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Pulsating Market Boundaries and Spatial Arbitrage in US Gulf Region: Impact of Panama Canal Expansion on US Agriculture

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PULSATING MARKET BOUNDARIES AND SPATIAL ARBITRAGE IN US GULF REGION: IMPACT OF PANAMA CANAL EXPANSION ON US AGRICULTURE

Abstract: US agricultural exports reached a record high of \$137.37 billion for fiscal year (FY) 2011, an increase of 26.5 percent from FY 2010. Export capacity of bulk grain and soybean is expanding at 10 percent nationally with up to 30 percent in Pacific North West. Several other expansions have taken place with two Greenfield facilities under development one of which is opening for 2011 fall harvest. Total US grain and soybean exports are forecasted to increase more than one billion bushels or 25 percent from 2011/12 to 2020/21. Most of these exports are expected through center gulf driven towards East Asian countries via Panama Canal. Panama Canal currently handles 44 percent of total US exports.

Some of the prospects from expansion of Panama Canal include increased loadings per vessel use of larger vessel size along with reduced canal transit time and lower transportation cost (overall). Grain exports are mostly exported during short time of the year, for example, soybeans are mostly exported from mid-September to mid-February. Such dynamics require efficient throughput capabilities. Other crops like Wheat and Corn have similar periodic surges and compete with surges in supply of other crops.

Increased capacity of inland shuttle locations and elevators, with reduction in loading time (increased efficiency gained from technology advancement at loading facilities) combined with increased handling capacity at ports expected to benefit from panama canal expansion will open up more draw areas or increase existing draw areas for crops producing/supplying regions. This means that the areas farther away from ports may be able to export considering the expected gain in transportation cost.

This study will focus on spatial arbitrage and pulsating market boundaries for some of crops at key ports specifically located in US Gulf Region and their expected impacts on US agriculture.

Market boundaries (area from which the supply is drawn) for ports are expected to increase with Panama Canal expansion combined with ongoing expansion at shuttle elevators elsewhere in inland. Market boundaries are subject to price expected at destination minus the total transportation cost. Other factors that might influence the market boundaries are reliability (risk) in terms of price and volume, cost of congestion and delay time may also play a role. Since these market boundaries are subject to spatial arbitrage (difference in markets located at different geographical region), draw area is expected to change as when any of parameters affecting price at destination and transportation costs are changed. Volatility in price and transportation cost will cause change in draw areas until equilibrium is reached. This equilibrium will be defined by maximum profit that a farm/elevator/shuttle in crop producing region can expect by exporting through different ports. Choice of ports will be based on maximizing profit. Origins at boundaries are expected to be indifferent in shipping to more than one ports, however, the convenience and other factors might play important role for shipper. With price volatility and different transportation cost (determined by rates at different volume between same pair of origins and destinations, and different ports), a rational shipper is expected to maximize profit while minimizing risk.

Price at destination and transportation cost are treated as random with certain distribution and expected gains will be compared from existing Panamax rates with those of post-expansion.

Other variables such as existing capacities of shuttle/elevators will be treated as fixed in base case and then relaxed in sensitivities.

Optimization of maximum profit through various combinations of shuttle and ports will be calculated by SAS or other statistical package and spatial aspect of distance and locations will be handled by using ArcMap (ESRI).

Key ports of consideration are primarily on east coast. Other ports will be considered based on their relevance to crop supplying regions. Corn and soybean will be potential crops to be analyzed.

INTRODUCTION

US agricultural exports reached a record high of \$137.37 billion for fiscal year (FY) 2011, an increase of 26.5 percent from FY 2010. Export capacity of bulk grain and soybean is expanding at 10 percent nationally with up to 30 percent in Pacific North West. Several other expansions have taken place with two Greenfield facilities under development one of which is opening for 2011 fall harvest. Total US grain and soybean exports are forecasted to increase more than one billion bushels or 25 percent from 2011/12 to 2020/21. Most of these exports are expected through center gulf driven towards East Asian countries via Panama Canal. Panama Canal currently handles 44 percent of total US exports.

Some of the prospects from expansion of Panama Canal include increased loadings per vessel use of larger vessel size along with reduced canal transit time and lower transportation cost (overall). Grain exports are mostly exported during short time of the year, for example, soybeans are mostly exported from mid-September to mid-February. Such dynamics require efficient throughput capabilities.

Increased capacity of inland shuttle locations and elevators, with reduction in loading time (increased efficiency gained from technology advancement at loading facilities) combined with increased handling capacity at ports expected to benefit from Panama Canal expansion will open up more draw areas or increase existing draw areas for crops producing/supplying regions. This means that the areas farther away from ports may be able to export considering the expected gain in transportation cost.

Problem

Before one can analyze the impact of expansion of shuttle and port capacities, one needs to know the market boundaries or the drawing region for the crop. In this study we will focus on production and supply regions for corn. The next question is that given the market boundaries, how do they change when the prices at regional markets change? Or how do the market boundaries change when cost of shipping changes for transporting corn from regional markets to ports (via railroad or barge)? Or how do the market boundaries change when the ocean shipping rates available at the port change?

Purpose/Contributions.

Main purpose of this study is to know the impact of change in prices available at regional markets and changes in cost of shipping on market boundaries. We considered cost of shipping within regional markets via truck at the cost of \$4.00 per truck mile, for a capacity of 1000 bu per truck for corn. Published cost of shipping from regional markets (source) to PNW (via railroad) and Gulf (railroad and barge) are used. Ocean shipping rates from PNW and Gulf to Japan are also used.

The prices at regional markets are dynamic subject to market conditions. Changes in market prices lead to arbitrage opportunity for both buyer and seller. The flow of crop within these regions is subject to maximizing profit considering distances of these markets from crop producing regions and respective transportation costs.

This study is useful in analyzing the impacts of changes in prices at inland market regions and costs of shipping along the supply chain. This study is also useful in visualizing the results obtained from optimizing the flow of corn from crop producing regions to nearest market that provides maximum price, while reducing the cost of transporting produce. The model is built to minimize the cost of procurement from an importers perspective which includes the price at regional markets in crop growing regions and from there on till crop reaches the demand point (Japan).

PREVIOUS STUDIES

Changes in underlying fundamentals of market have resulted in more robust outlook for grain shipping from United States. Impacts among shipping costs and basis values at origins and destinations and relationships are analyzed in study by (Wilson and Dahl 2011). The econometric results indicate that variables that are significant in explaining variability in origin basis values are shipping costs, Gulf-PNW ocean rate spreads, outstanding export sales, shipping industry concentration, measures of rail cars late, the ratio of stocks to storage capacity, futures prices, and varying measures of futures and destination spreads.

Coleman 2009 indicated that there is considerable variation in transport prices because transport prices rise when demand to ship goods exceeds the capacity limit. This variation is necessary to attract shipping capacity into the industry causing difference in pricing at different point of time by a varying amount.

Hill and Davis 1974 mentioned that corn price differentials among country elevators often exceed norms of perfect competition. The authors further indicated that variables of seasonal adjustments, local demand and supply conditions, availability of transportation facilities, and governmental loan rate have significant influences in price variation.

DATA SOURCES

Production Data:

Production data for corn by counties from (NASS,USDA) is used for 2010 as base case and from 2007 to 2009 for comparing the results with base case.

Price Data:

Price at regional markets and cost of shipping from regional markets to ports (PNW and Gulf) via railroad and Barge are used in optimizing the flow of corn from origins to final destinations. (Wilson and Dahl 2011). Price data is used for following dates (year, month, and day): 2010 01 08 (Base Case), 2010 05 28 (Base Case), 2009 09 18, 2008 09 19, 2007 09 21.

METHODOLOGY

The concepts used in this study are based on theories of market prices and interregional trade (Bressler and King 1970) and agricultural prices and commodity market analysis (Ferris

2005). The basic concept is of arbitrage is that commodity flows from origin to destination till the destination provides the maximum price. In essence the commodity flows to dominant market given the same transportation cost. As the flow of commodity occurs, the prices at destination changes as per market laws of supply and demand, and there flow of commodity adjusts to new prices at the destinations. Commodity flow occurs till an optimum level of markets is achieved. In case there are two markets that offer a same price, then flow will occur to the destination that has least transportation cost. Methodology for this study is presented in stepwise manner as below. When both market prices and transportation costs change, the flow will occur where profit is maximized for seller. In case of this study, the corn will flow such as to minimize the cost of procurement from and importer's perspective.

