Progress Report Meeting November 20th, 2020

Technology-Enabled, Rapid-Response Fresh Food Supply Chains (TERRa-Fresh) Market Intelligence Workshop

Facilitated by George Runger and Hector Flores

Agenda

- Introductions
- Vision
- Opportunity Discovery Example
- Components of Market Intelligence
- Yield Models
- Visualization
- Conclusions

Introductions

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Vision

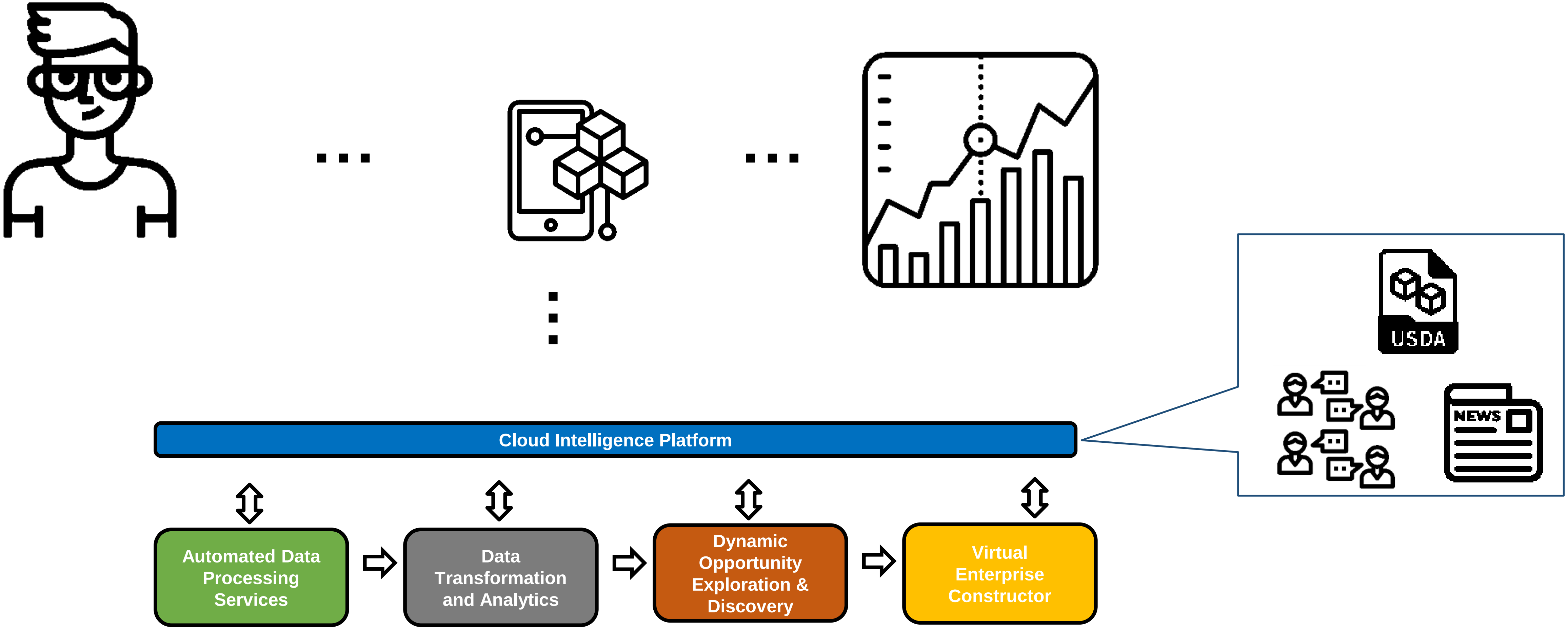
An integrated **intelligence system** continuously assessing relevant market signals to identify and recommend actionable opportunities.

