International trade in agricultural products at the U.S. state level

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Overview

Background and Motivation

- How exposed are individual states to international markets?
- Imports and exports of goods are measured accurately at the 40 U.S. Customs port-districts (e.g., The New Orleans, Louisiana, port district).
- The production-source state of exports and the absorption-destination state of imports are not identified in these data.
- Bureau of Census "Origin of Movement" state-level trade data does not indicate trade exposure.

Current measures of state-level trade exposure

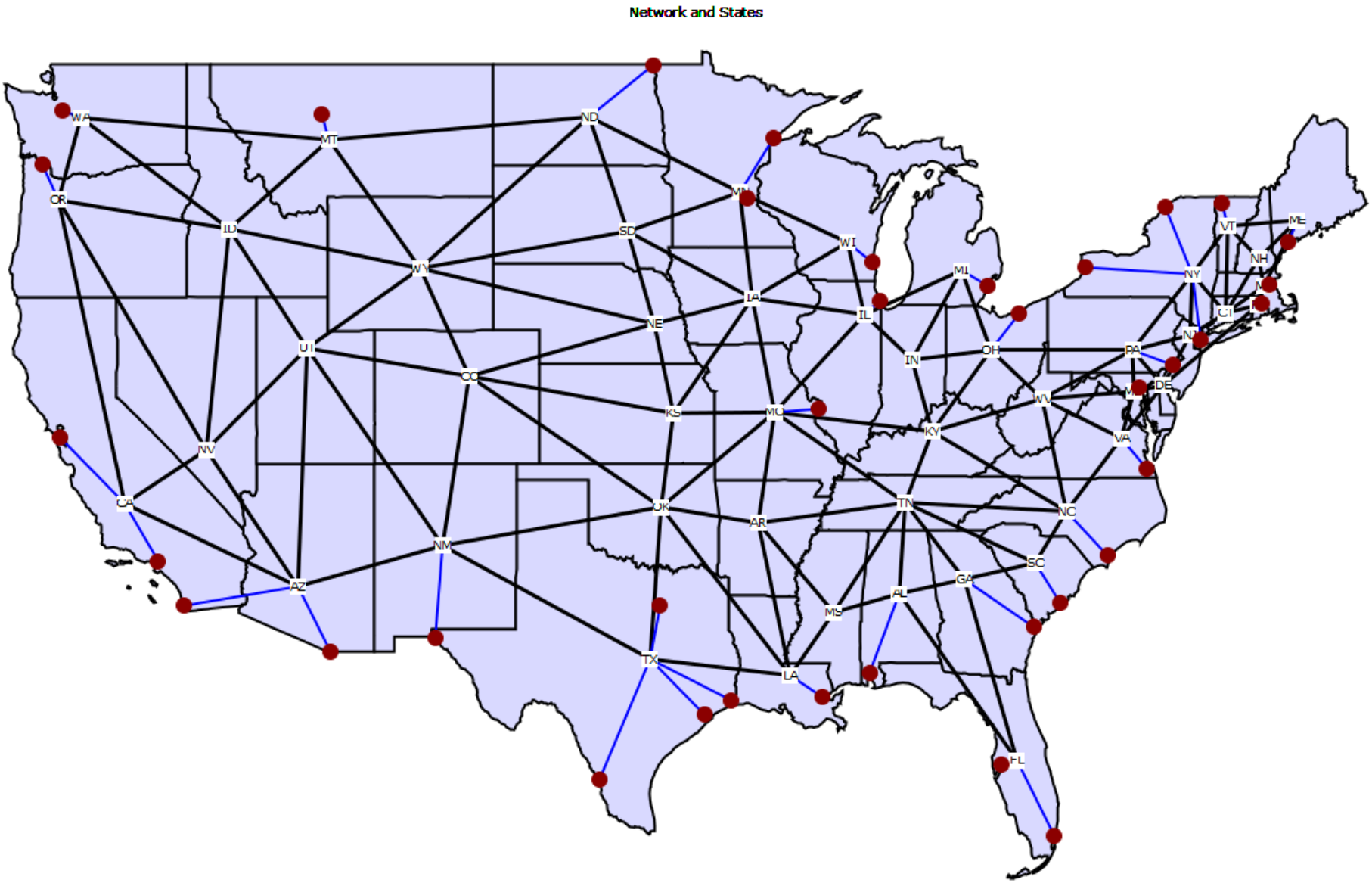
- Bureau of Census "Origin of Movement" state-level trade data does not indicate trade exposure.
  Example:
  - Louisiana's exports of soybeans (HS 1201) in 2017: \$10,612 million (source: Census Bureau, USA Trade) 49% of US exports.
  - Louisiana's production of all oil seeds in 2017 \$750 million (source USDA Cash Receipts) 1.6% of US production.
  - Nebraska's exports \$335 million (source: Census) 1.6% of US exports.
  - Nebraska's production \$3,275 million (source: USDA) 6.8% of US production.
- We could measure trade exposure based on U.S. production shares (USDA).
  Nebraska exports \$1,464 million of soybeans = (0.068)(21532).

