Market Intelligence in Agriculture
Terra-Fresh Project

Xaimarie Hernández Cruz, George Runger, J. Rene Villalobos
International Logistics and Productivity Improvement Laboratory
Arizona State University

http://ilpil.asu.edu, www.terra-fresh.com

Arizona State University

FFAR

NM STATE UNIVERSITY

ILPIL
International Logistics & Productivity Improvement Lab

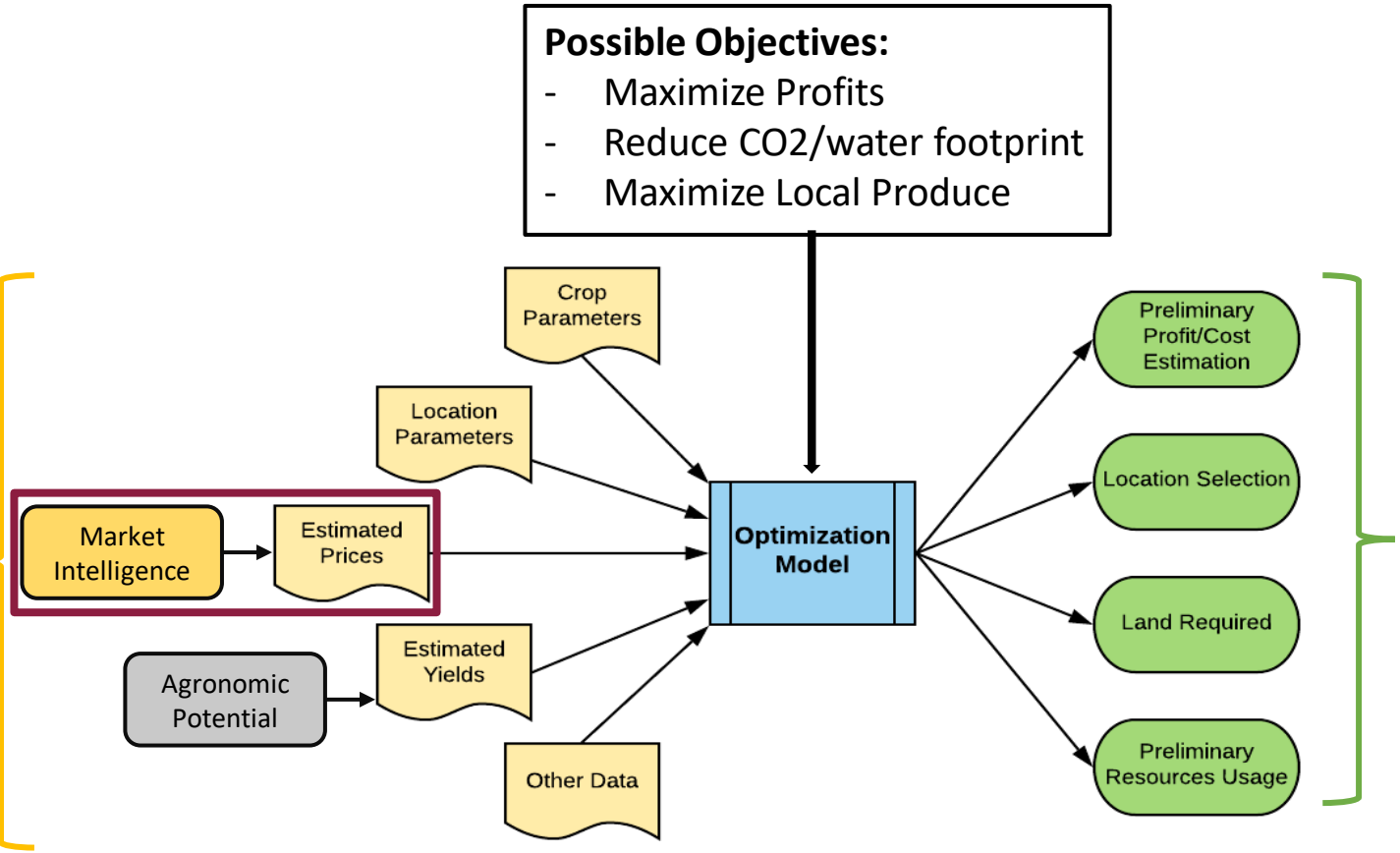
Outline

- Market Intelligence in the Big Picture
- What is Market Intelligence?
- What is a Market Opportunity?
- Opportunity Discovery Goals
- Layer System Framework
- Future Work
- Case Study
  - Goals
  - Crop Basket
  - Locations
  - Celery Market Opportunity
  - Price Prediction
  - Platform Demo
- Summary and Next Steps

Market Intelligence in the Big Picture

Goals:

- Identify and verify the feasibility of pursuing **market opportunities**
- Develop **input data** needed for the optimization planning models



Model Inputs:

Specific parameters that helps modelling the planning process

Model Outputs:

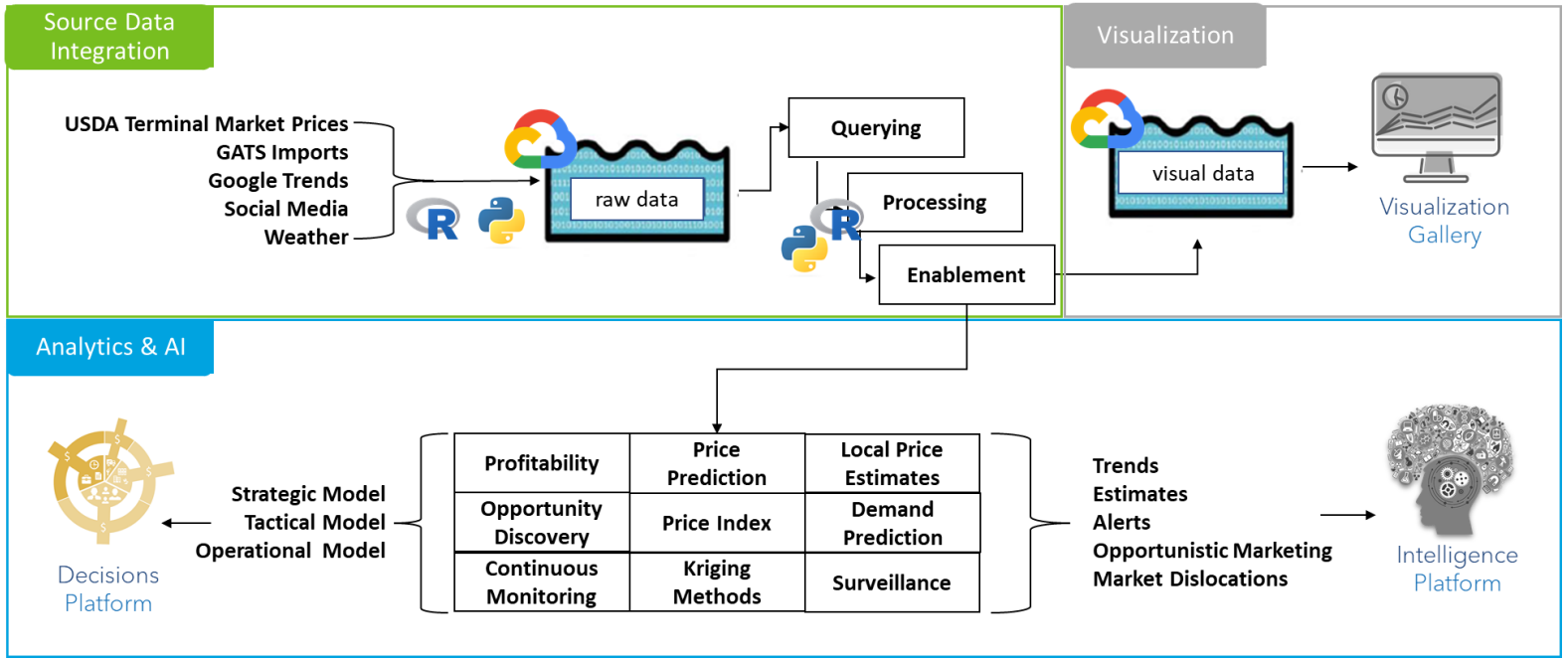
Results that can be used to assist the planning process, depending on the desired objective

What is Market Intelligence?

An integrated intelligence system that continuously assesses relevant market signals to identify and recommend actionable opportunities.