Uber gone agricultural…

Key Components

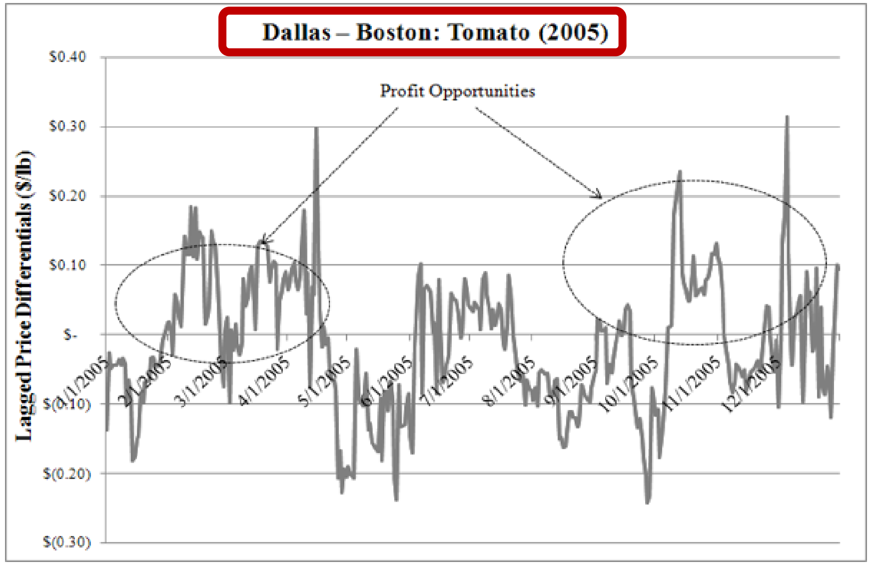
- Customer-centric front-end design
  - ✓ Intuitive and easy-to-use
  - ✓ Clear and transparent transactions
- Efficient and secure back-end systems
  - ✓ Protects sensitive information
  - ✓ Consistent and reliable
- Host for latest AI technologies
- Seamless integration with decision support systems