Problems with production-share (consumption-share) based measures of export (import) exposure

- Using production shares to estimated export exposure is perhaps *b*etter but...
  - There are trade costs associated with getting goods to the port (bias in estimates could go either way).
  - Co-location of crops and their use: Pig farms co-locate with corn and soybean crops (estimates of export exposure are too high—upward bias).
- A better approach would consider production, but incorporate state-level
  - geography (currently just distance) to indicate trade costs, combined with
  - US state-level absorption of goods (intermediate inputs and in final demand) to capture proximate demand.
- One answer: Structural Gravity!

  state→port, port→state, and state↔state.

The Network


Network and States
WA
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OR
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Structural Gravity

- The familiar Anderson and van Wincoop (2003) gravity model:

$$x_{rs} = \frac{Y_r Y_s}{\sum_s Y_s} \left(\frac{t_{rs}}{\Pi_r P_s} \right)^{1-\sigma}$$

  - inward MLR (CES price index): P_s
  - outward MLR: $\Pi_r \equiv \left[\sum_s \frac{Y_s}{\sum_s Y_s} \left(\frac{t_{rs}}{P_s} \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$

- Identifying assumption: Consumers in every region have identical and homothetic preferences over regional goods.
- Corollary: In the absence of trade frictions each region consumes goods from region r based on the product share supplied from r $(Y_r / \sum_s Y_s)$ and total expenditures in s (Y_s)

$$x_{rs} = \frac{Y_r Y_s}{\sum_s Y_s} \quad at \quad t_{rs} = 1 \ \ \forall r, s$$

Estimation strategy

- Estimate each of the following for each good
  state→port, port→state, and state↔state.
- Calibrate an identical and homothetic Armington structure to the frictionless equilibrium under observed (GTAPWiNDC augmented with Census port-level trade):
  - state supply,
  - port import-supply,
  - state absorption, and
  - export demand.
- Iceberg trade costs inserted under a given distance elasticity (maintaining observed total supply and demand identities).
- Consistent intra-national and international trade flows by state.

Accounting identities (micro-consistency):

$$P_{is} A_{is} \equiv \sum_{r} \hat{X}_{irs} + \sum_{k} \hat{M}_{iks}$$

$$p^{w}_{ir} Y_{ir} \equiv \sum_{s} \hat{X}_{irs} + \sum_{k} \hat{E}_{irk}$$

$$M_{ik} \equiv \sum_{r} \hat{M}_{ikr}$$

$$E_{ik} \equiv \sum_{r} \hat{E}_{irk}$$

Generalized nested CES demand system for state s's absorption

$$P_{is} = \left[\left(\theta_{is} (t_{ss} p_{is}^{y})^{1-\sigma_{ln}} + \left[\sum_{r \neq s} \theta_{ir} (t_{rs} p_{ir}^{y})^{1-\sigma_{nn}} \right]^{\frac{1-\sigma_{ln}}{1-\sigma_{nn}}} \right)^{\frac{1-\sigma_{dm}}{1-\sigma_{ln}}} + \left(\sum_{k} \theta_{ik} (t_{ks} p_{ik}^{m})^{1-\sigma_{mm}} \right)^{\frac{1-\sigma_{dm}}{1-\sigma_{mm}}} \right]^{\left(\frac{1-\sigma_{dm}}{1-\sigma_{mm}}\right)} \Bigg]^{\frac{1}{(1-\sigma_{dm})}}.$$

where

$$\theta_{ir} \equiv \frac{Y_{ir}}{\sum_s Y_{is}} \left[\frac{\sum_s Y_{is} - \sum_k, E_{ik}}{\sum_s Y_{is} + \sum_k M_{ik} - \sum_k, E_{ik}} \right], \text{and}$$