The model of optimization for determining the flow of corn is presented below (Figure 15):

$$\begin{aligned} \text{Min Cost} = & \sum_{i=0}^n X_{ij} * OPrice_j + \sum_{i=0}^n X_{ij} * TransC_{ij} \\ & + \sum_{i=0}^n Y_{jk} * ShipCost_{j,k}) + \sum_{i=0}^n Z_k * Oship1_k \end{aligned}$$

Where:

X_{ij} = Volume of flow from FFID_Point to Dest_ID

Y_{jk} = Volume of flow from DEST_ID to Ports

Z_k = Volume of flow from Ports onwards

$OPrice_j$ = Price at regional markets Desti_ID_j.

$TransC$ = Transportation cost from Origin_i to Dest_ID_j

$ShipCost_{j,k}$ = Shpping cost from Dest_ID_j to Ports_k.

$Oship_k$ = Ocean shipping cost at Ports_k.

.....Equation 1

The model presented above is used in SAS 9.2 for optimizing flows from all the origins to destinations. a stepwise description is presented below for further understating of the reader.

Production data for Corn 2010 (NASS,USDA) is used to determine the counties that are to be considered as production regions in ArcMap (ArcGis Desktop). The map of USA is allocated in 50 equal columns and rows and intersected with production counties to get the production grids. These production grids are then aggregated by county, such the area of a grid is calculated in proportion to the area that falls in a particular county (Figure 1). This provides production in a particular grid (Figure 2) each production grid is indexed with a name FFID_Grid) and a corresponding centroid point (FFID_Point)(Figure 3).

Prices for 26 available regional markets are used (DEST_ID)(Figure 4).

Major roads network from Bureau of Transportation Statistics are used to calculate origination-destination matrix (all FFID_Point to all Dest_ID, OD Matrix) to get total miles between any origin destination pair.

Optimization of corn flow is done in SAS 9.2 using equation 1 presented before, using the OD Matrix obtained from ArcMap.

Results from optimization in sas are joined back in ArcMap to get the resulting flows depicting flows from origin to destination. With further sorting and merging of data in SAS,

flows were obtained for origins to regional market (FFID_Point to Dest_ID, Xij), and from regional markets to ports (Dest_ID to Ports, Yjk) as well as demand fulfilled at final destination (Zk).

RESULTS

Tables and figures are presented in Appendix to maintain continuity in reading for the reader.

Base Case

Results are first presented for base case and then results are presented for other dates to show how the market boundaries change with change in pricing at regional market and how they after the flow further down the supply chain.

First for the prices on date 2010 01 08, Figure 5 shows the amount of corn flowing from origins to regional markets, with darker color referring to more flow. When classified by regional markets, these flows represent the market boundaries for regional markets, in essence the draw area for the price Figure 6. The same is done by the category of ports, which refers to draw area from origins to final port destination Figure 7. When flow from origins to regional markets (lines) are overlaid on top of market boundaries by ports (grids), we get an idea of both the supply chains, the supply chain from origins to regional market as well as from regional markets to ports Figure 8.

Now for the same year but a different date 2010 05 28, the prices at regional markets are different with no change in cost shipping from regional markets to ports and ocean shipping to show how flow of crop changes Figure 9. This clearly shows that as the price at regional markets changed, the flow of corn from origins to final port destination also changes. The lines of different color depict flow based on a particular day's price.

By comparing flow of corn from origins to ports for 2010 01 08 (Figure 7) with that of 2010 05 28 (Figure 10), we see the change in draw area of corn that flows to Gulf and PNW. While there was no flow to PNW initially on Jan 08, 2010, there is a flow to PNW at price of May 28th, 2010.

Comparable Cases

For comparison, similar analysis was done for the prices from 2009 09 18, 2008 09 19, and 2007 09 21

When we compare the flow during the same period of year, we get different flows for different years based on corresponding change in prices at regional markets. When flow of corn from origins to ports are compared for May 28th, 2010 with those on Sept 21st, 2007, the draw areas are quite different for same ports (Figure 11).

There is more number of origins that ship to PNW at price of September 21st 2007 (Figure 12) and September 18th, 2009 (Figure 13), than on September 19th, 2008. After the panama canal expansion, the ocean shipping rates are expected to fall from Gulf to Japan, due to reduced operations costs at ports and higher capacity of loading per unit time. This will likely cause reduction in ocean shipping rates from Gulf to Japan. This means, what is currently flowing to PNW, will have greater chance to be drawn to Gulf.

During the analysis, we found that based on reduced cost for flow that is currently going to PNW, will enter the optimal solution for Gulf for an increase of 64 cents per bushel reduction in

ocean shipping from Gulf to Japan. This translates to roughly more than \$4 per metric tons reduction in ocean shipping cost from Gulf to Japan. This cost seems to be high. And thus more detailed data is required to conduct analysis. This cost seems to be inflated based on other concurrent studies. The reason for that is limited data availability for prices at various regional markets and ports. If there are more locations for which the prices of delivery are known, the reduced cost for corn that is currently now flowing to Gulf can be deduced more accurately.

This has many further implications. The simplest one is that post panama canal expansion, the advantage in cost of ocean shipping to Japan and other East Asia bound regions via Gulf (using post panama vessels) has to be good enough to justify the current ongoing infrastructural expansion at ports as well as at inland locations (shuttles and elevators).

REFERENCES

- ArcGis Desktop, ESRI. ArcGIS for Desktop - Advanced Desktop GIS Mapping | GIS Editing Software. <http://www.esri.com/software/arcgis/arcgis-for-desktop/index.html>.
- Bressler, Raymond George, and Richard A. King. 1970. *Markets, Prices and Interregional Trade*. John Wiley & Sons Inc, October 21.
- Coleman, Andrew. 2009. "A Model of Spatial Arbitrage with Transport Capacity Constraints and Endogenous Transport Prices." *American Journal of Agricultural Economics* 91 (1) (February 1): 42 -56. doi:10.1111/j.1467-8276.2008.01183.x.
- Ferris, John N. 2005. *Agricultural Prices and Commodity Market Analysis*. 2nd ed. Michigan State University Press, July 26.
- Hill, Lowell, and Leroy Davis. 1974. "Spatial Price Differentials for Corn among Illinois Country Elevators." *American Journal of Agricultural Economics* 56 (1) (February): 135-144.
- NASS,USDA. NASS - National Agricultural Statistics Service. *National Agricultural Statistics Service, USDA*. <http://www.nass.usda.gov/>.
- Wilson, William W, and Bruce Dahl. 2011. "Grain pricing and transportation: dynamics and changes in markets." *Agribusiness* 27 (4) (September 1): 420-434. doi:10.1002/agr.20277.