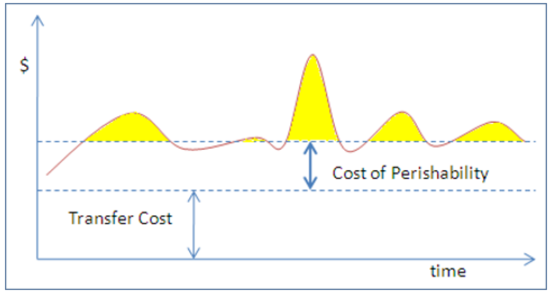
Broad Strokes



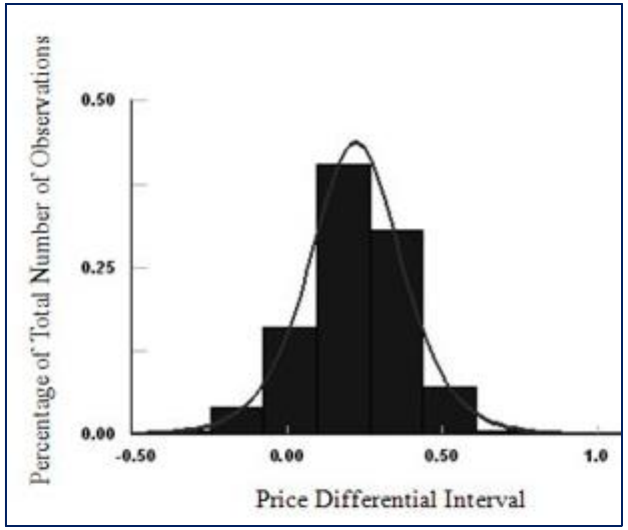
Case in Point: Blast from the Past

Back in 2009…





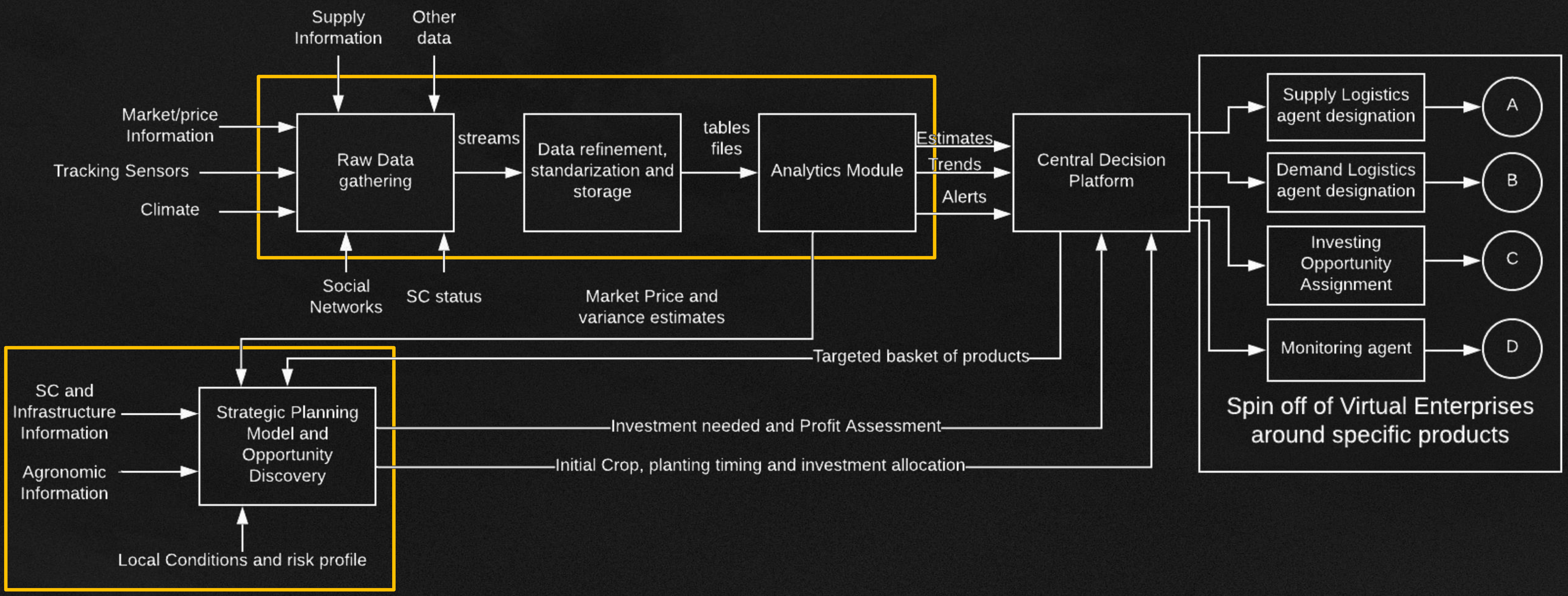
Avg. profit margin: $0.12/lb*



* After applying profit maximization algorithms (in 2009 dollars)