Main Goals:

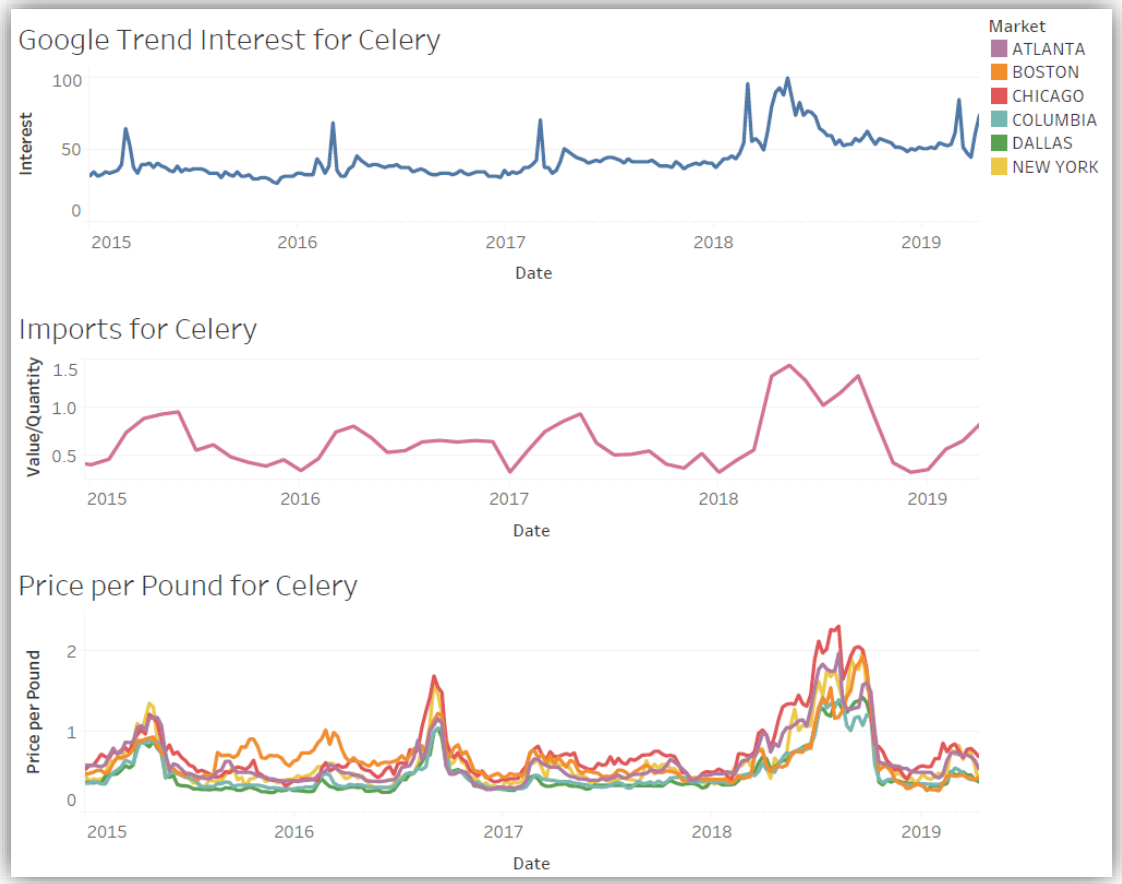
- Continuously access, extract, process, and publish relevant data
- Provide forecasts for planning and coordination model input parameters
- Identify relevant market opportunities and characterize them



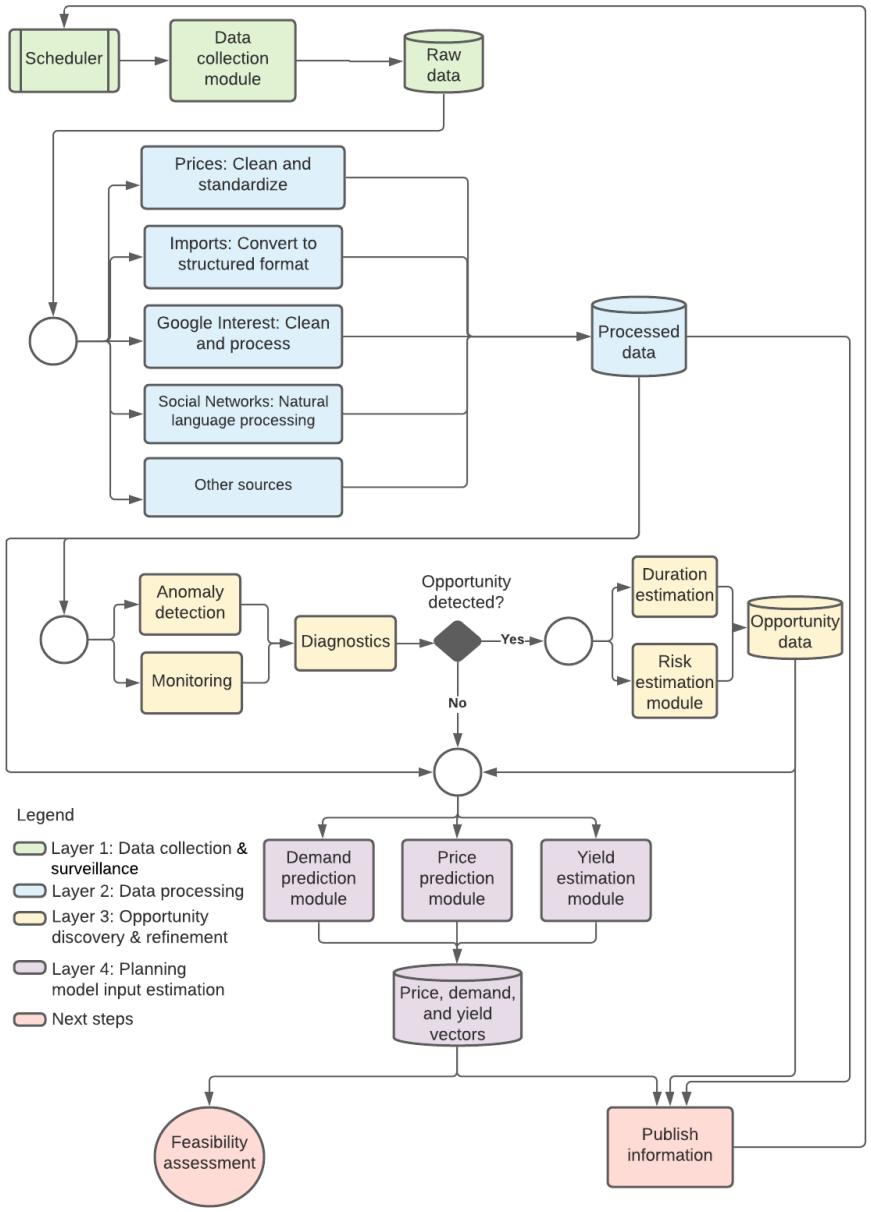
What is a Market Opportunity?

- A market opportunity occurs when a product is required in higher volumes than the norm at a specific time.
  - Causes market prices to increase significantly.

- Leading indicators of such opportunities could be:
  - import data
  - consumer interest
  - weather data
  - others