APPENDIX

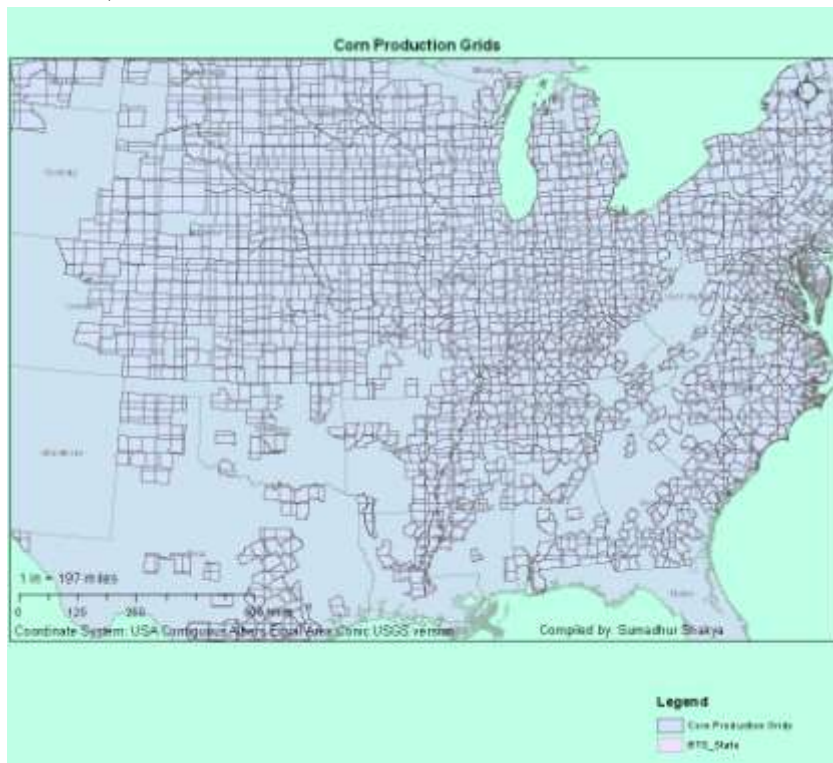


Figure 1 Production Grids

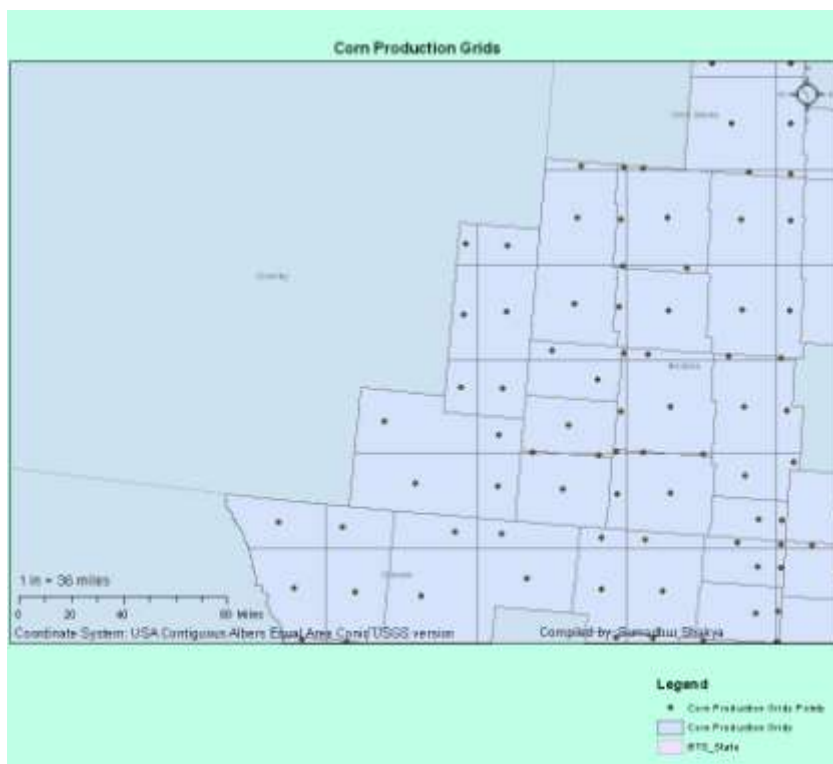


Figure 2 Production Grids with Their Respective Centroids (a close up of Grids intersected by county boundaries).

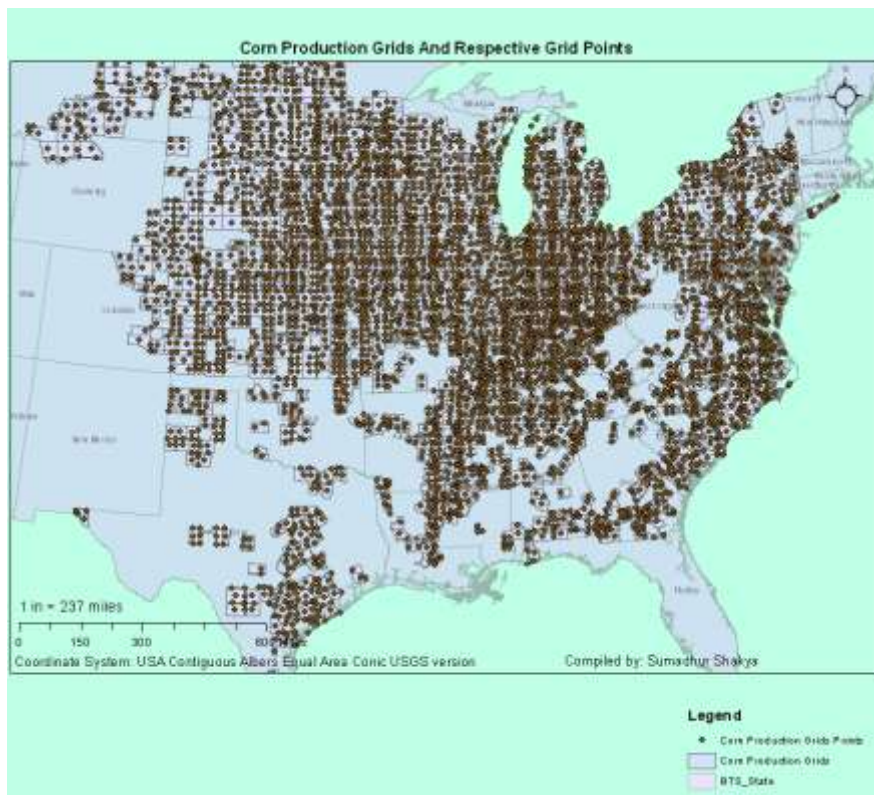


Figure 3 All Origin Points Showing Production Grids and Their Respective Centroid (FFID_Point)



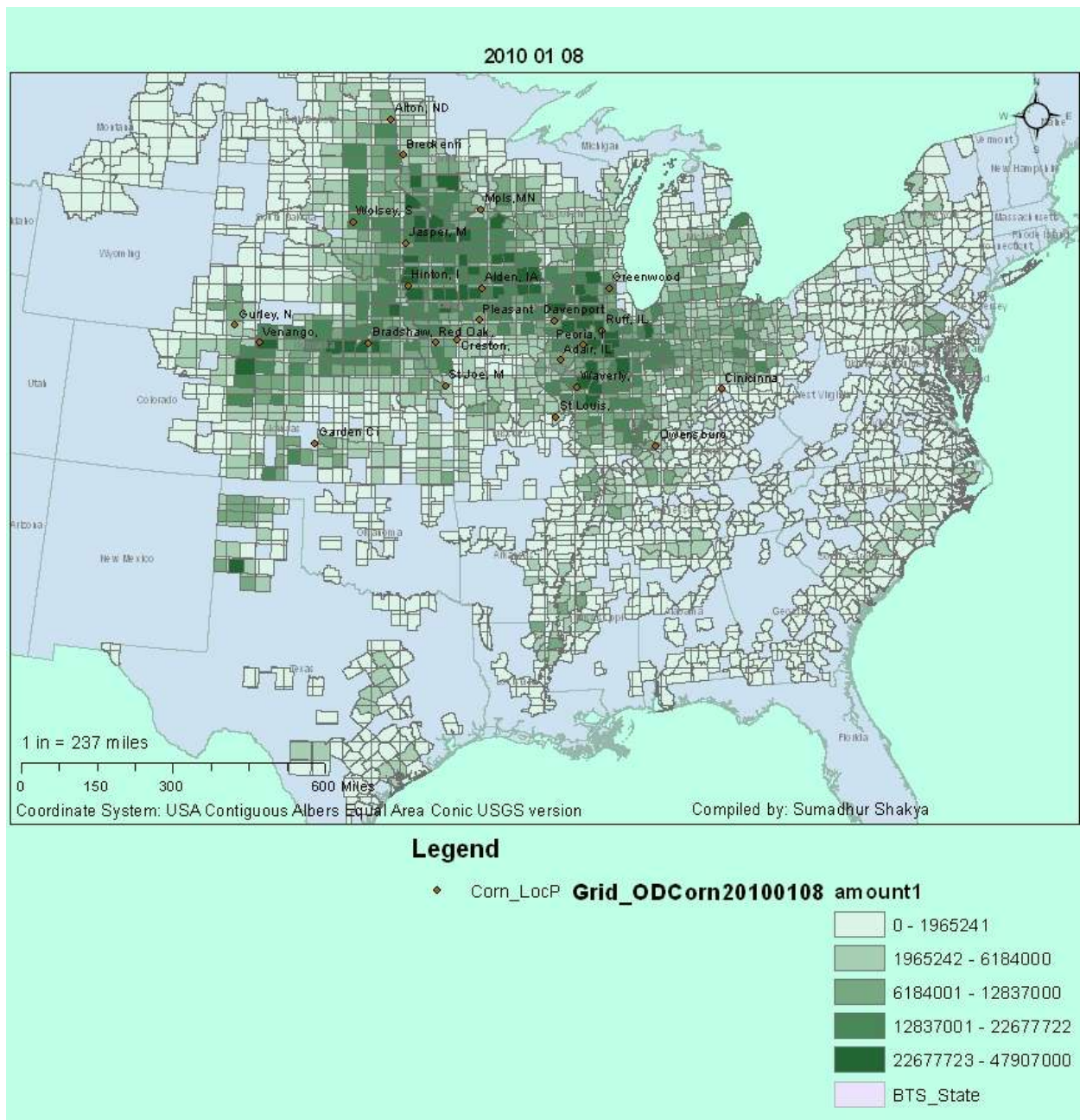


Figure 5 Amount of Corn Flowing From Origins to Regional Markets (Xij) Based on Price of Jan 08, 2010

