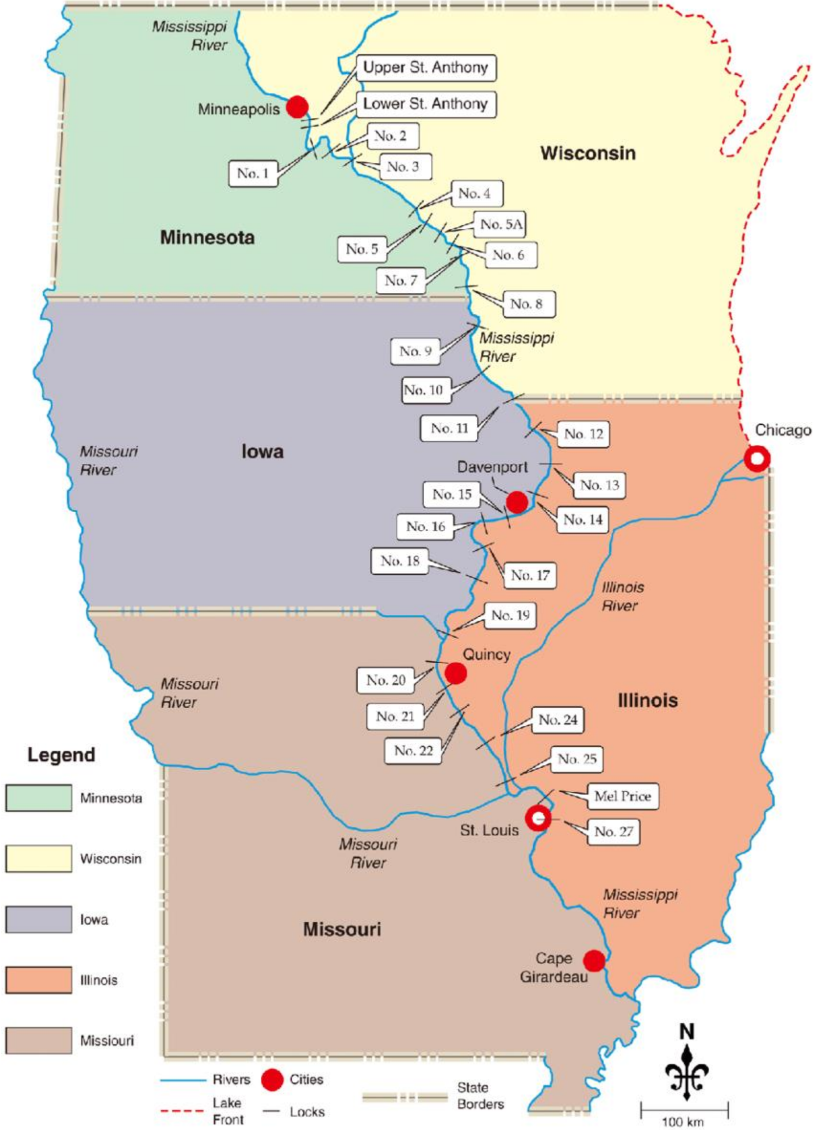
Road

The trucking industry plays a vital role in the daily movement of goods with more than 2,000 trucks hauling cargo in and out of Port NOLA each day.

Rail



Lock



https://www.youtube.com/watch?v=5bxEV95LKMI

A lock and dam system is an engineered structure used on rivers to **control water levels and enable vessels to navigate changes in elevation** along the waterway.
A **lock** is like a **water elevator for boats and barges**. It is a chamber with gates at both ends that can fill with water (to lift boats up to a higher level) or drain (to lower boats to a lower level).

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Barge

Container-On-Barge


Grain Loading Barges

Goal: Demand Forecasting (for Reallocation)

- **Objective:** Estimate the potential demand for a new barge service by forecasting demand that could feasibly be reallocated from other transportation modes.

- **Why Reallocation?**
  - The fast barge service does not yet exist, so there is no historical demand data for it.
  - Therefore, demand must be inferred from existing intermodal flows where a modal shift to barge could have been viable.