Opportunity Discovery: Layered System Framework

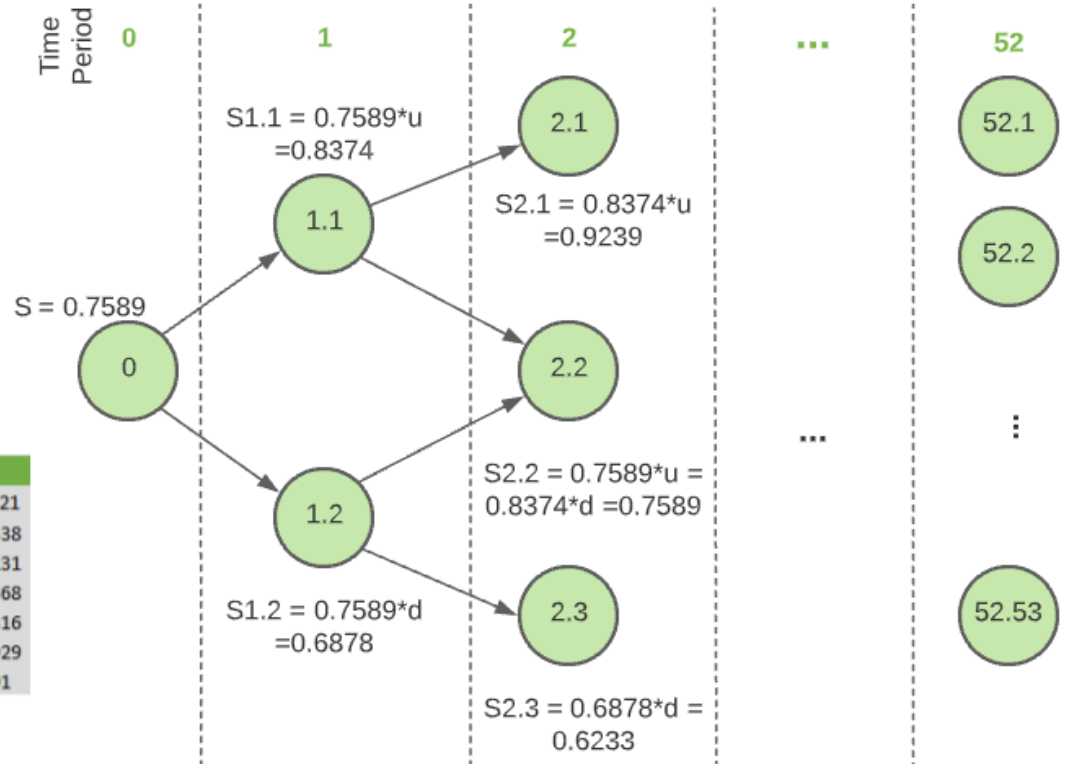


- **Layer 1:** Data collection through APIs and custom adapters, automation, and storage.
- **Layer 2:** Clean and process for each data source with using custom software.
- **Layer 3**: Data monitoring using statistical control methods to detect signals and diagnose them as possible opportunities or false alarms.
- **Layer 4**: Evaluate the opportunity in terms of its estimated duration, risk, and demand generation.

Price Scenarios Determination: Binomial Lattice

- The binomial lattice was used to obtain a 1-year projections for each combination of crop, location, and week.
- This method considers, for each time period the events in which the price increases or decreases.

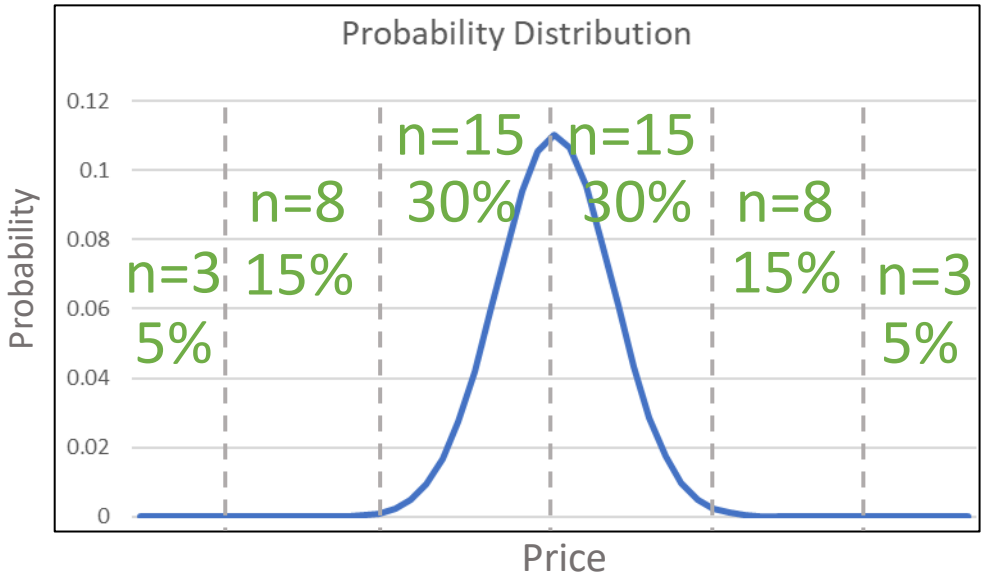
Parameters	
Yearly Avg ln(RoR)	-0.00921
Yearly StDev ln(RoR)	0.709338
Delta_t	0.019231
u	1.103368
d	0.906316
S	0.758929
p	0.4991

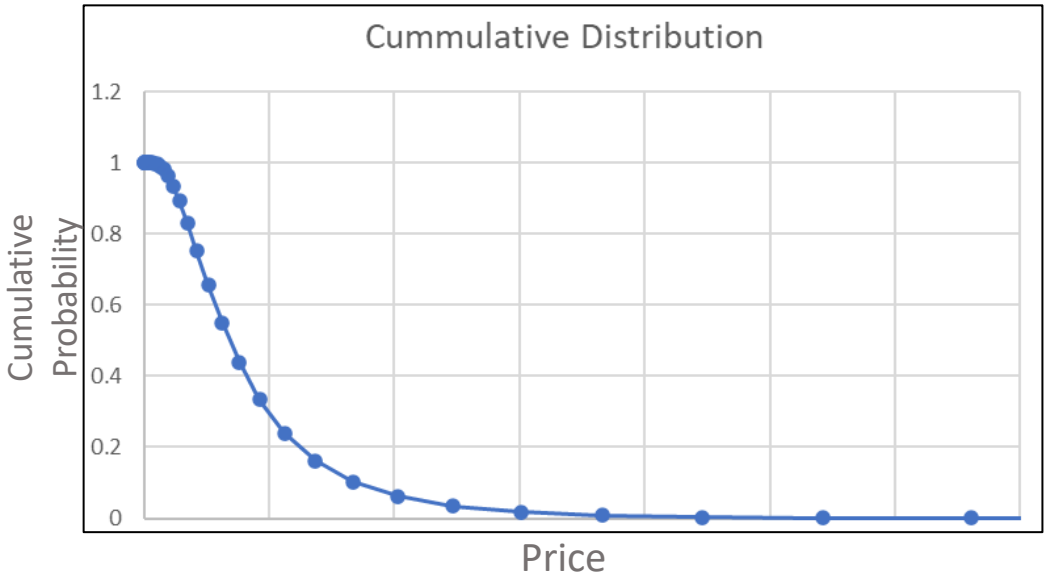


- Results include a total of **53 price estimations** with their respective **probabilities of occurrence**.

Price Scenarios Determination: Stratified Sampling

- Using the results from the binomial lattice, stratified sampling is used to create the price scenarios.
- A total of 50 price scenarios is obtained for each crop, location, and week



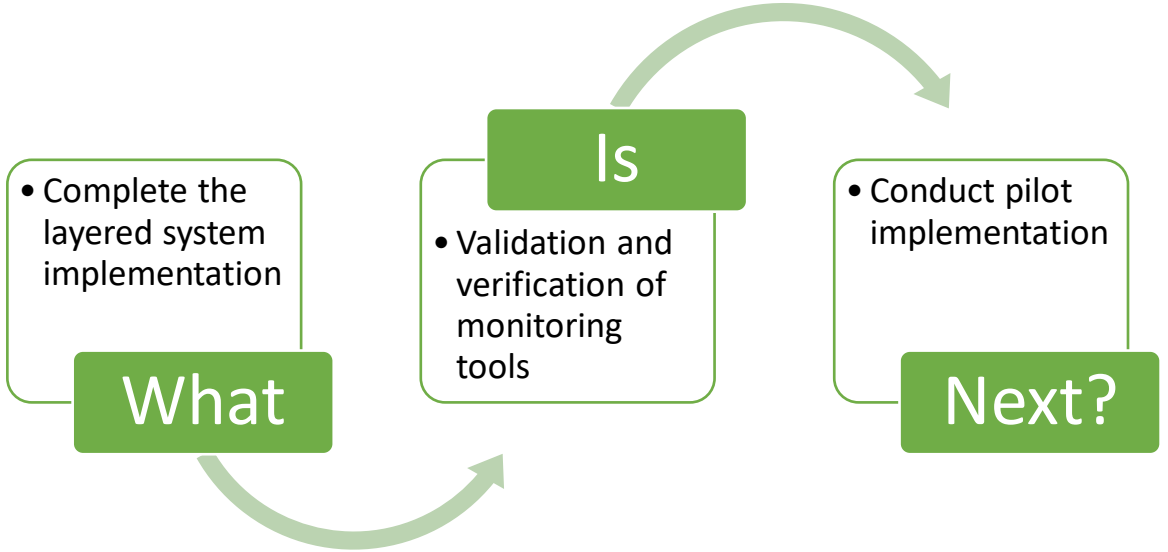


Future Work

Using data-driven tools, a more efficient supply chain that

- better connects the growers with the consumers,
- reduces food waste along the chain, and
- identifies relevant opportunities for growers can be obtained.