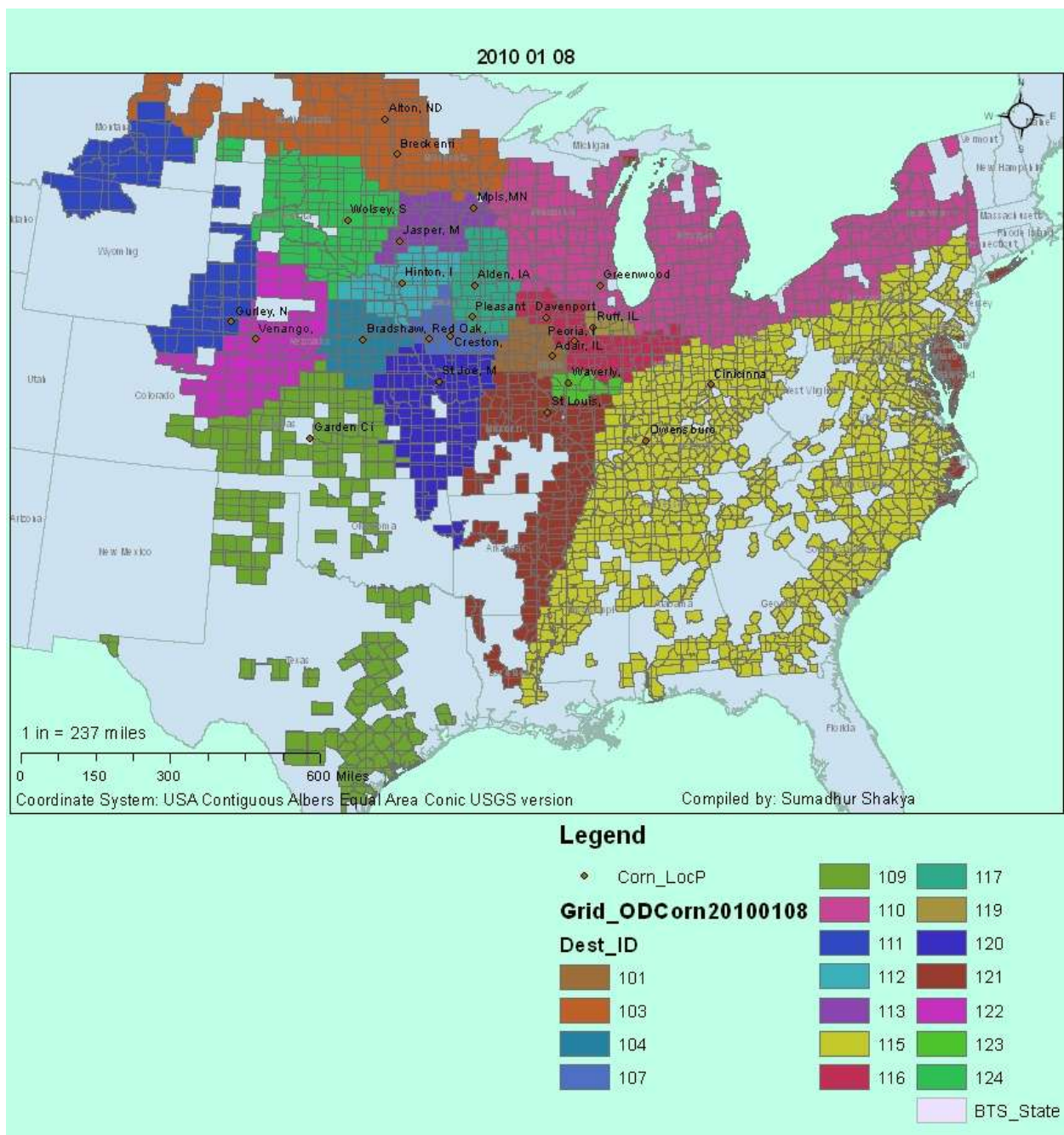


Figure 6 Market Boundaries by Regional Markets (DEST_ID) Based on Price of Jan 08, 2010