Fast forward to 2020…

High Level View of How it Will Work

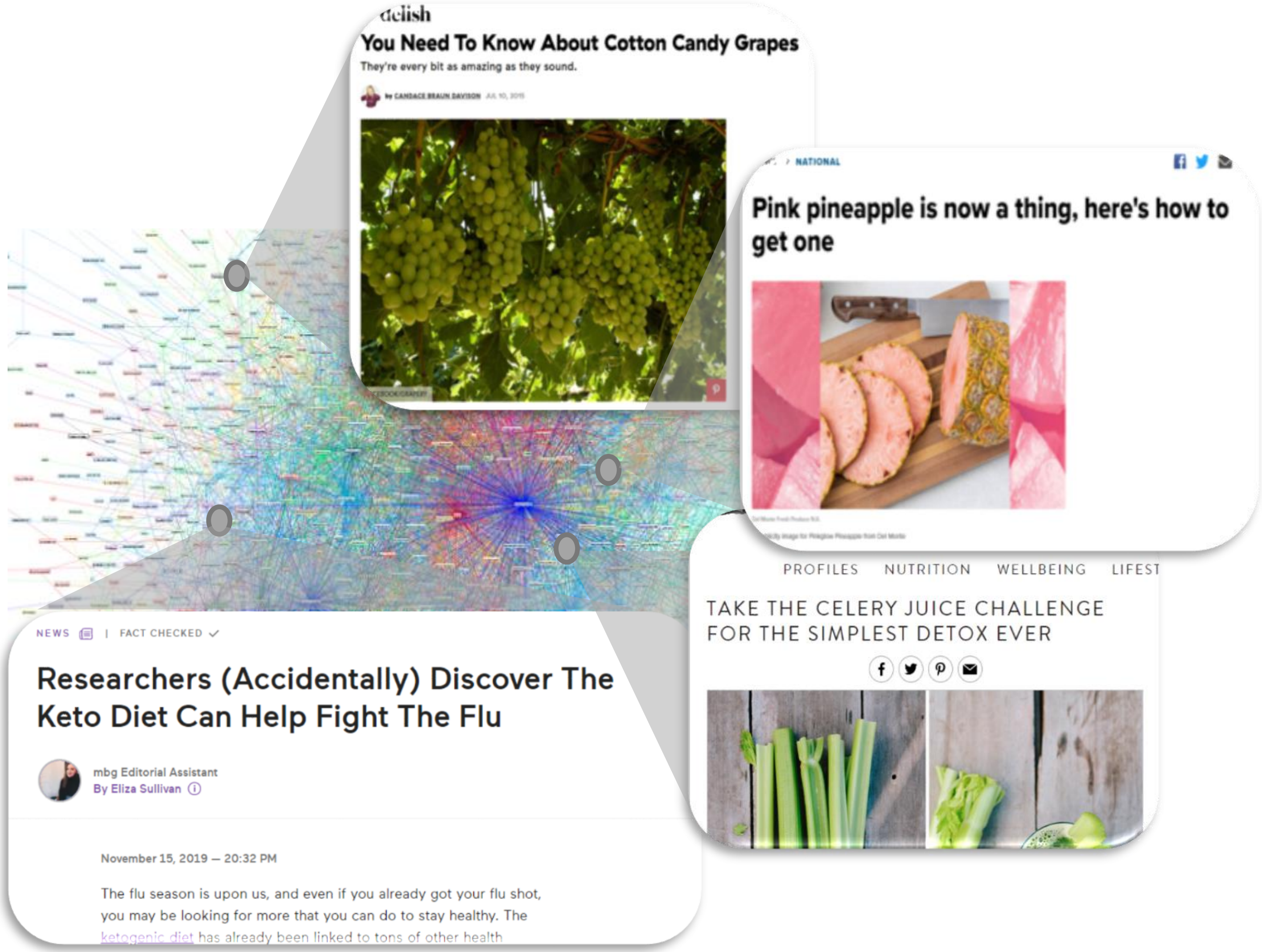


Opportunity Identification

There is a market opportunity when a product is required by consumers at levels significantly higher than usual and there is a shortage of resources to satisfy such a demand.

By monitoring demand and price signals for the current and future market, we can identify opportunities.

Continuous monitoring and surveillance functionalities are employed to identify trends that have the potential to become market opportunities, estimate their duration, and calculate the risk related with the occurrence of these events.



The Celery Juice Challenge

Universe of Web Information:

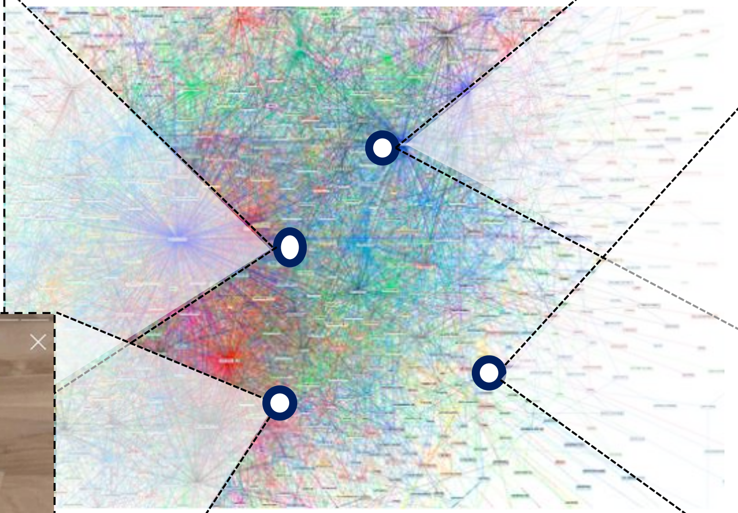

LIVE - February 27, 2019

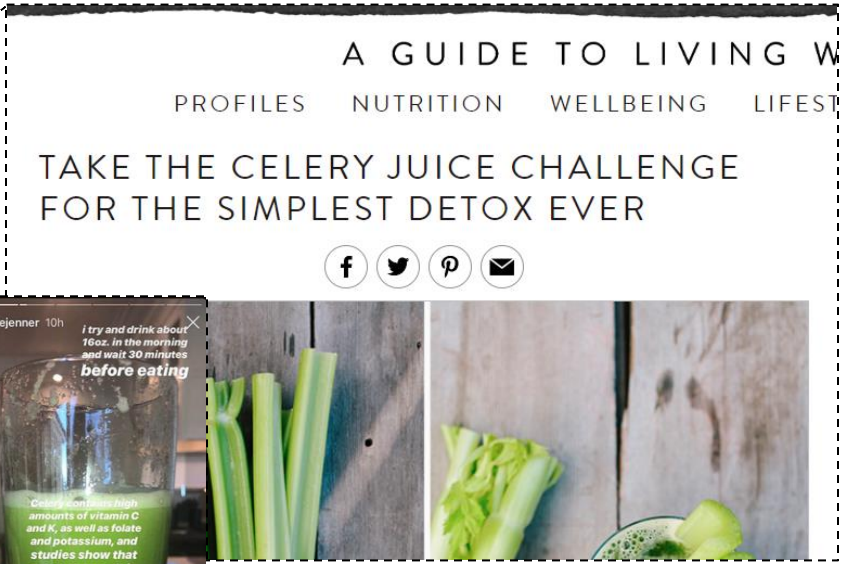
30-Day Celery Juice Challenge Update #30daysmaed