- **Key Steps:**
  - **Identify total trade demand**
    - Use import/export volumes by commodity, origin-destination pairs, and time
    - Incorporate seasonality, trends, and exogenous drivers.
  - **Filter & forecast eligible demand**
    - Produce time-series forecasts for this "latent" barge-eligible demand.
    - Restrict forecasting to combinations that are both feasible and advantageous for barge.
  - **Bonus Objective - Assess feasibility**
    - *Time effectiveness*: Are delivery windows compatible with barge transit time?
    - *Cost competitiveness*: Compare all-in transportation costs by mode.

Goal 2: Optimization

Idea of stochastic dual dynamic programming (SDDP) for barge allocation under demand uncertainty:
For each stage $t = 1, \cdots, 12$ (if monthly data), we solve a stage-wise subproblem:

$$V_t(I_t, \omega_t) = \min_{\mathrm{B_t, C_{bt}, C_{it}, E_t}} \alpha_t B_t + \beta_t C_{bt} + \gamma_t C_{it} + \delta E_t + \mathbb{E}[V_{t+1}(I_{t+1}, \omega_{t+1})]$$

$$s.t.\, C_t^f(\omega_t) = C_{bt} + C_{it}$$

$$C_{bt} \leq M \cdot cap_b$$

$$I_{t+1} = I_t + E_t - B_{t+1}$$

$$B_t \bar{D}_t \leq W_t^{avail}$$

Decision variable:
B_t barges put into use; C_{bt} containers go on barges; C_{it} containers go intermodal; E_t repositioning empty barges.
State variable:
I_t available barge inventory at the beginning of the stage
Objective function:
immediate cost (α_t fixed cost per barge; β_t variable transportation cost by barge; γ_t variable transportation cost by intermodal; δ_t empty barge repositioning cost; assuming they are all dynamic across time) + V_{t+1} cost-to-go
Constraints:
Total containers handled are equal to forecasted demand with uncertainty; barge capacity; waterway capacity.
Extension:
Add dimension of container type; Use Markov chain processes to handle uncertainty.

Typical barge costs estimation

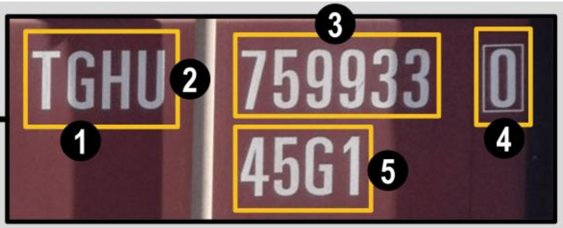
Component	Typical range (USD)	Notes
Fixed monthly cost per barge	\$30,000 – \$50,000 /month	includes capital amortization, insurance, crew salaries
Variable barge cost per container	\$30 – \$50 / TEU	covers fuel, port charges, handling
Intermodal (train/truck) per container	\$150 – \$300 / TEU	much higher due to road/rail costs
Empty repositioning cost	\$10 – \$20 / TEU-equivalent moved empty	cheaper, covers minimal fuel & port fees

- Average operation days: For Mississippi River: typical barge voyages last **10–20 days**, depending on length (Memphis → New Orleans ≈ 6-7 days one way + time in port). Barges generally run **80–90% of days in a month** (allowing time for loading/unloading & some downtime).
- Available waterway capacity: can assume a target market share e.g. 5%. For example, a lock might have a capacity of **500 barge transits / month**. Your share depends on market share. Industry average is to allow per operator **5–10% of total lock capacity**, depending on contracts.

Data

Column(s)	Description
arrivalDate	Date shipment arrived in the U.S.
billOfLading, masterBillOfLading	Unique shipment identifiers (house/master B/L).
entryId, inbondEntryType	Customs entry tracking and type.
houseVsMaster	Indicates if HBL vs MBL.
voyageNumber, vesselName	Ship and voyage carrying the cargo.
carrierCode, carrierName	Shipping line SCAC code and name.
carrierAddress, carrierCity, carrierState, carrierZip	Carrier’s registered U.S. contact info.
foreignPort, countryOfOrigin, placeOfReceipt	Where goods originated and were first received.
usPort, distributionPort	U.S. arrival and subsequent distribution port.
shipper, shipperAddress	Exporter name & address.
consignee, consigneeEntity, consigneeAddress	Importer (buyer) name, entity type & address.
notifyParty, notifyAddress	Additional contact for shipment updates.
marksAndNumbers, seal	Package markings and container seal ID.
containerNumber, containerType	Container ID and type (e.g. 45G0 for 40’ HC).
noOfContainers	Number of containers in shipment.
quantity, quantityUnit	Shipped product amount & unit (e.g. PCS, CTN).
measurement, measurementUnit	Volume (CBM / CUFT) of goods.
grossWeightKg, grossWeightLb	Shipment weight in kg and lbs.
shipmentRegisteredIn	Country where vessel or shipment is registered.
productDescription	Text description of the goods shipped.
zipCode	Delivery ZIP.

