International Trade in Agricultural Products at the U.S. State Level

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What is the Gravity Model?

A structural model that leverages both input-output accounts and economic-geography to estimate state-level imports and exports of agricultural products (and, eventually, other manufactured goods).

What does the Gravity Model do?

Allocates farm revenue across observed exports and allocates imports across state-level absorption. Accounts for economic geography under a gravity theory.

What does this approach provide?

Empirically-informed estimates of the link between farms, agricultural products, domestic absorption of these goods, and international trade.

Overcomes the attribution of state-level trade to ports of entry.

Produces a key component for assessing a given state's exposure to trade shocks.

Motivation

An individual U.S. state's exposure to international markets is often a topic of social commentary and economic analysis. Informed analysis seems to require an estimate of a state's exports and imports. Unfortunately, published measures of state-level trade often fall short of accurately reflecting trade exposure.

Reported State-Level Trade Flows af Flawed

U.S. Customs tracks international trade at specific ports of entry (exit) rather than the ultimate destination of imports or source of export shipments. In the official state-trade statistics from the U.S. Census Bureau too much trade exposure is reported for states with major sea ports or border crossings, and nearly zero exposure for interior states producing major export commodities like wheat and soybeans. An alternative is to simply share total U.S. exports to states based on production shares. While transparent, this method fails to account for trade costs over economic geography and the co-location embeded in input-output relationships.

Problems with Census

Census reports of imports and exports by state are measured by Port of Entry. The port from which agricultural exports exit the United States, however, are not necessarily or even likely located in the States where those products are produced. For instance, corn exports departing the ports located in the New Orleans Port District were not necessarily grown in the State of Louisiana. In fact, the large volume of Louisiana exports of grains (as reported by Census and thus inferred in the WiNDC accounts) is only explained by Louisiana's purchase of grains through the pooled national market.

ERS Estimates

Faced with the problematic Census state-trade data, the U.S. Department of Agriculture's Economic Research Service (ERS) generates an alternative measure of state agricultural exports based on cash receipts. For these estimates, the products that make up U.S. agricultural exports are grouped to match the 24 product groups in U.S. farm sales estimates. For each of these 24 product groups, U.S. agricultural exports are allocated by State in approximate proportion to the State's share of national cash receipts for that product group. Thus, Nebraska, with 12.4 percent ($8.9 billion) of U.S. cash receipts for corn in 2021, is estimated to have accounted for 12.6 percent ($2.3 billion) of U.S. corn exports that year. In contrast, the Census Bureau's State Trade Data indicate Nebraska's corn exports (HS-6 100590) totaled about $609 million in 2021.

Problems with the Commodity Flow Survey

The U.S. Department of Commerce's Bureau of Census (Census) reports in the Commodity Flow Survey (CFS) might be considered the best source for bilateral state trade, but these data suffer from a fundamental problem. The CFS tracks shipments of goods not the goods themselves. For example, a rail shipment of a bushel of corn from Eastern Nebraska to Kansas City plus the barge shipment of the same bushel from Kansas City to New Orleans escalates the quantity (and value) of the actual corn shipped. This double counting in the CFS data has been noted by Anderson and van Wincoop estimates that some flows are exagerated by more than a factor of 2. Our proposed method for generating bilateral interstate trade imposes consistency between state-level production and aggregate absorption and export demand.

We use a structural gravity model following the theory of Anderson and van Wincoop as presented in Yotov et al. This begins with a fundamental proposition from trade theory which posits *equal absorption shares of regionally differentiated goods in the absence of trade frictions*. Two specific features of this theory

1. Identical and homothetic preferences. This provides an anchor point for calibration, where in the absence of trade frictions expenditure shares on regionally differentiated goods are the same across regions.
2. Iceberg trade cost. Trade costs are paid in units of the good being shipped. This allows us to establish trade at normalized prices at both the frictionless anchor and the benchmark equilibrium.

These assumptions allow us to calibrate a commodity-specific Armington demand system to input-output accounts that establish supply and demand vectors for each state and each port.

We then utilize the structure with trade frictions included to establish the benchmark flows of goods from the point of production to domestic uses and port-level exports. Similarly, we distribute port-level imports to their use in specific states. While our primary focus is on international trade the method yields a bilateral interstate trade matrix for each commodity.

Agricultural Products in the 43 Sector Database

C_B	Sugar cane, sugar beet
CTL	Bovine cattle, sheep, goats and horses
GRO	Cereal grains nec
OAP	Animal products nec
OCR	Crops nec
OSD	Oil seeds
PDR	Paddy rice
PFB	Plant-based fibers
V_F	Vegetables, fruit, nuts
WHT	Wheat, and
WOL	Wool, silk-worm cocoons.