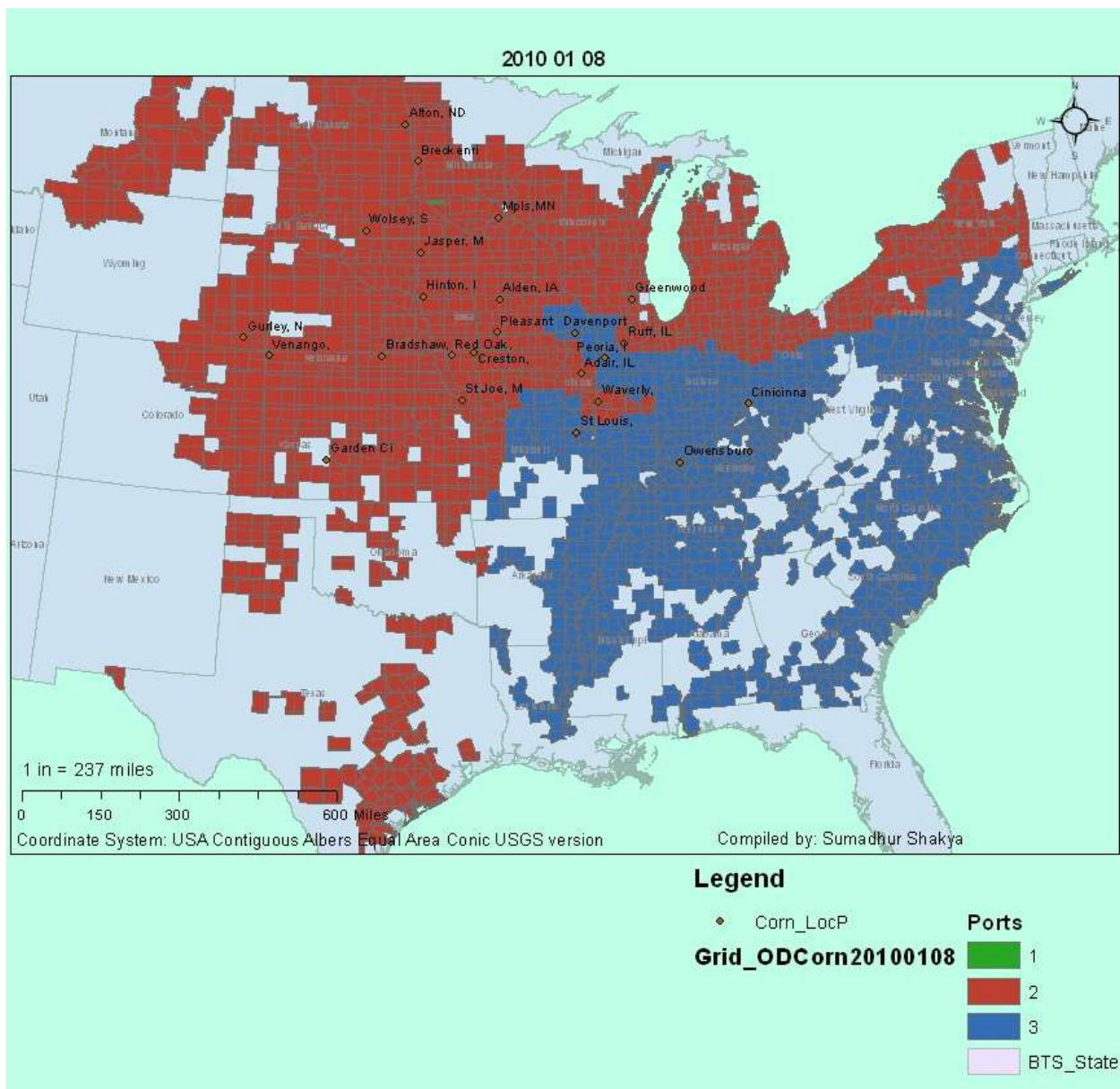


Figure 7 Market Boundaries by Ports (Ports) Based on Price of Jan 08, 2010

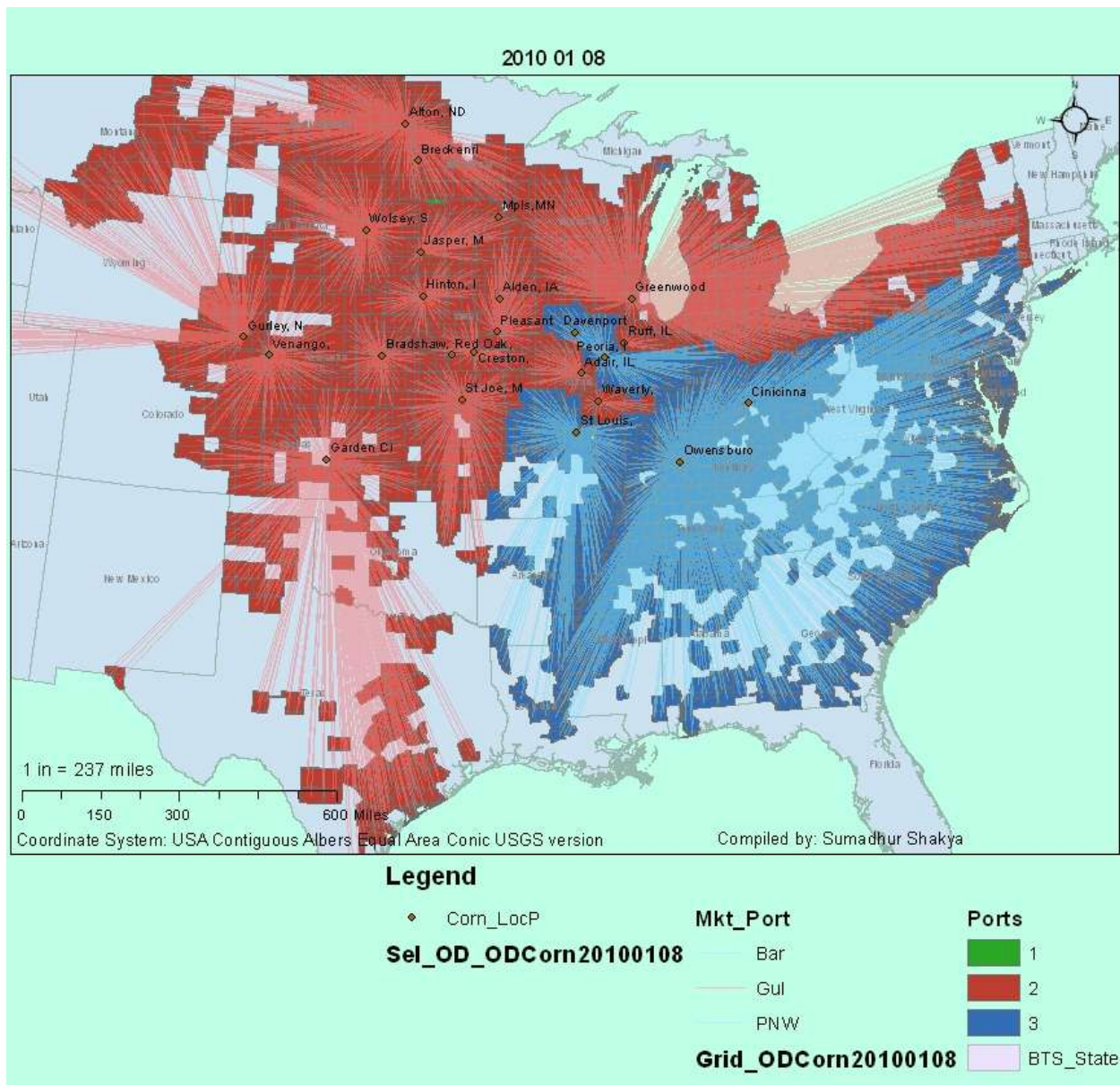


Figure 8 Market Boundaries and Flow of Corn Based on Price of Jan 08, 2010

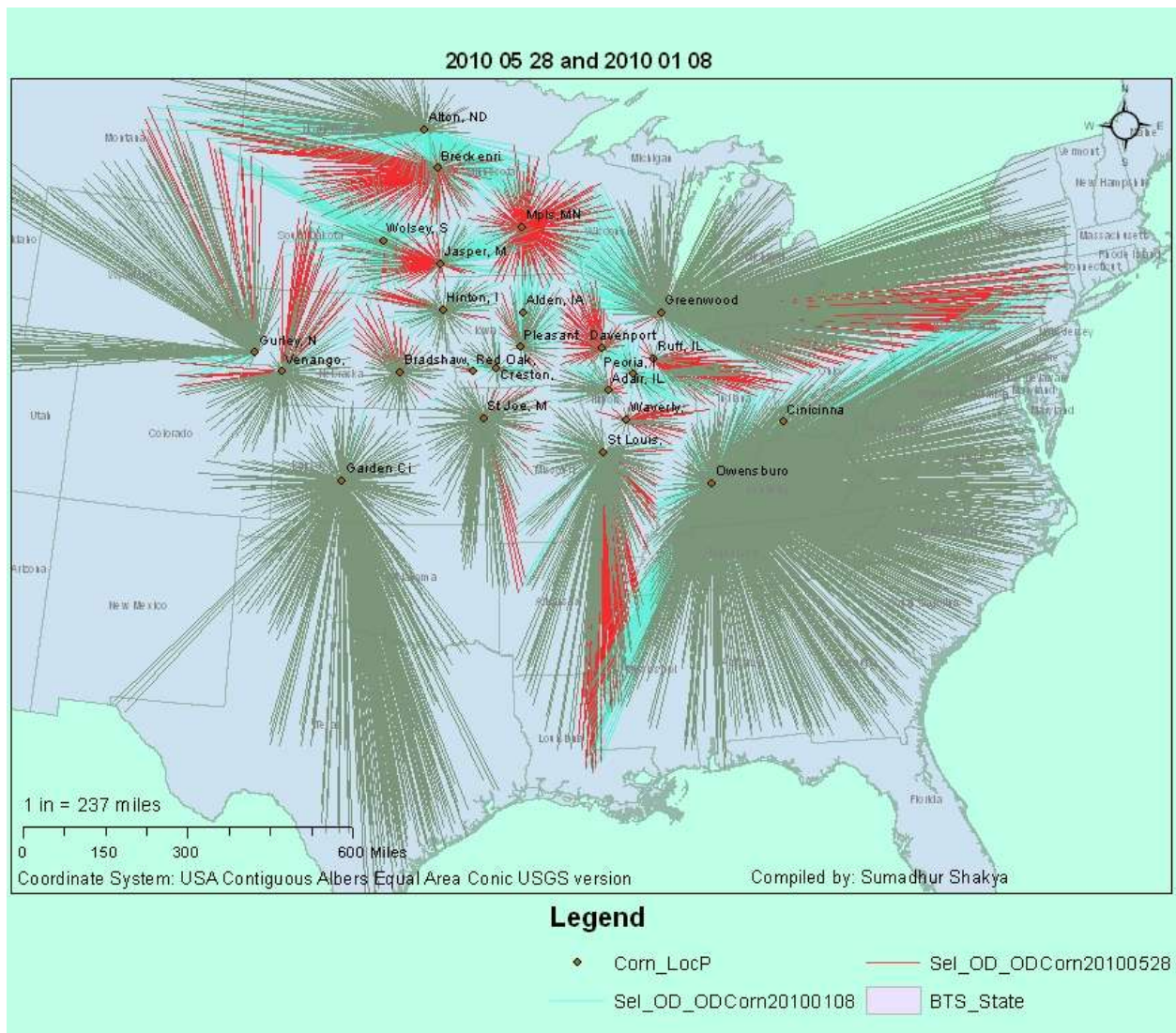


Figure 9 Flow of Corn from Origins to Ports Based on Price of 2010 01 08 Overlaid on top of Flow of Corn From Origins to Ports Based on Price of 2010 05 28