Container



1. Owner Code (3 letters): TGH
2. Product Group Code (1 letter): U
3. Registration Number (6 digits): 759933
4. Check Digit (1 digit): 0
5. Size & Type Code (4 digits/letters): 45G1

Operational Characteristics

Maximum weight: 30,480 kg
Container weight: 3,870 kg
Payload weight: 26,610 kg
Cubic capacity: 2,700 cubic feet

© GTS

Date: **BILL OF LADING** Page 1 of ______

SHIP FROM
Name:
Address:
City/State/Zip:
SID#: FOB: ☐

Bill of Lading Number: ______________________

BAR CODE SPACE

SHIP TO
Name: Location #: ____________
Address:
City/State/Zip:
CID#: FOB: ☐

CARRIER NAME: ______________________
Trailer number:
Seal number(s):
SCAC:
Pro number:

BAR CODE SPACE

THIRD PARTY FREIGHT CHARGES BILL TO:
Name:
Address:
City/State/Zip:

Freight Charge Terms: ***(freight charges are prepaid unless marked otherwise)***
Prepaid ________ **Collect** ________ **3rd Party** ________

SPECIAL INSTRUCTIONS:

☐ (check box) Master Bill of Lading: with attached underlying Bills of Lading

CUSTOMER ORDER INFORMATION

CUSTOMER ORDER NUMBER	# PKGS	WEIGHT	PALLET/SLIP (CIRCLE ONE)		ADDITIONAL SHIPPER INFO
			Y	N	
			Y	N	
			Y	N	
			Y	N	
			Y	N	
			Y	N	
			Y	N	
			Y	N	
GRAND TOTAL					

CARRIER INFORMATION

HANDLING UNIT		PACKAGE		WEIGHT	H.M. (X)	COMMODITY DESCRIPTION Commodities requiring special or additional care or attention in handling or stowing must be so marked and packaged as to ensure safe transportation with ordinary care. *See Section 2(e) of NMFC Item 360*	LTL ONLY	
QTY	TYPE	QTY	TYPE				NMFC #	CLASS
						RECEIVING STAMP SPACE		
						GRAND TOTAL		

Where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property as follows:
"The agreed or declared value of the property is specifically stated by the shipper to be not exceeding ____________ per ____________."

COD Amount: $ ______________________
Fee Terms: Collect: ☐ **Prepaid:** ☐
Customer check acceptable: ☐

NOTE Liability Limitation for loss or damage in this shipment may be applicable. See 49 U.S.C. ▪ 14706(c)(1)(A) and (B).

RECEIVED, subject to individually determined rates or contracts that have been agreed upon in writing between the carrier and shipper, if applicable, otherwise to the rates, classifications and rules that have been established by the carrier and are available to the shipper, on request, and to all applicable state and federal regulations.

The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.
______________________ **Shipper Signature**

SHIPPER SIGNATURE / DATE
This is to certify that the above named materials are properly classified, packaged, marked and labeled, and are in proper condition for transportation according to the applicable regulations of the DOT.

Trailer Loaded:
☐ By Shipper
☐ By Driver

Freight Counted:
☐ By Shipper
☐ By Driver/pallets said to contain
☐ By Driver/Pieces

CARRIER SIGNATURE / PICKUP DATE
Carrier acknowledges receipt of packages and required placards. Carrier certifies emergency response information was made available and/or carrier has the DOT emergency response guidebook or equivalent documentation in the vehicle.
Property described above is received in good order, except as noted.

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