The framework and tools presented serve as an initial step towards the inclusion of market intelligence as a mechanism to target promising produce markets and reduce the possibility of scarcity events for highly demanded produce.



Case Study

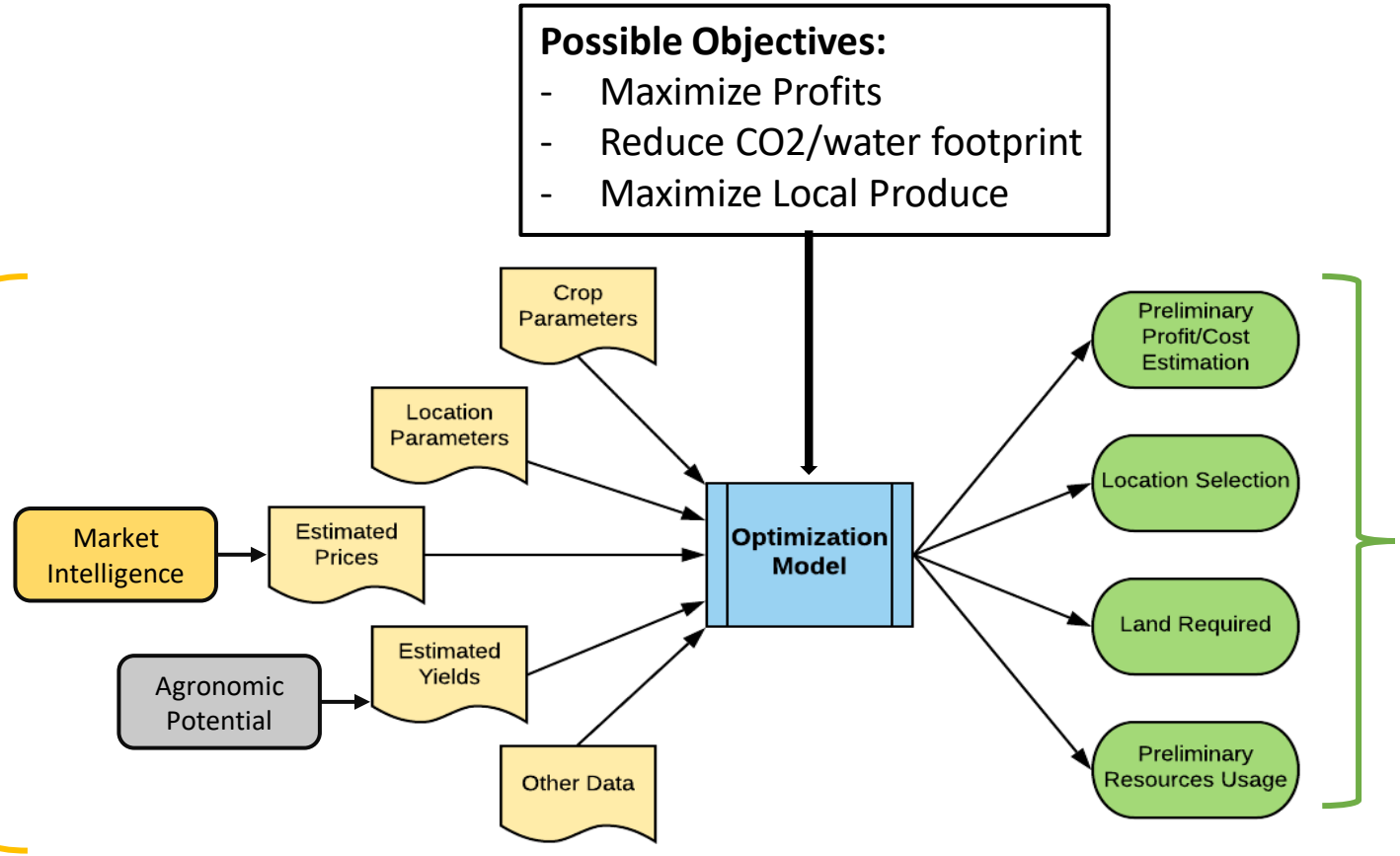
Market Intelligence in the Big Picture

Goals:

- Identify and verify the feasibility of pursuing market opportunities
- Develop input data needed for the optimization planning models

Model Inputs:

Specific parameters that helps modelling the planning process



Model Outputs:

Results that can be used to assist the planning process, depending on the desired objective

Market Intelligence is responsible for deriving the inputs for opportunity and non-opportunity scenarios!

Case Study Description – Cont.

Basket of crops considered:

Bell Peppers

Cauliflower

Celery

Cucumbers

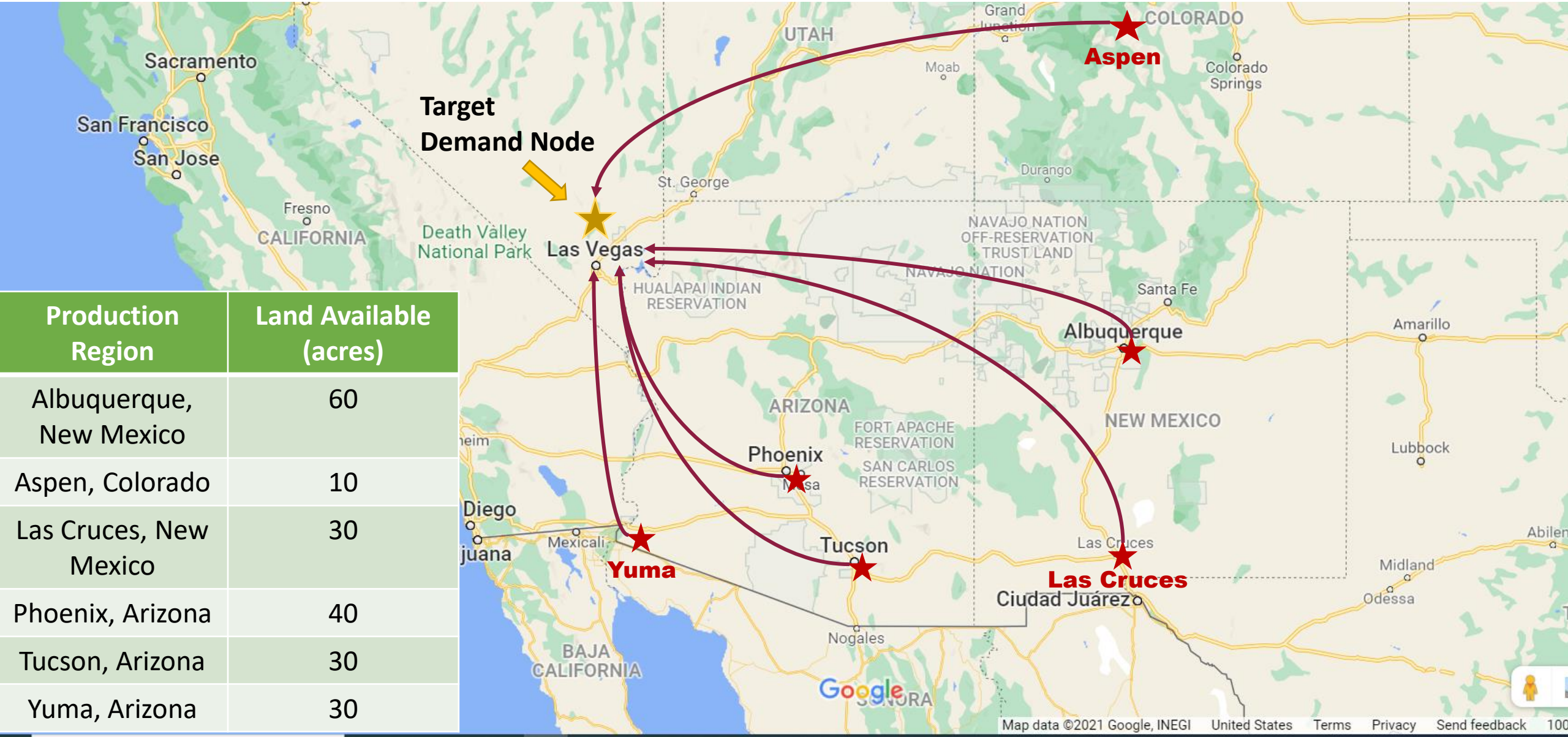
Green Beans

Romaine Lettuce

Roma Tomatoes

Case Study Description – Cont.