$$\theta_{ik} \equiv \frac{M_{ik}}{\sum_k M_{ik}} \left[\frac{\sum_k M_{ik}}{\sum_s Y_{is} + \sum_k M_{ik} - \sum_k, E_{ik}} \right], \text{so}$$

$$\sum_r \theta_{ir} + \sum_k \theta_{ik} = 1$$

Port-district k's export demand is also CES (Armington)

$$P_{ik}^{x} = \left(\sum_{r} \theta_{ir}^{x} (t_{rk} p_{ir}^{y})^{1-\sigma_x} \right)^{\frac{1}{1-\sigma_x}},$$

where

$$\theta_{ir}^{x} = \frac{Y_{ir}}{\sum_{s} Y_{is}}.$$

Estimated nominal demand

$$\hat{X}_{irs} = p^{y}_{ir} P_{is} A_{is} \frac{\partial P_{is}(\boldsymbol{p})}{p^{y}_{ir}}$$

$$\hat{M}_{iks} = p^{m}_{ik} P_{is} A_{is} \frac{\partial P_{is}(\boldsymbol{p})}{p^{m}_{ik}}$$

$$\hat{E}_{isk} = p^{y}_{is} E_{ik} \frac{\partial P^{x}_{ik}(\boldsymbol{p})}{\partial p^{y}_{is}}$$

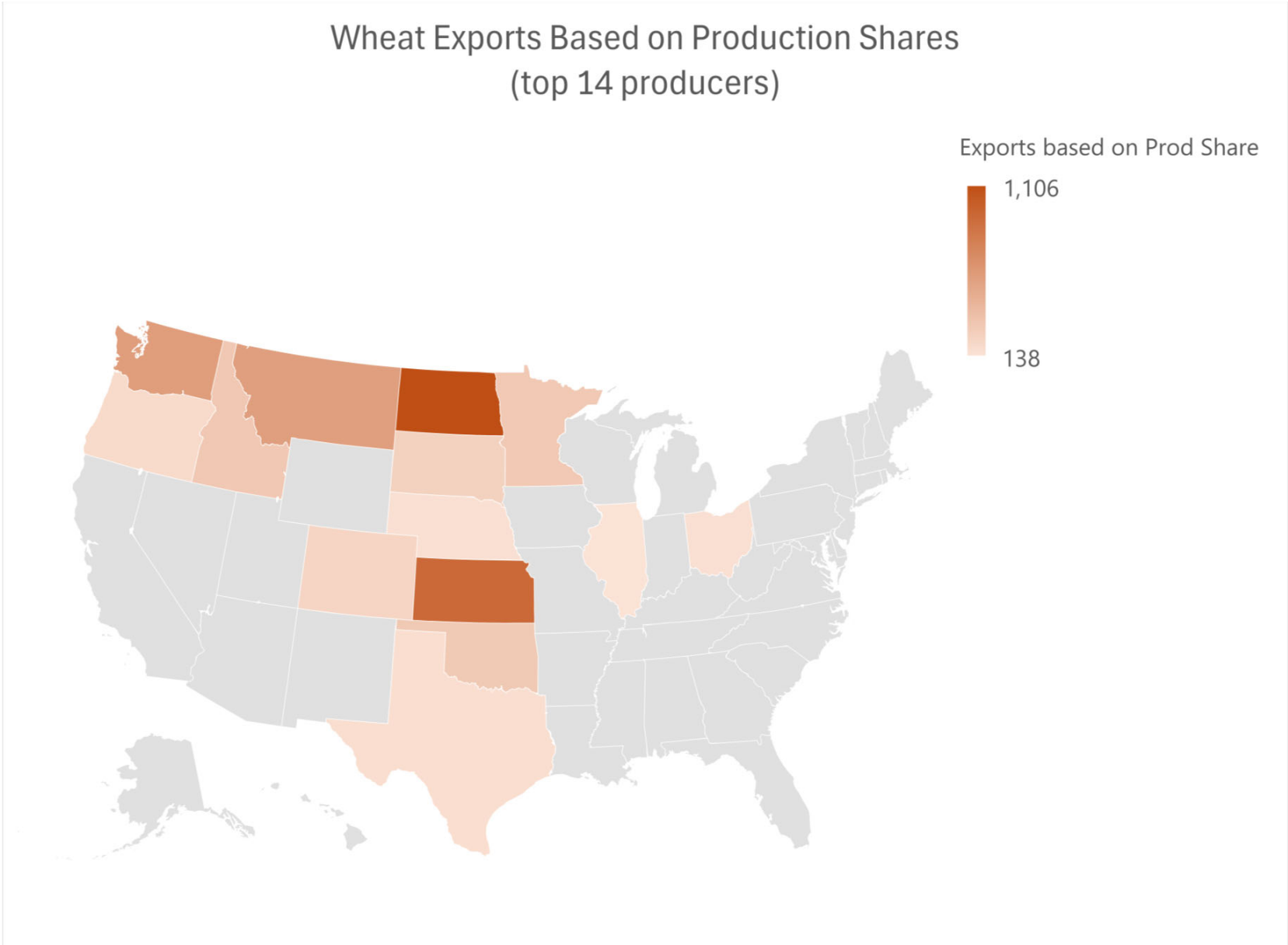
Results: OSD (mostly soybeans)