International Trade Ports (40)

AK_ANCH	Anchorage
MD_BALT	Baltimore
MA_BOST	Boston
NY_BUFF	Buffalo
SC_CHAR	Charleston
IL_CHIC	Chicago
OH_CLEV	Cleveland
OR_COLU	Columbia-Snake
TX_DALL	Dallas-Fort Worth
MI_DETR	Detroit
MN_DULU	Duluth
TX_ELPA	El Paso
MT_GREA	Great Falls
HI_HONO	Honolulu
TX_HOUS	Houston-Galveston
TX_LARE	Laredo
CA_LOSA	Los Angeles
FL_MIAM	Miami
WI_MILW	Milwaukee
MN_MINN	Minneapolis
AL_MOBI	Mobile
LA_NEWO	New Orleans
NY_NEWY	New York City
AZ_NOGA	Nogales
VA_NORF	Norfolk
NY_OGDE	Ogdensburg
ND_PEMB	Pembina
PA_PHIL	Philadelphia
TX_PRTA	Port Arthur
ME_PORT	Portland
RI_PROV	Providence
CA_SAND	San Diego
CA_SANF	San Francisco
GA_SAVA	Savannah
WA_SEAT	Seattle
VT_STAL	St. Albans
MO_STLO	St. Louis
FL_TAMP	Tampa
DC_WASH	Washington
NC_WILM	Wilmington.

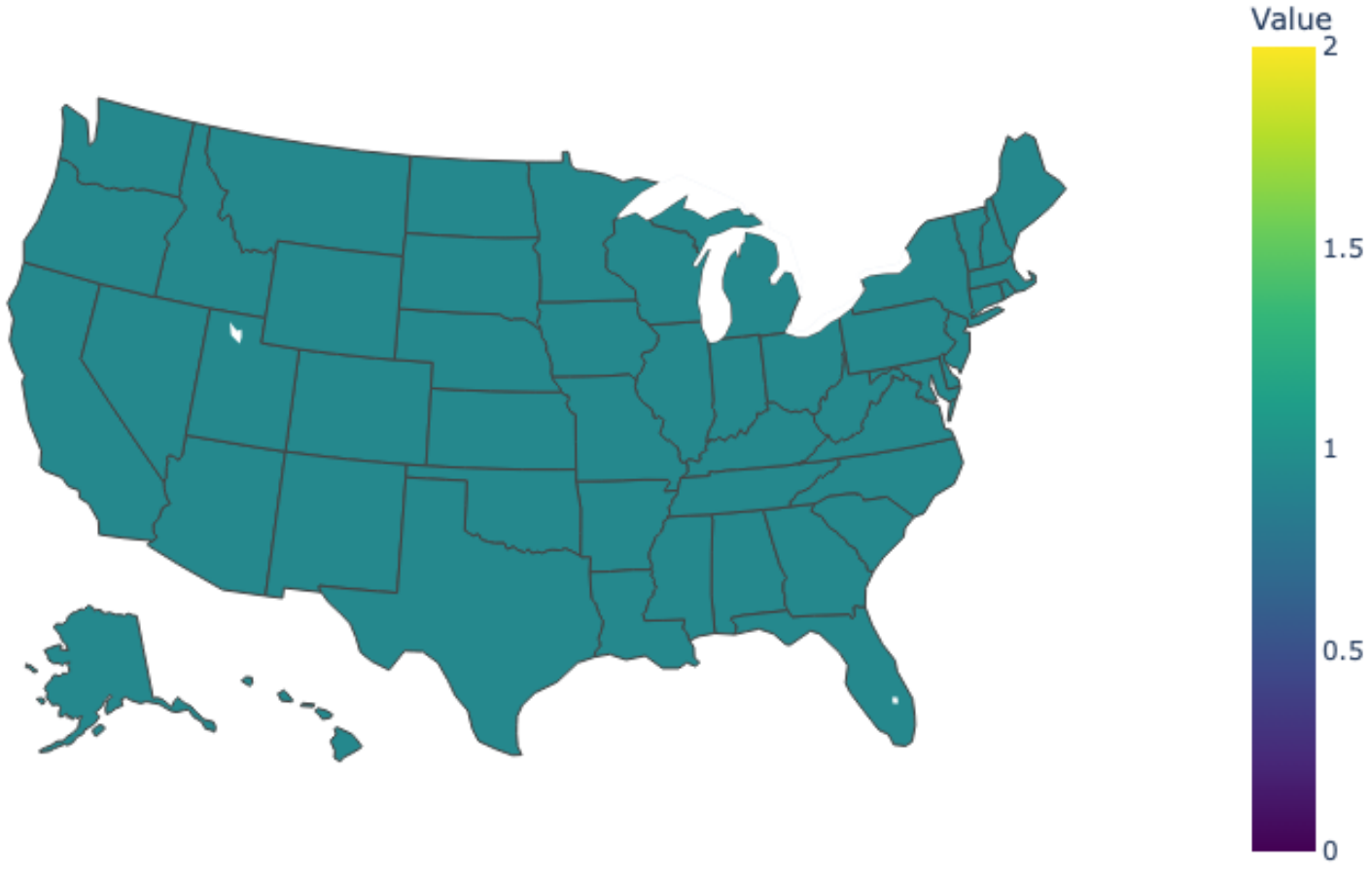
Table 1. State exports of Soybeans (OSD)