Production Region	Land Available (acres)
Albuquerque, New Mexico	60
Aspen, Colorado	10
Las Cruces, New Mexico	30
Phoenix, Arizona	40
Tucson, Arizona	30
Yuma, Arizona	30



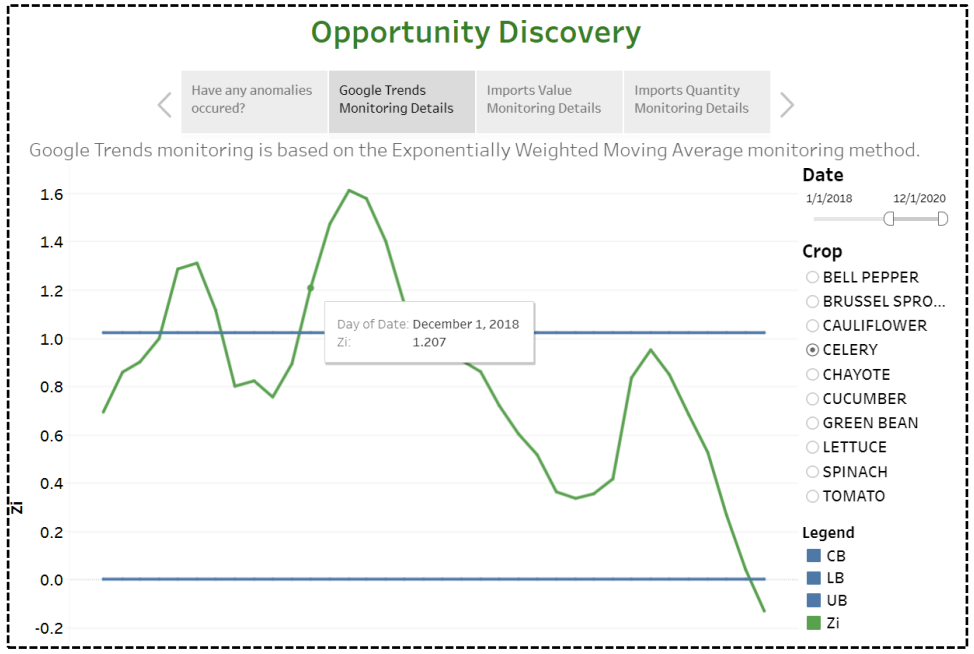
Opportunity Identification

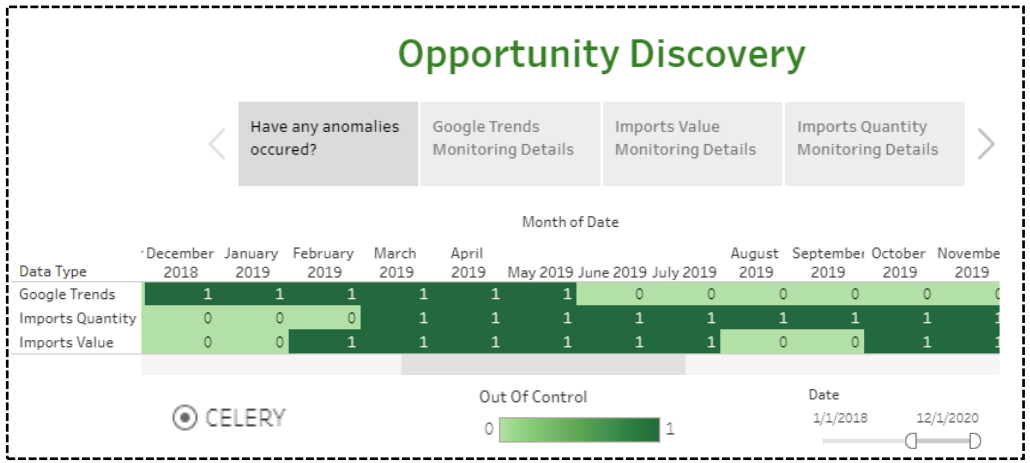
Techniques Used:

- Time series decomposition
- EWMA monitoring

Data Monitored:

- Import Value
- Import Volume
- Google Interest

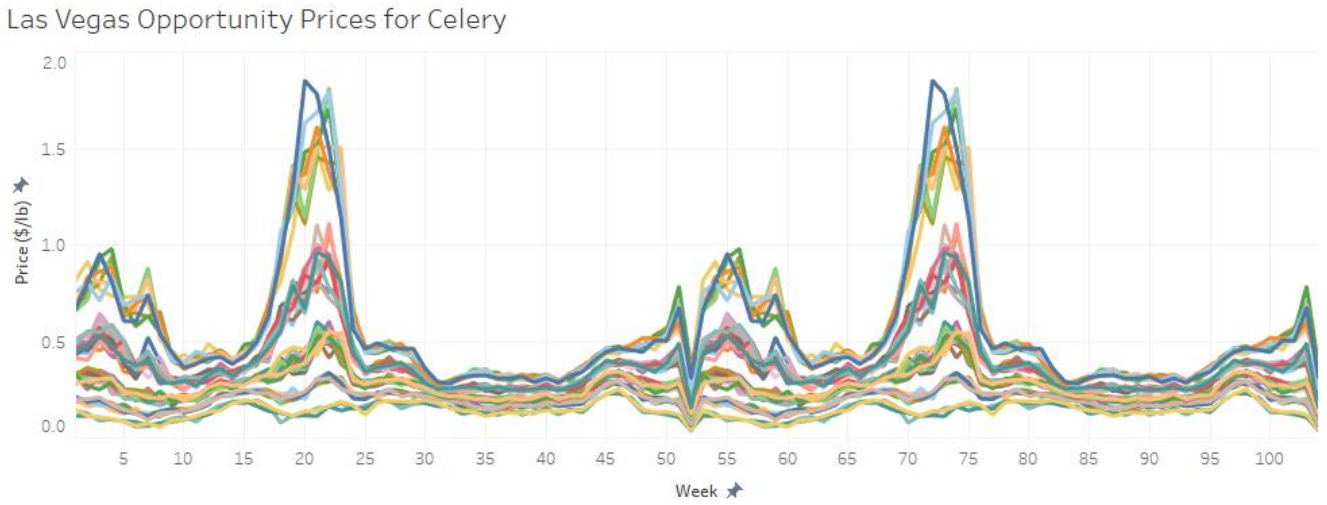


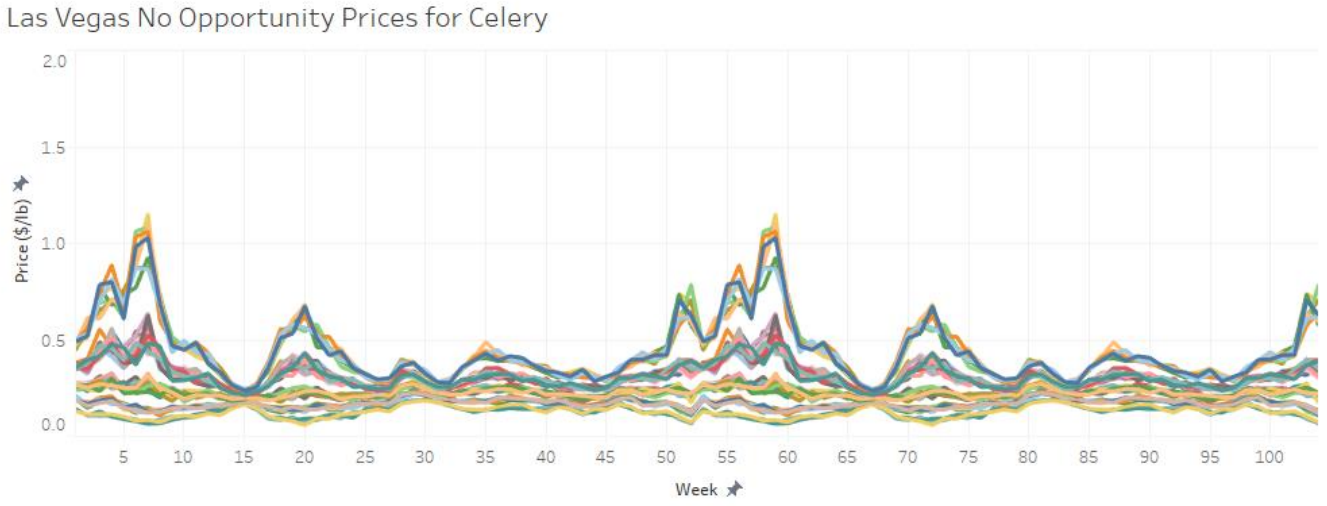


A possible market opportunity was identified for celery!