State		Production ($M)	Production Share	Exports based on Prod Share	Exports by Port	Gravity Based Exports	Gravity Based Export Share	Ratio Gravity to Prod Shr
Illinois	IL	6,637	13.1%	3,074	-	2,663	11.4%	0.87
Iowa	IA	5,849	11.6%	2,710	-	2,622	11.2%	0.97
Minnesota	MN	3,975	7.9%	1,841	-	1,878	8.0%	1.02
Indiana	IN	3,548	7.0%	1,644	-	1,379	5.9%	0.84
North Dakota	ND	3,238	6.4%	1,500	239	1,777	7.6%	1.18
Nebraska	NE	3,164	6.3%	1,466	-	1,534	6.6%	1.05
Moissouri	MO	3,032	6.0%	1,404	-	1,423	6.1%	1.01
Ohio	OH	2,881	5.7%	1,334	239	1,111	4.7%	0.83
South Dakota	SD	2,770	5.5%	1,283	-	1,398	6.0%	1.09
Arkansas	AR	1,829	3.6%	847	-	987	4.2%	1.17
Kansas	KS	1,825	3.6%	845	-	904	3.9%	1.07
Mississippi	MS	1,352	2.7%	626	-	867	3.7%	1.38
Mishigan	MI	1,165	2.3%	540	239	475	2.0%	0.88
Wisconsin	WI	1,156	2.3%	536	-	488	2.1%	0.91
Kentucky	KY	1,124	2.2%	521	-	451	1.9%	0.87
North Carolina	NC	1,011	2.0%	468	-	405	1.7%	0.86
Georgia	GA	950	1.9%	440	-	446	1.9%	1.01
Tennessee	TN	858	1.7%	398	-	396	1.7%	0.99
Louisiana	LA	829	1.6%	384	13,374	616	2.6%	1.60
Texas	TX	448	0.9%	208	1,194	276	1.2%	1.33
Pennsylvania	PA	369	0.7%	171	-	128	0.5%	0.75
Alabama	AL	363	0.7%	168	239	197	0.8%	1.17
Florida	FL	316	0.6%	146	-	182	0.8%	1.24
Virginia	VA	314	0.6%	145	955	122	0.5%	0.84

Results: Wheat (WHT)

State		Production ($M)	Production Share	Exports based on Prod Share	Exports by Port	Gravity Based Exports	Gravity Based Export Share	Ratio Gravity to Prod Shr
North Dakota	ND	2,604	16.8%	1,096	-	1,078	16.6%	0.98
Kansas	KS	2,194	14.2%	923	-	778	11.9%	0.84
Washington	WA	1,386	9.0%	583	66	1,001	15.4%	1.72
Montana	MT	1,368	8.8%	576	-	704	10.8%	1.22
Idaho	ID	739	4.8%	311	-	400	6.1%	1.28
Minnesota	MN	739	4.8%	311	132	261	4.0%	0.84
Oklahoma	OK	714	4.6%	300	-	277	4.3%	0.92
South Dakota	SD	582	3.8%	245	-	216	3.3%	0.88
Colorado	CO	536	3.5%	226	-	227	3.5%	1.01
Oregon	OR	455	2.9%	192	3,420	347	5.3%	1.81
Texas	TX	401	2.6%	169	1,907	210	3.2%	1.24
Nebraska	NE	379	2.5%	160	-	133	2.0%	0.83
Ohio	OH	368	2.4%	155	-	69	1.1%	0.45
Illinois	IL	333	2.1%	140	-	76	1.2%	0.54
Missouri	MO	303	2.0%	127	-	92	1.4%	0.73
Michigan	MI	292	1.9%	123	-	60	0.9%	0.49
California	CA	272	1.8%	114	-	134	2.1%	1.17
Kentucky	KY	227	1.5%	96	-	48	0.7%	0.51
North Carolina	NC	180	1.2%	76	-	36	0.6%	0.48
Indiana	IN	176	1.1%	74	-	36	0.6%	0.49
Tennessee	TN	165	1.1%	69	-	44	0.7%	0.63
Arizona	AZ	141	0.9%	59	-	60	0.9%	1.02
Wisconsin	WI	117	0.8%	49	-	30	0.5%	0.60
Maryland	MD	112	0.7%	47	-	13	0.2%	0.27
Pennsylvania	PA	104	0.7%	44	-	14	0.2%	0.33