DENISE VASI

Happy 30 Days!! Congratulations and thank you to everyone who went on this challenge with me, here is our celery juice challenge update.

When I **first wrote** about celery juice and the Medical Medium's ideas behin trend, I was pretty skeptical. While I am a self-proclaimed wellness junkie a yourself from the inside out, something about the whole celery juice trend Spring when it first popped up on my radar I thought it was merely another




A GUIDE TO LIVING W

PROFILES NUTRITION WELLBEING LIFEST

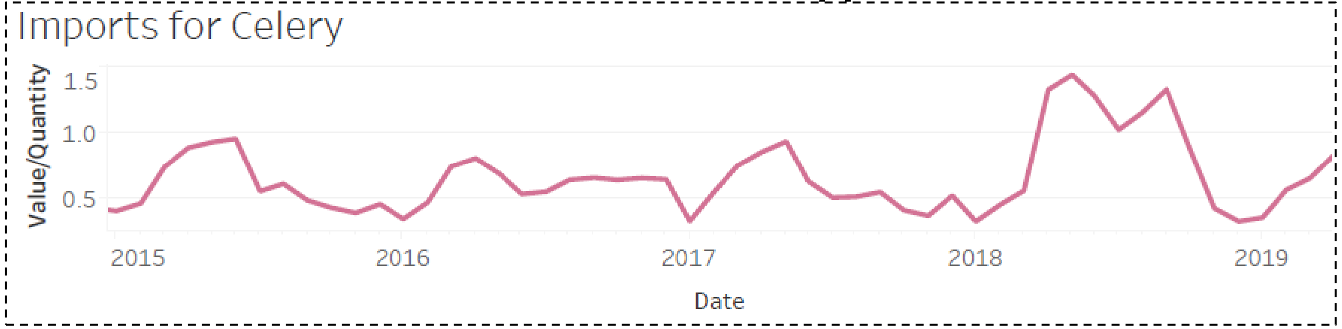
TAKE THE CELERY JUICE CHALLENGE FOR THE SIMPLEST DETOX EVER

What kind of insights can be obtained from online presence?

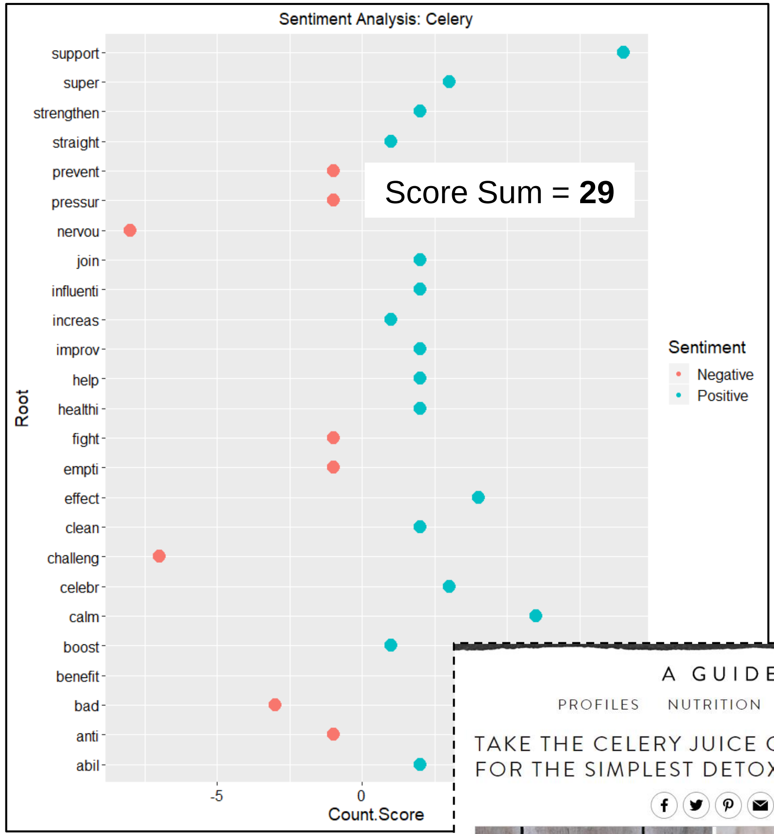
What Data Can We Use and How?