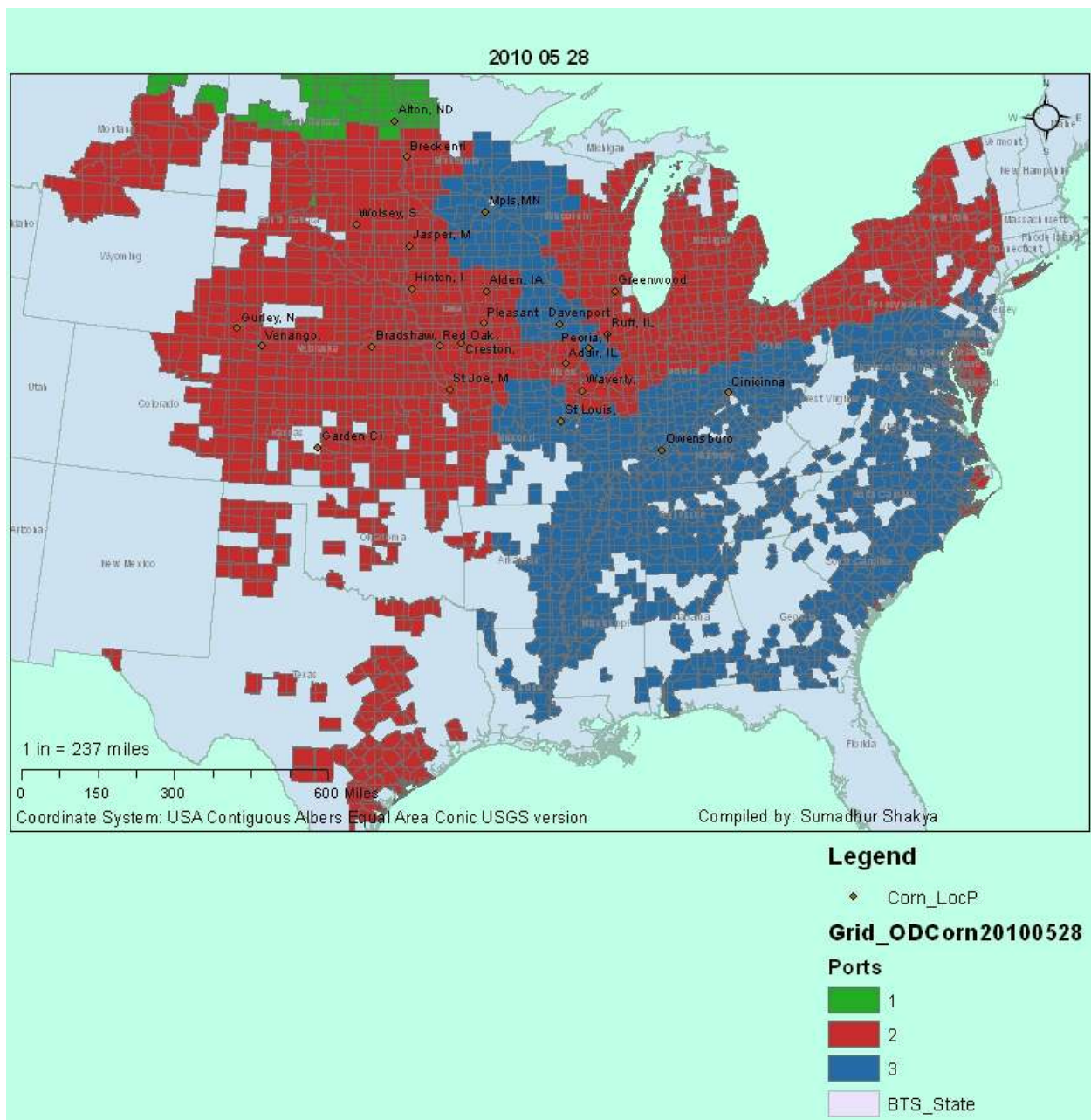


Figure 10 Market Boundaries by Ports (Ports) Based on Price of May 28, 2010

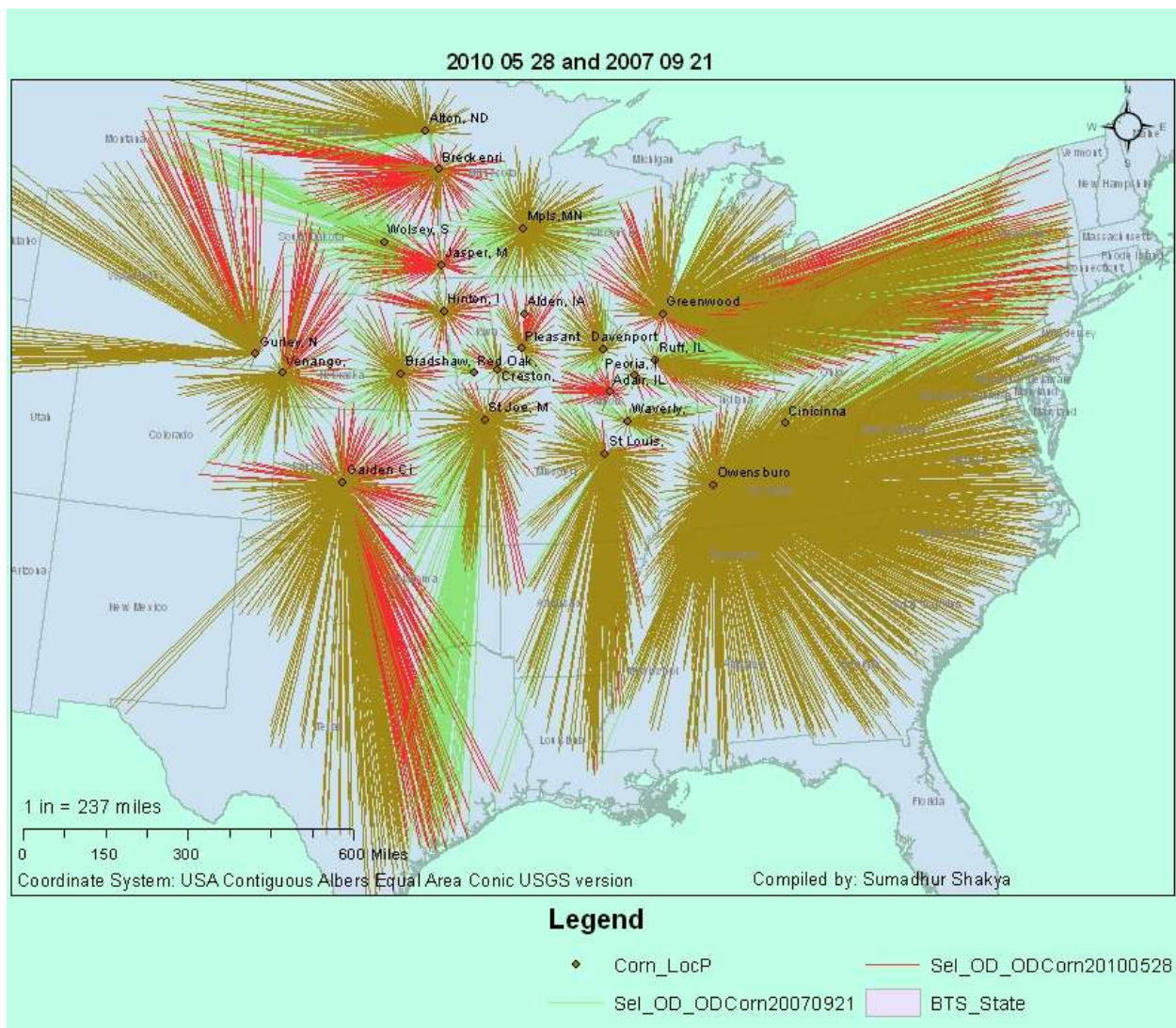


Figure 11 Flow of Corn from Origins to Ports Based on Price of 2010 05 28 Overlaid on top of Flow of Corn From Origins to Ports Based on Price of 2007 09 21