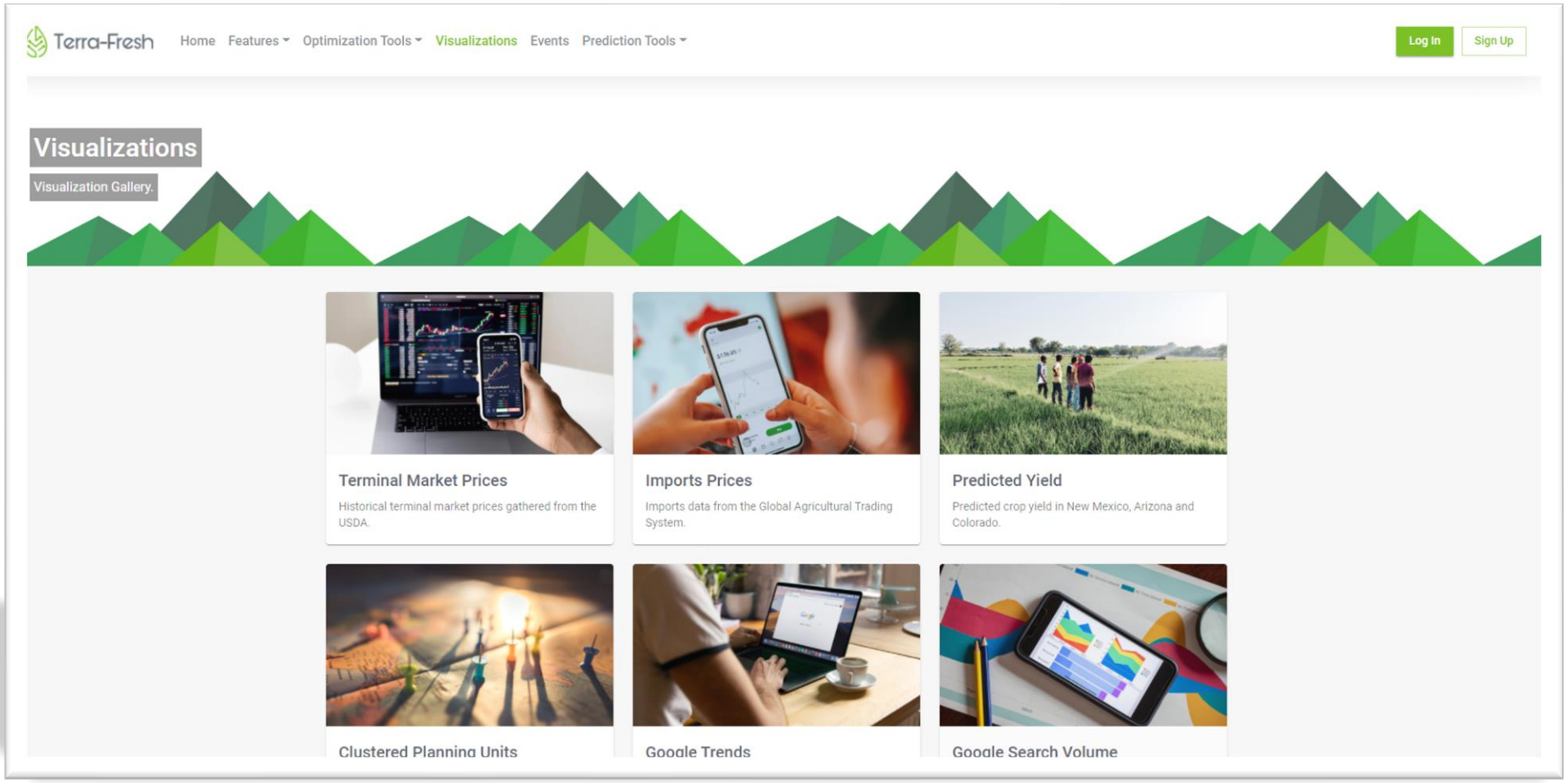
Price Scenarios

- A total of 50 price scenarios were obtained for celery with and without considering the market opportunity for the demand location of Las Vegas.
- The optimization model used this data to consider the variability and uncertainty of future prices.
- All other crops without opportunities also have price predictions for a 2-year range.





Terra-Fresh Platform Demo for Market Intelligence



Summary and Next Steps

Summary:

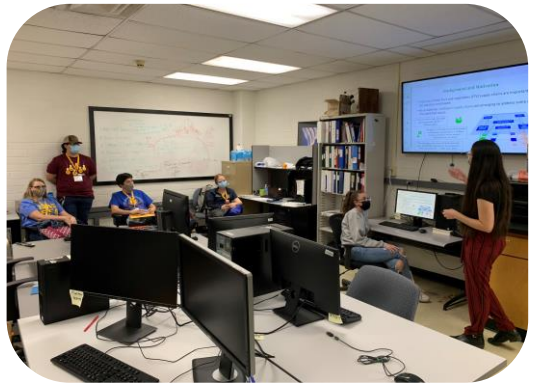
- Discovered a possible market opportunity for celery by monitoring import and Google Trends data
- Predicted prices for the 7 products included in the case study's basket of crops

Next Steps:

- Obtain yield estimates
- Provide demand estimates
- Verify the technical and financial feasibility of pursuing the celery opportunity

Acknowledgements






FFAR Officers: Lucyna Kurtyka, John Reich

ILPIL
International Logistics & Productivity Improvement Lab

FFAR

ASU Team

J. Rene Villalobos
George Runger
Arnie Maltz
Pat Phelan
Rodrigo Ulloa
Xaimarie Hernández Cruz
Grace Neal
Francisca Quijada Dibarrat
Darshil Shaileshkumar Shah
Aryan Bisht
Miguel Peinado
Alexander Eierle

Former ILPIL members

Hector Flores
Omar Ahumada
Octavio Sánchez

NMSU Team

Paul Gutierrez
Madhav Regmi
Chadelle Robinson
Eric Nez

Other Partners

Jim Kallof
Patty Emmert
Paul Cordero
Duncan Family Farms
La Montañita Coop
Sol y Tierra Growers
Local First
Stern Produce
CH Robinson

ASU Arizona State University

NM STATE UNIVERSITY

THANK YOU

Xaimarie Hernández Cruz

xhernan5@asu.edu

George Runger, Ph.D.

george.runger@asu.edu

J. Rene Villalobos, Ph.D.

Rene.Villalobos@asu.edu

Visit Us!