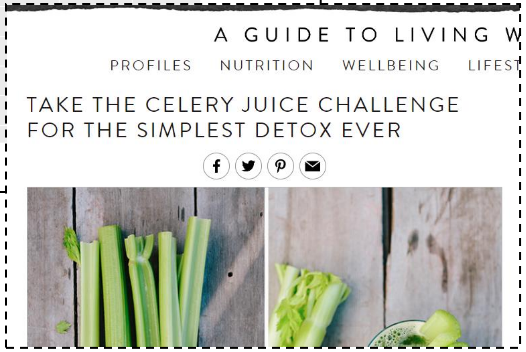
What is the online presence saying?

What other indicators support this?



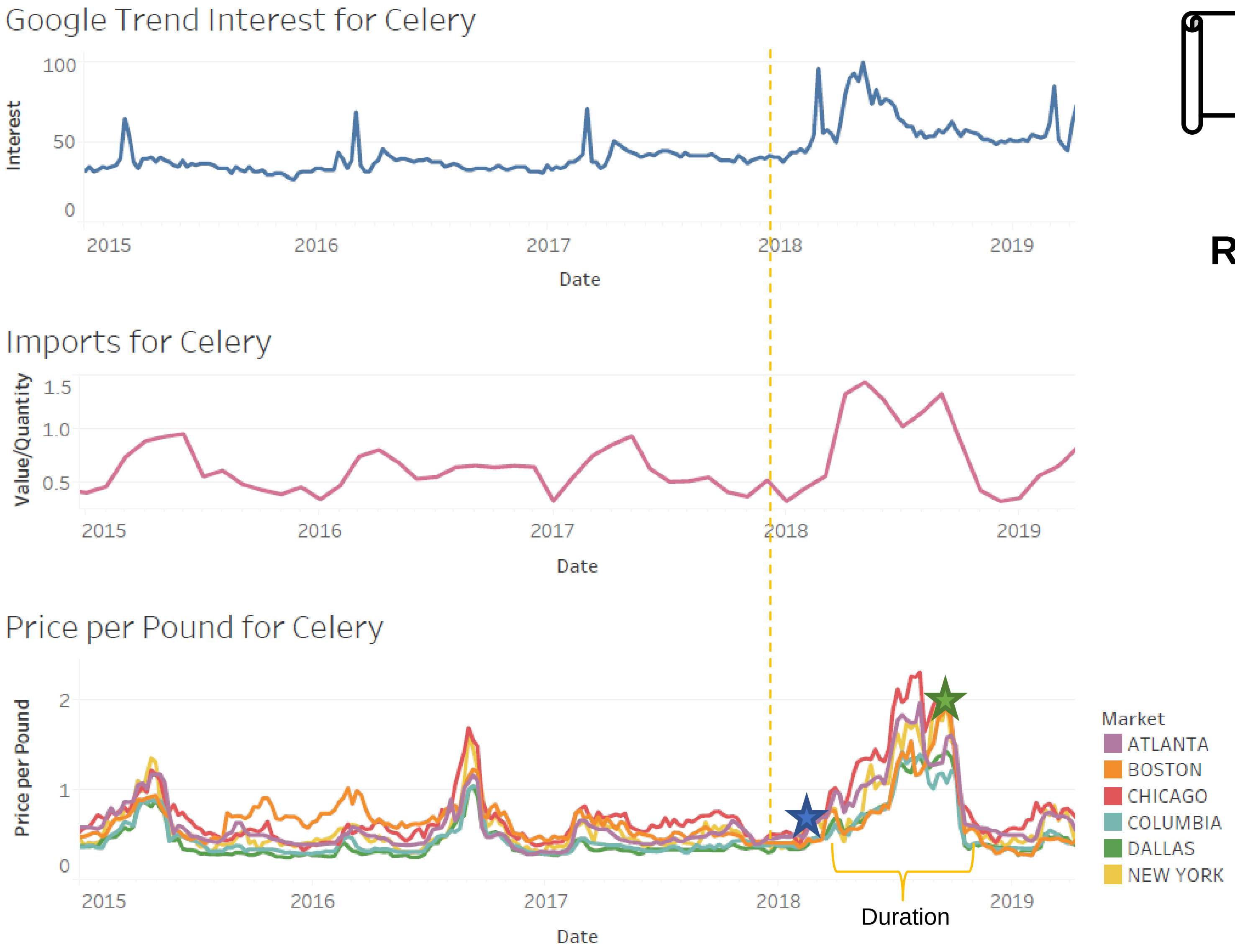
How do we know the polarity of interest?