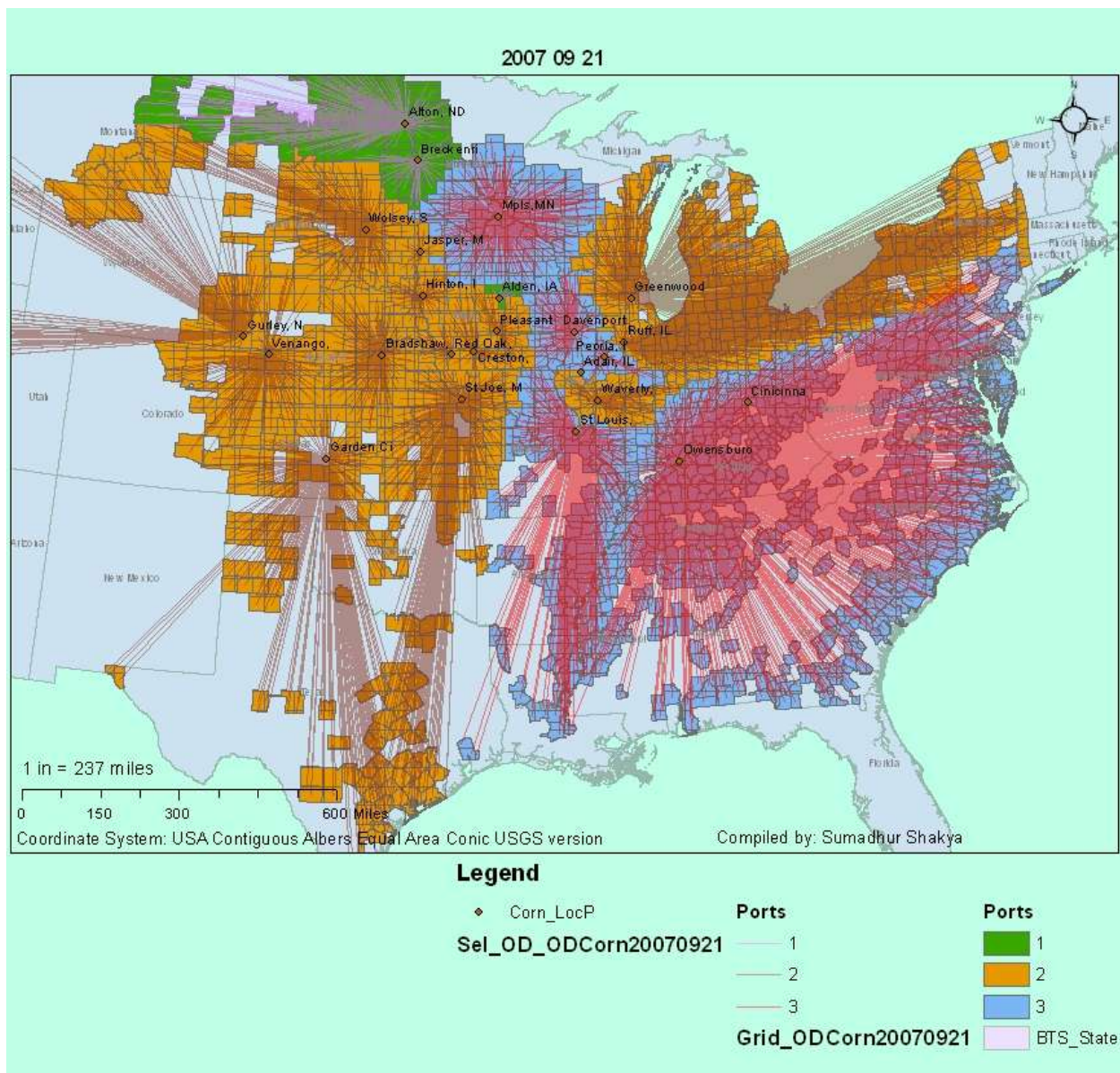


Figure 12 Market Boundaries and Flow of Corn Based on Price of Sept 21, 2007

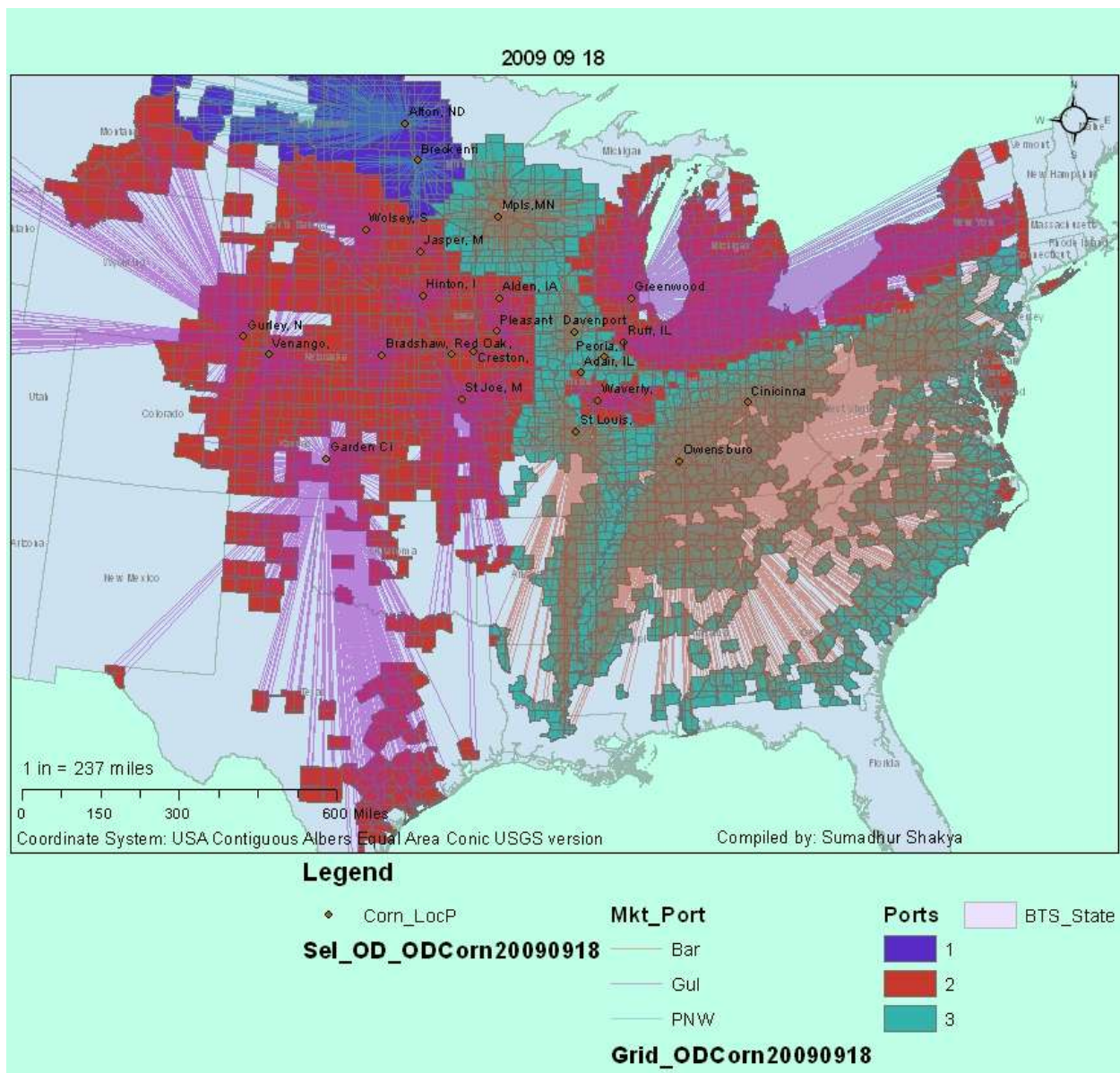


Figure 13 Market Boundaries and Flow of Corn Based on Price of Sept 18, 2009

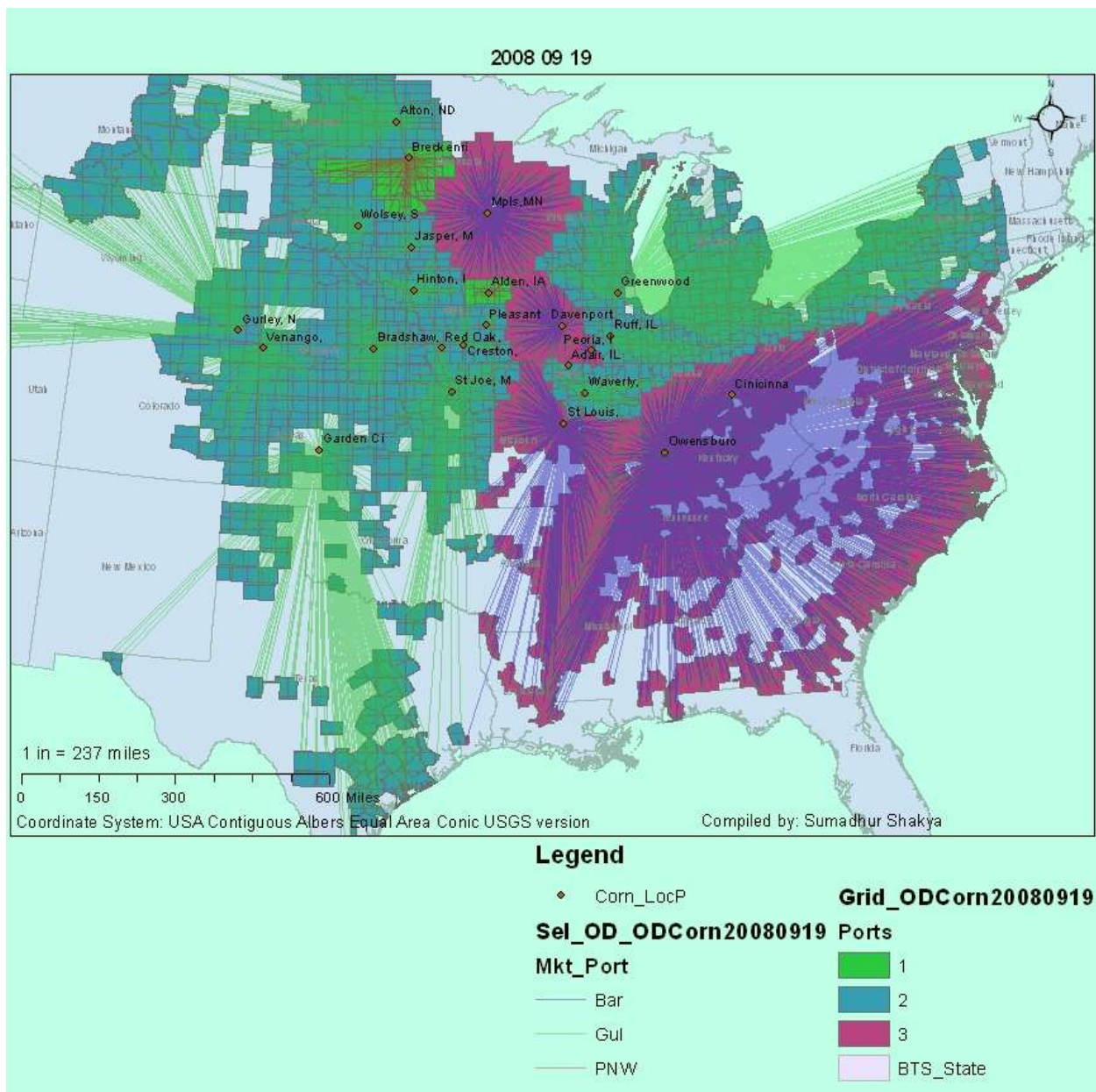