Terra-Fresh

ILPIL

Backup Material

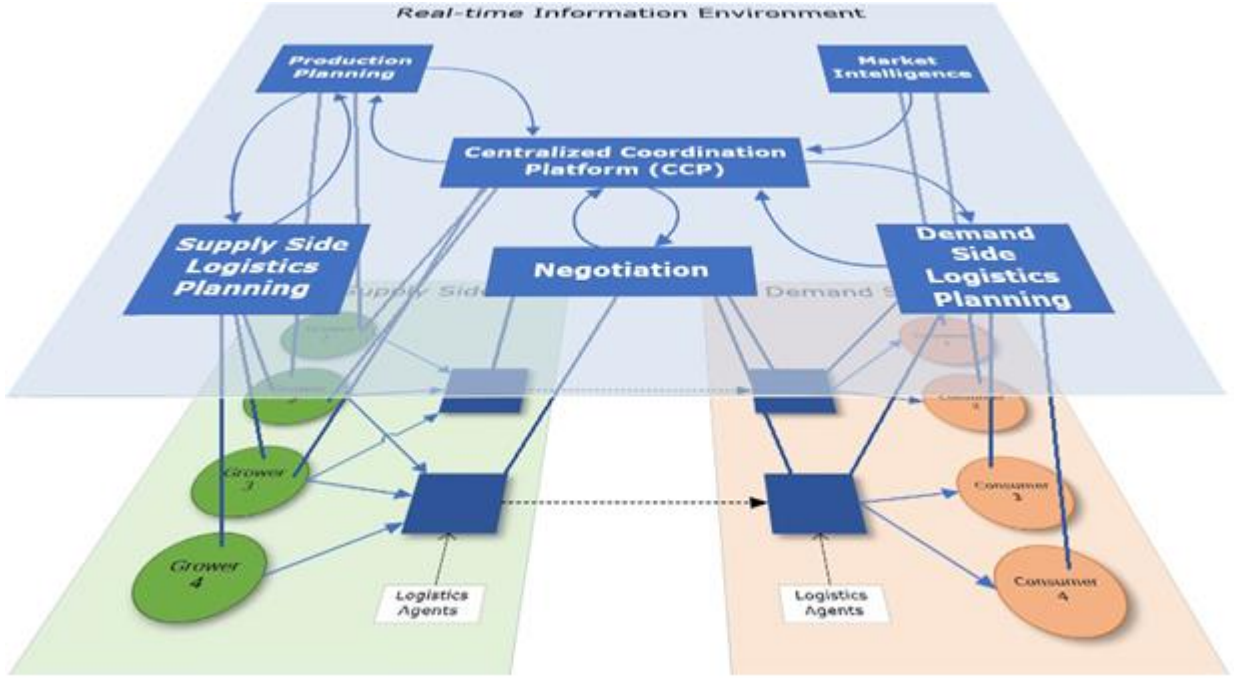
Background and Motivation

- Traditional fresh fruit and vegetables (FFV) supply chains are important for nutrition and health.
- As a response, intelligent supply chains are emerging to address some of the identified issues.

"Out of every $1 sale, the small grower generates $0.20." – (Roberta, 2001)

"Roughly 1/3 of food produced for human consumption, amounting to 1.3 billion tonnes annually, is lost or wasted." - (Gustavsson et al., 2011)

"We find higher prevalence of food insecurity since the COVID-19 pandemic, as compared to before the pandemic."- (Niles et al., 2021)



Terra-Fresh Project

- Fragmented tools have been developed to aid decision making in the FFV agri-business:
  - Planning models
  - Price prediction
  - Yield estimation
  - Opportunistic marketing
- Terra-Fresh projects provides an integrated solution of models for fresh produce supply chains.
- The focus here is market intelligence.

Topic	References
Intelligent Supply Chains	(Villalobos et al., 2019), (Onwude et al., 2020), (Defraeye et al., 2021), (Li, et al., 2006), (Kamble et al., 2020), (Lejarza et al., 2021)
Yield Estimation	(Zhao et al., 2019), (Ferencz et al., 2004), (Quarmby et al., 1993), (Sanchez et al., 2014), (Porter et al., 2000), (Tribouillois et al., 2018)
Price Prediction	(Hernández-Cruz, et al., 2021), (Nassar et al., 2020), (Chaudhary et al., 2021), (Subhasree et al., 2016), (Wang et al., 2014)
Production Planing	(Flores et al., 2019), (Ahumada et al., 2012), (Mason et al., 2015), (Ahumada et al., 2011), (Ahumada et al., 2009)
Market Intelligence	(Flores et al., 2013), (Madaan et al., 2019)

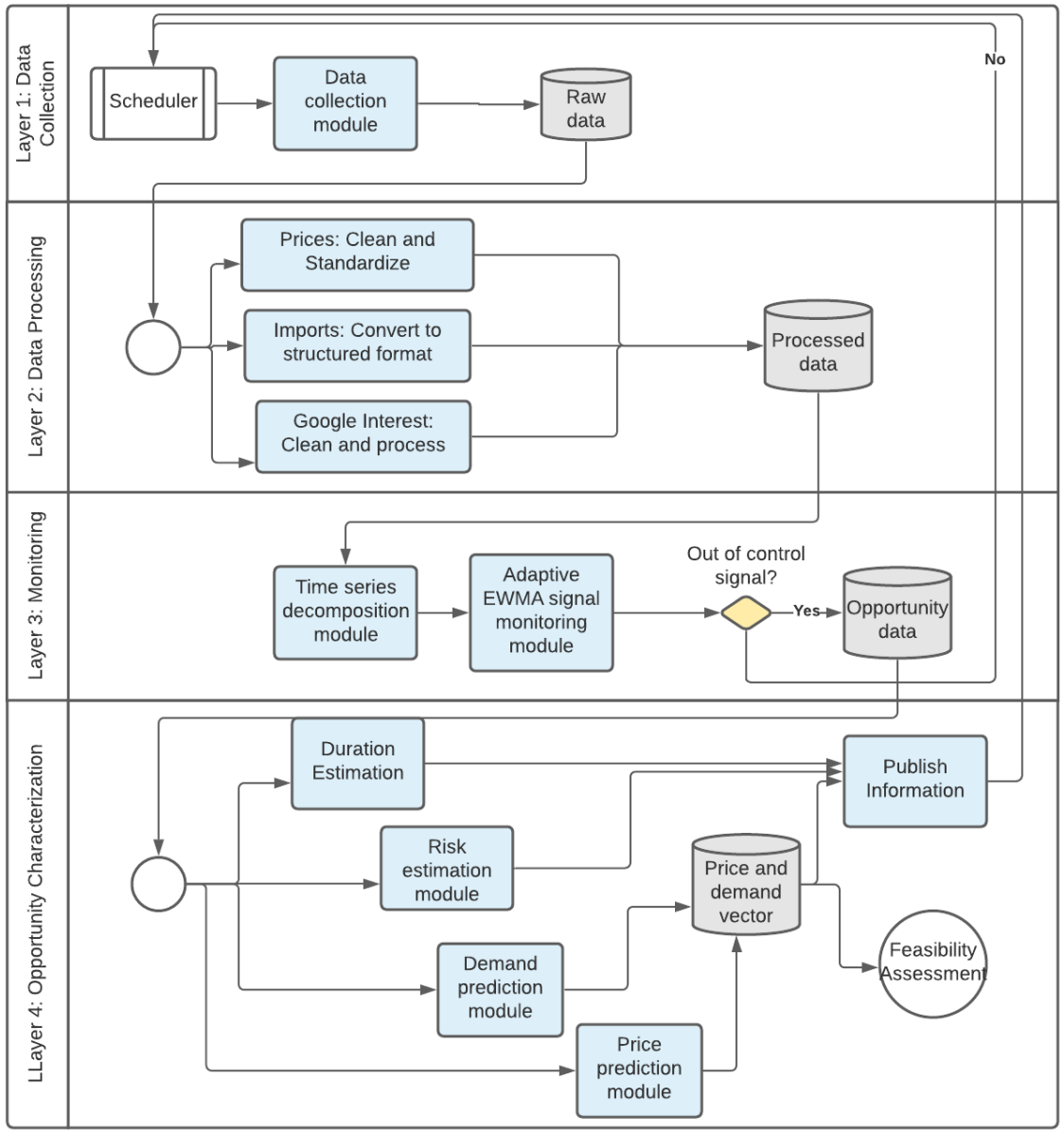
Opportunity Discovery Goals

Detect: Opportunity signals based on leading indicators such as market prices, import value and volume, web data, among others.

Diagnose: Validate, estimate impact and duration and demand generation.

Evaluate: Feasibility of capturing the opportunity in terms of the required resources and provides an estimate of its profitability.

Opportunity Discovery: Layered Systems Approach



- **Layer 1:** Data collection through APIs and custom adapters, automation, and storage.
- **Layer 2:** Clean and process for each data source with using custom software.
- **Layer 3**: Data monitoring using statistical control methods to detect signals and diagnose them as possible opportunities or false alarms.
- **Layer 4**: Evaluate the opportunity in terms of its estimated duration, risk, and demand generation.

Case Study Description

- **Goals**:
  - Optimally allocate the production of a basket of crops amongst several production regions such that profits are maximized
  - Identify and verify the feasibility of pursuing market opportunities
- **Inputs**, What is needed to run the models?
  - Price estimates for the location of interest
  - Demand estimates for the location of interest
  - Yield estimates for the crop basket of interest
  - Production cost estimates for the crop basket of interest
- **Outputs**, What will be obtained from the models?
  - Production allocation for each region
  - Planting and harvesting schedule for each region
  - Profitability analysis for each region

Market Intelligence is responsible for deriving the inputs!