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

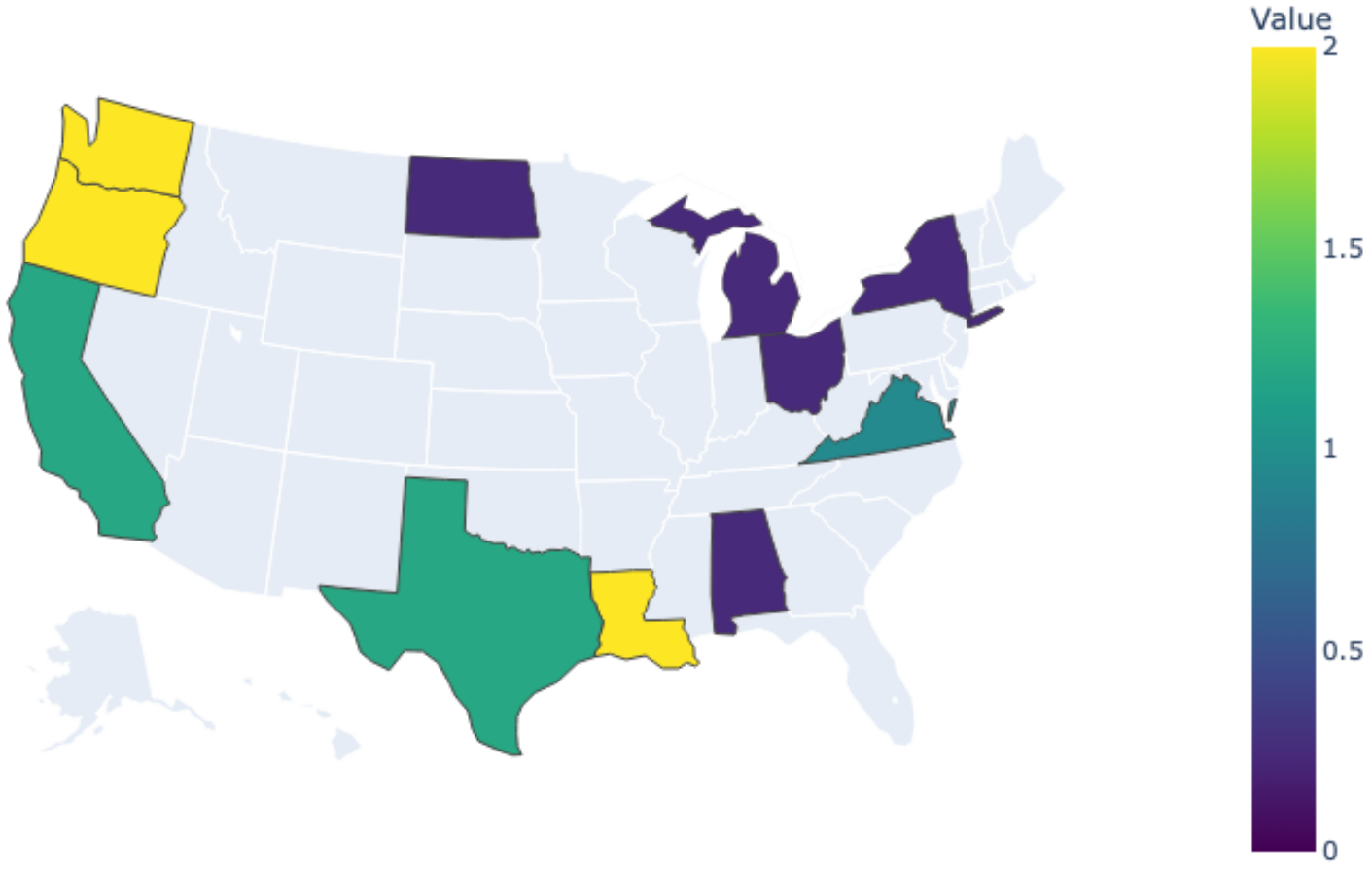
Table 2. State exports of Wheat (WHT)