Other data sources?

Characterizing the Opportunity



To characterize the opportunity we need ***duration, profit, and risk measures.***

An opportunity was identified and characterized. Is it feasible?

Components of Market Intelligence

Data Gathering

Data Source Identification
Data Download
Storage Creation
Processing Codes

Analytics

Price Prediction Models
Profitability Analysis
Yield Models
Surveillance

Visualizations

Data Summaries
Analyzed Data Visuals
Intelligence Visuals
Platform Creation

Data Gathering, Data-to-Information, and Centralization

1. Semi-continuous collection, standardization, and storage of relevant data
   - Market news APIs (e.g. *https://www.ams.usda.gov/datasets/apis-open-data*)
   - Climate data repository APIs (e.g. *https://graphical.weather.gov/xml/rest.php*)
   - Social and web-based APIs
2. Data transformation to continuous intelligent signals (e.g. trends, predictions, anomalies, etc.)
3. Data and intelligence uploads to a cloud-based centralized platform

Construction of Short/Long Term Supply Chain Opportunities

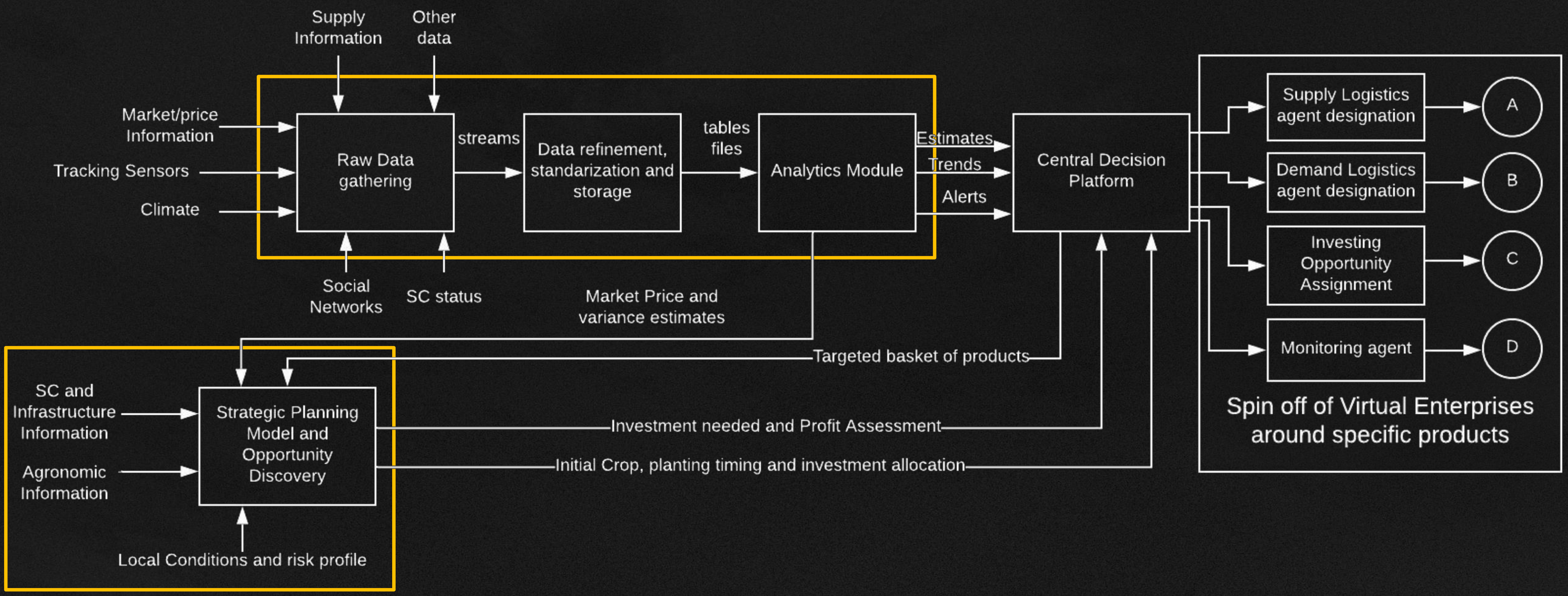
4. Continuously construct and assess different supply chain options formed by temporal market, climate, and logistics conditions at different levels
   - Strategic (i.e. long-term opportunities that require careful development and implementation)
   - Tactical (i.e. seasonal contracts given by mid-term temporal conditions)
   - Operational (i.e. one-time transaction opportunities given by market dislocations)
5. Identification of potential:
   - Demand agents (e.g. product specs, service level and logistics requirements)
   - Supply agents (e.g. producing regions, infrastructure, and logistic links)
   - Negotiation agents (e.g. speculator investment entities, brokerage)
6. Profitability estimations for parties involved (including risk mark-up costs)