Results: Wheat (WHT)



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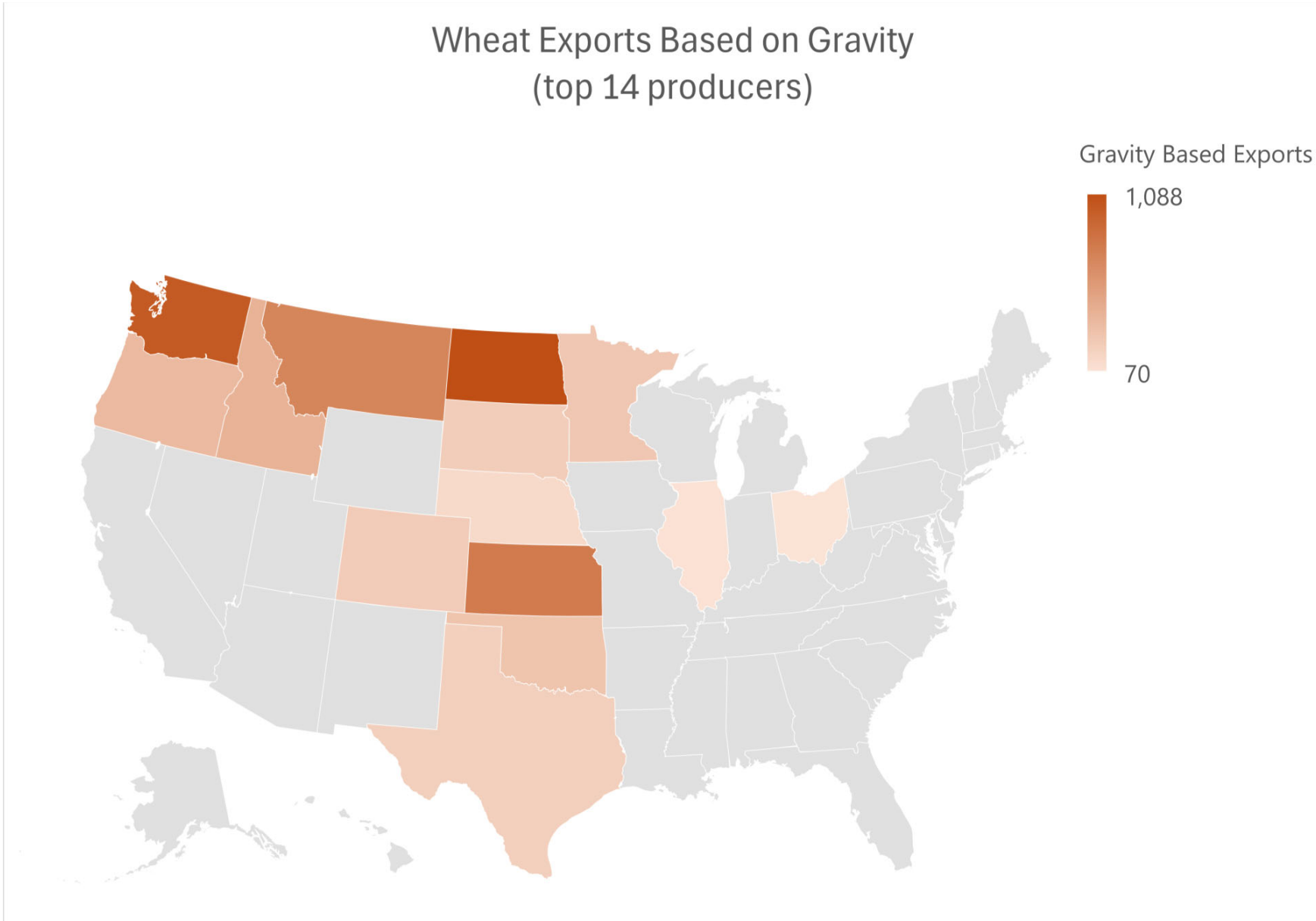
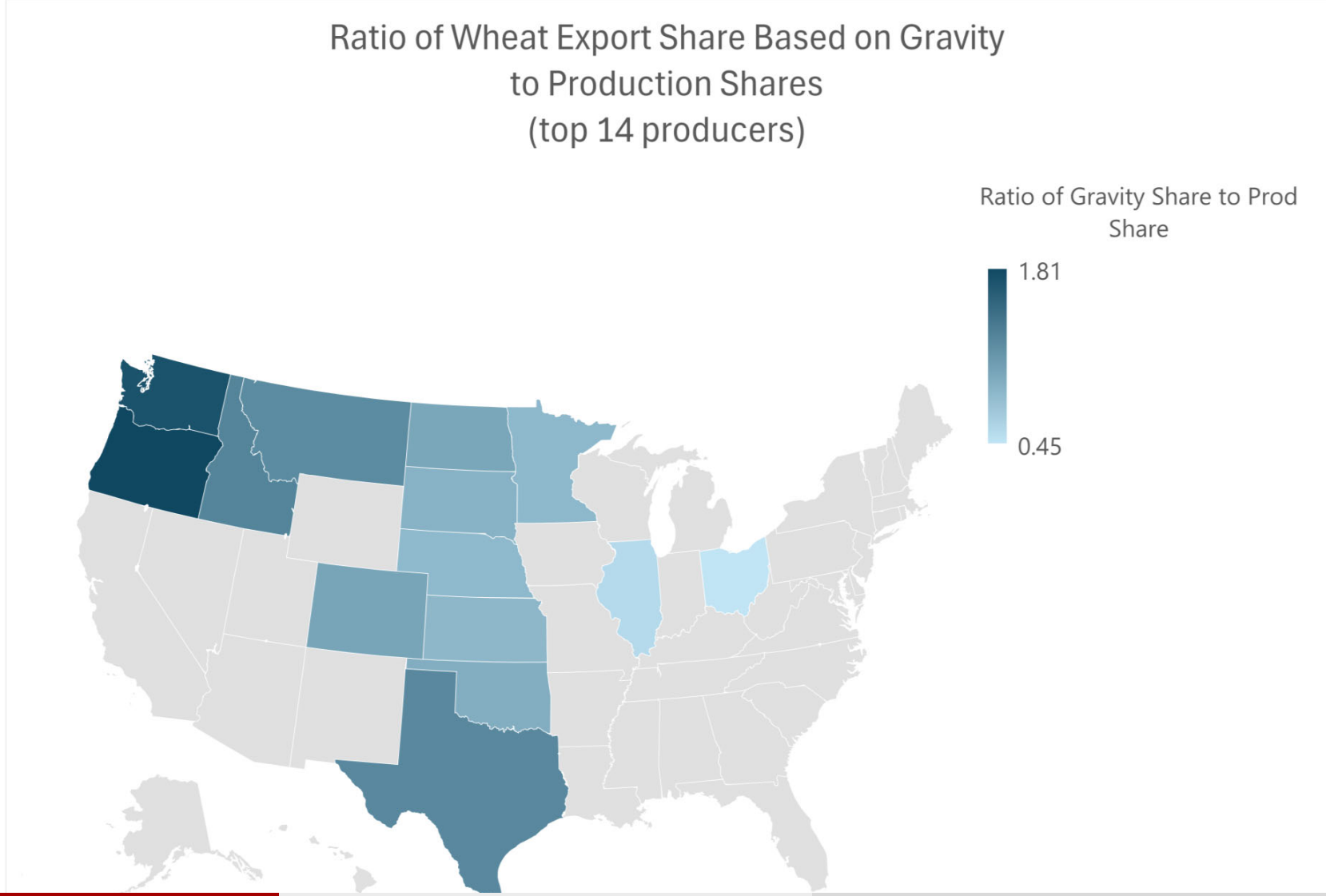


Results: The Palouse (WA) is trade exposed. Kansas, Illinois, Ohio less so



Conclusion

- Initial estimates seem reasonable
- Further ideas we want to explore:
  - Country-specific trade exposure
  - Sensitivity to distance elasticity
  - Commodity disaggregation
  - Richer Geography/Transport Networks
- Validation:
  - Commodity Flow Survey
  - Proprietary Data (Census RDC)