Figure 14 Market Boundaries and Flow of Corn Based on Price of Sept 19, 2008

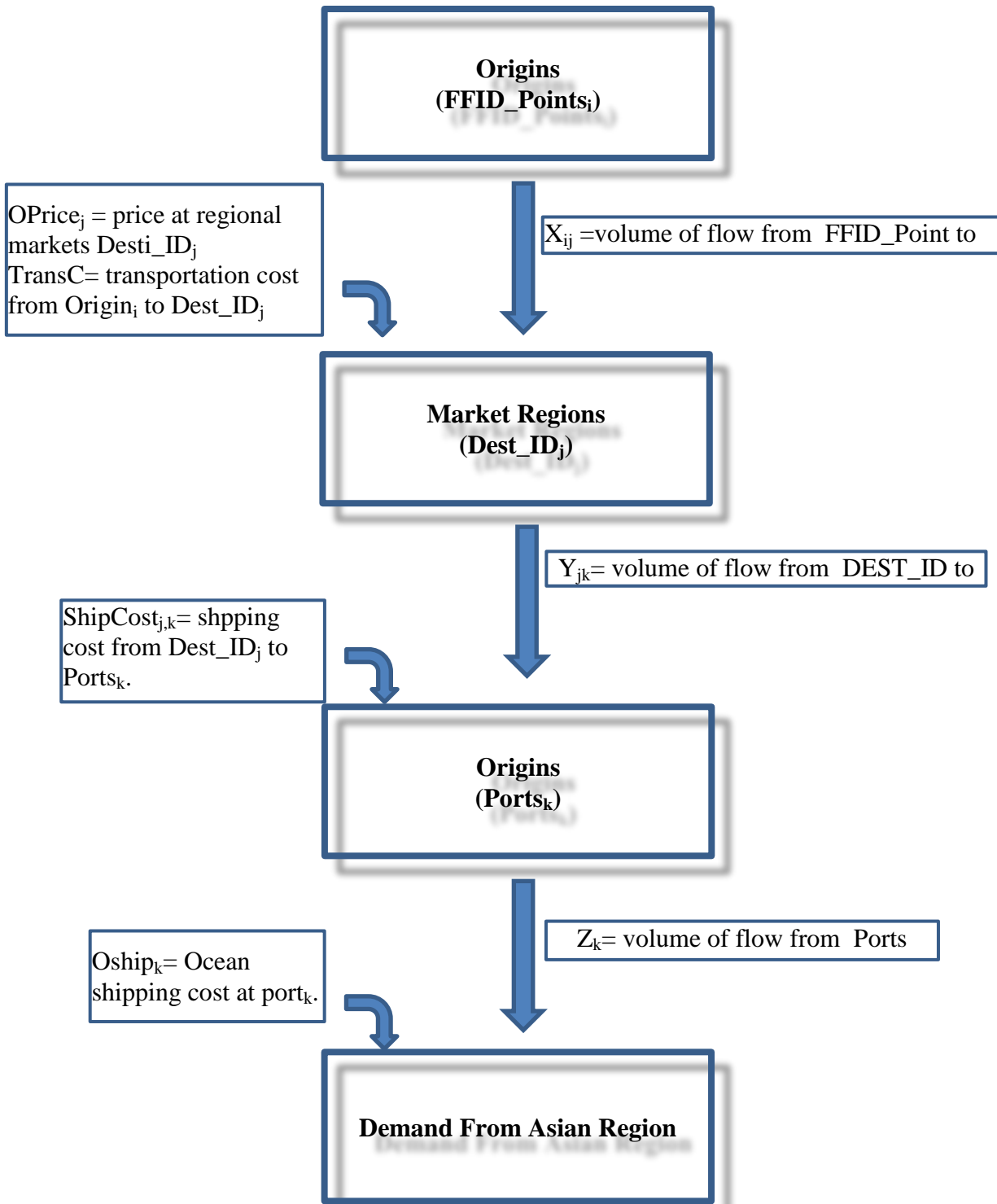


Figure 15 Summary Diagram Showing Optimization Model as Proposed in Equation 1

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