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

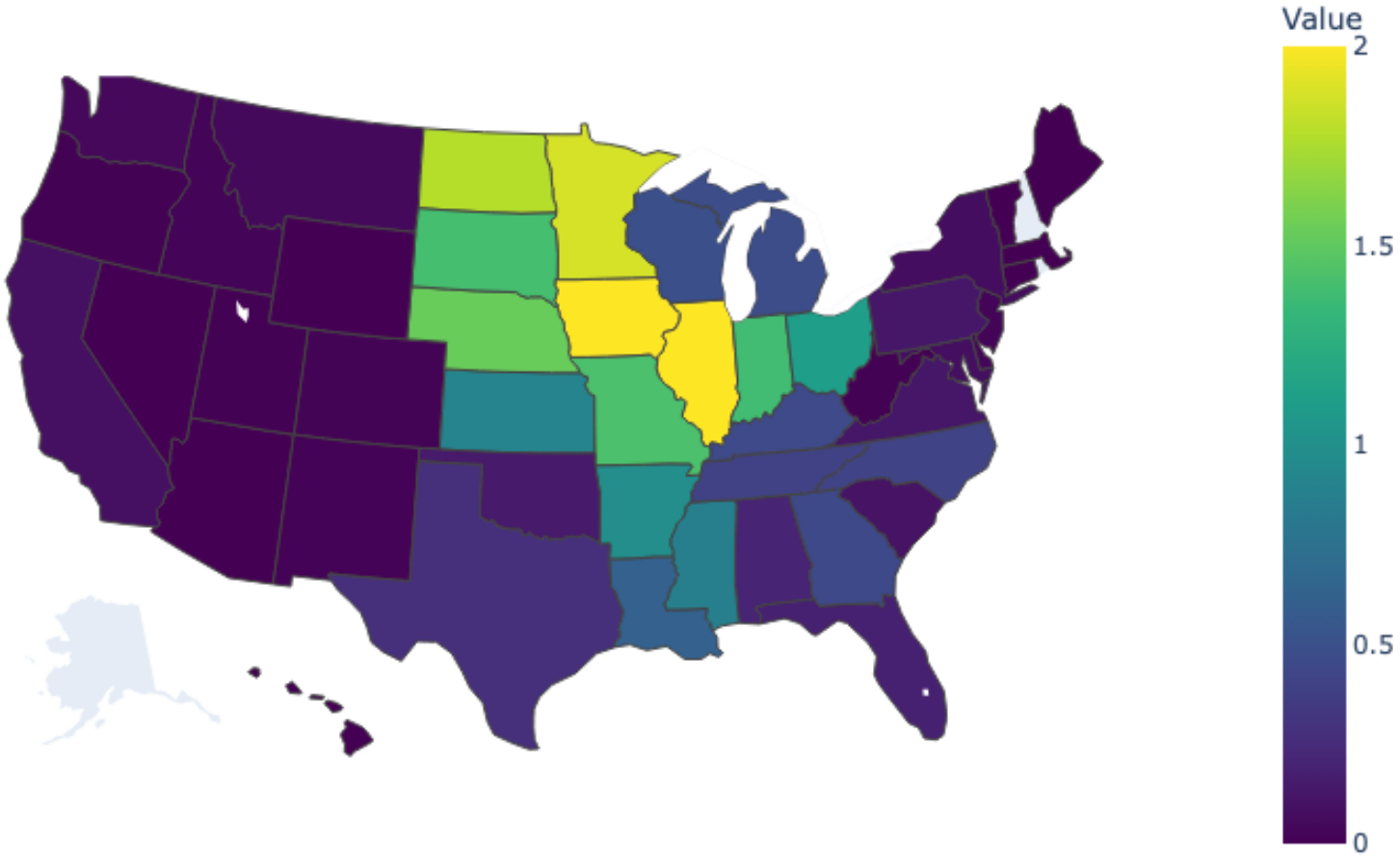
Uniform Value Map for Exports (Model: SHRS, Crop = osd)



Heatmap of Exports by State (Model: Port, Crop = osd)



Heatmap of Exports by State (Model: Gravity, Crop = osd)



Research Agenda Going Forward

- Address problems with *density* which arise when we incorporate gravity estimates for bilateral trade for both countries and states. We would like to provide a GTAP-WiNDC database which covers most of the G20 countries, oil exporters, and rest of world, as well as the 50 states.
- Write up an overview focusing on the implications for trade in manufactured goods and energy-intensive / trade-exposed products.
- Leverage Census data on the bilateral composition of port-level imports and exports to produce a GTAPWiNDC dataset which connects state-level imports and exports to specific countries.