Market Intelligence Implementation Status: Opportunity Discovery

Layer 1

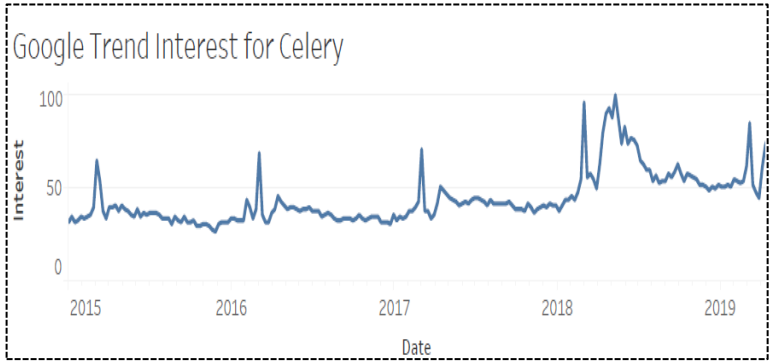
- ☑ Identified relevant indicators.
- ☑ Development of data extraction tools.
- ☑ Process automation via server.

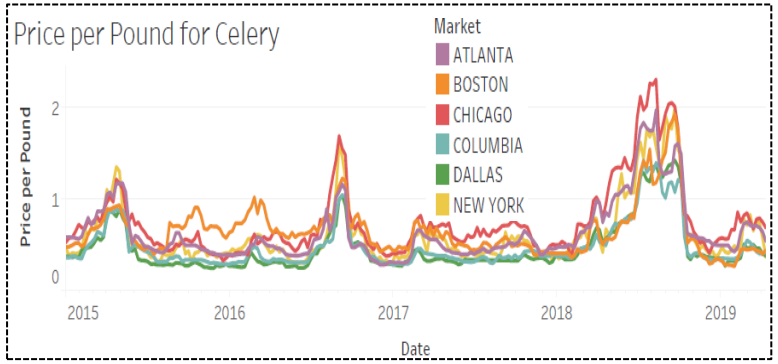
Layer 2

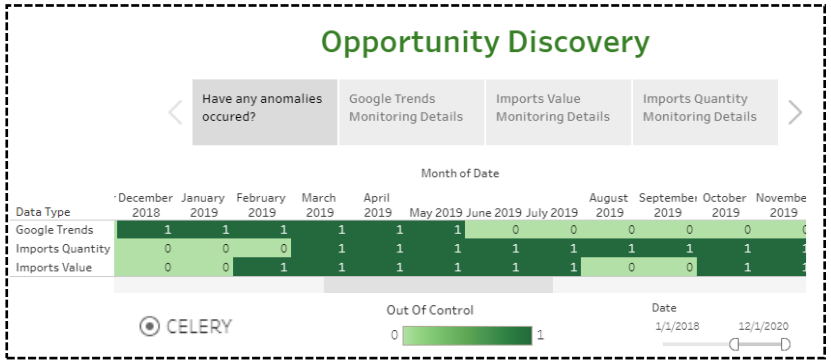
- ☑ Development of processing methods and tools.
- ☑ Process automation via server.
- ☑ Data storage requirements.

Layer 3

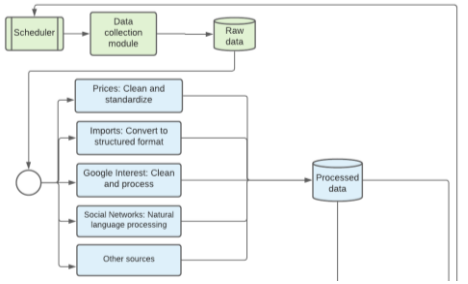
- ☑ Development of statistical monitoring methods.
- ☑ Development of machine learning monitoring methods.
- ☑ Validation and selection of monitoring method.







Layer 1&2: Data Collection and Processing



Implementation Status

Completed Work

- ☑ Identified relevant 5 data sources
  - Terminal Market Prices
  - Google Trends
  - Import Data
  - Temperature and Precipitation
  - Solar Radiation
- ☑ Developed data extraction tools
- ☑ Developed processing methods and tools for 5 data sets.
- ☑ Developed data integrity code for the terminal market prices dataset
- ☑ Automation via server
- ☑ Publication of data through visualization platform

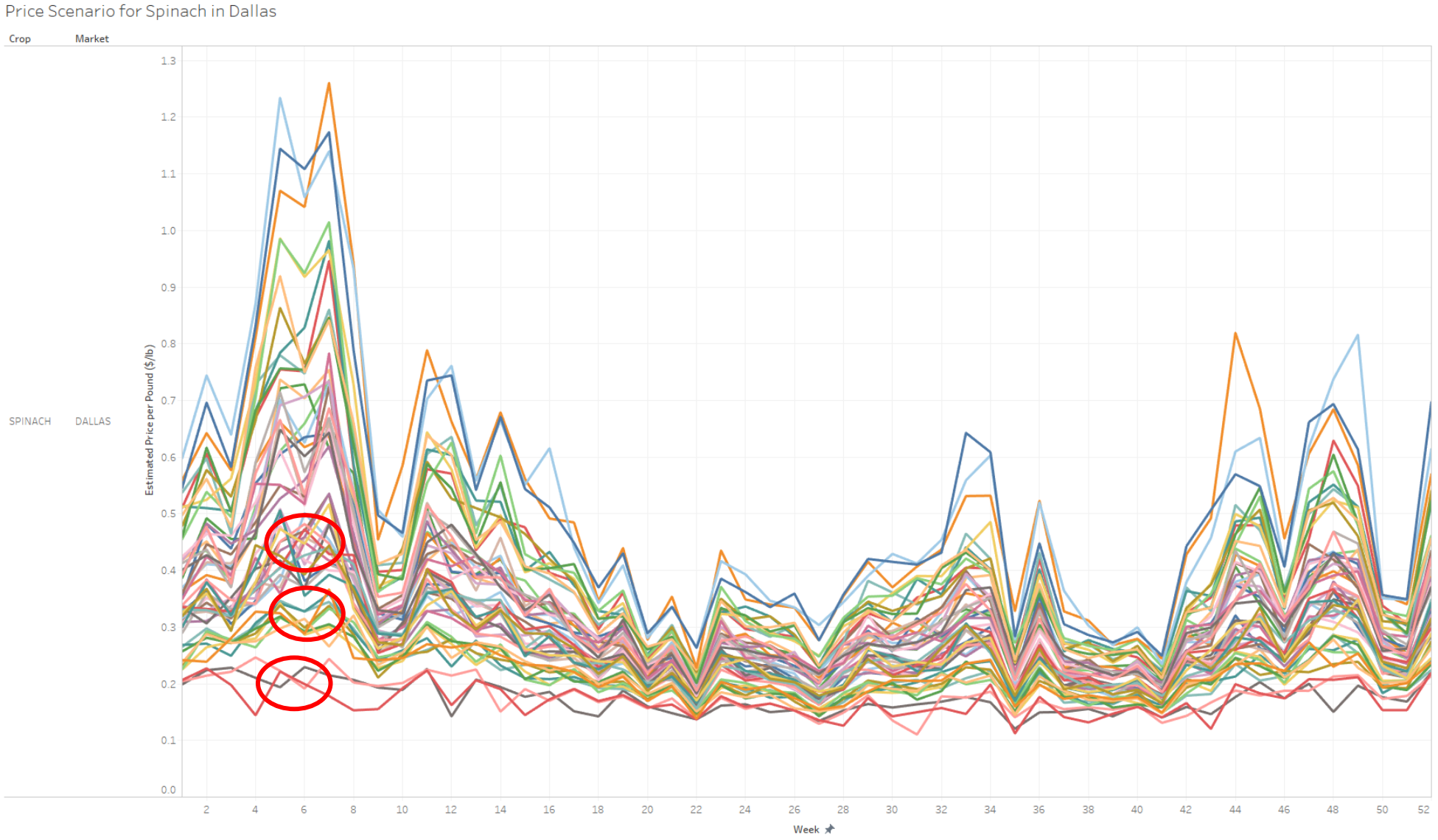
Work In Progress

- ☑ Developing extraction tools for 3 additional data sources
  - Twitter Data
  - Export Data
  - Point of Sale (Kilts)
- ☑ Developing NLP processing tools for Twitter Data

Future Work

- ☑ Automate current work in process data sets via server
- ☑ Identify relevant source of information for transportation and logistics data
- ☑ Add new data visuals and update previous ones to include 2021 data
- ☑ Develop price index

Results


Price Scenario for Spinach in Dallas
Crop
Market
SPINACH
DALLAS
Estimated Price per Pound ($/lb)
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
52
Week