Deployment of Transaction Opportunities to Centralized Decision Platform

7. Constructed supply chain options, which includes a description of temporal production, market, and logistics conditions, as well as estimated profitability

8. Continuous monitoring of the state of supply chain
    - Using real time information detect anomalies in echelons of the supply chain, recommend recovery procedures
    - Get metrics for continuous improvement of the supply chain

High Level View of How it Will Work



Analytics

Price Prediction

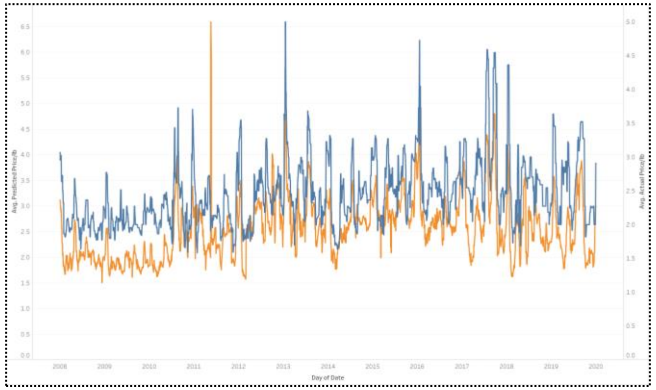
Prediction of non-terminal market prices for crops using a Gaussian Regression Random Field approach.

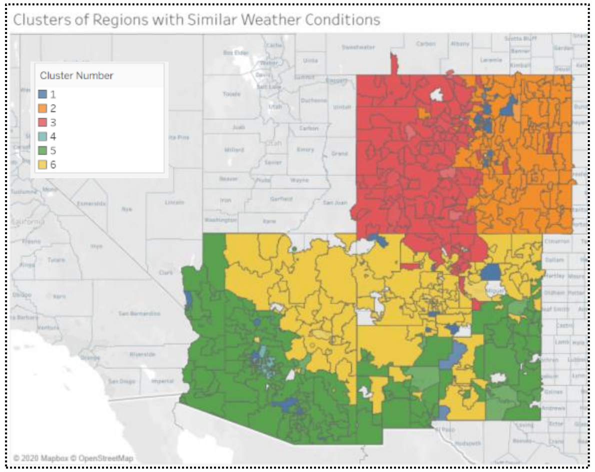
Cluster Analysis

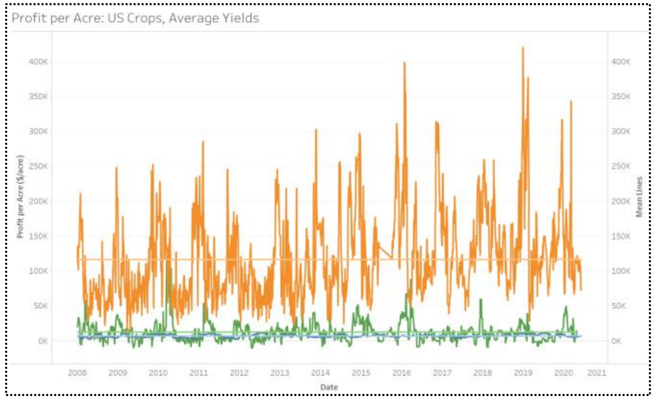
Identifying 4-digit zip code regions with similar temperature, precipitation, and radiation patterns.

Profit Analysis

Profit estimation using predicted prices, transportation costs, and crop budget costs.







Analytics: A SIMPLE Crop Model

- Simple generic crop model (SIMPLE) developed by Zhao et al. (2019) is used to predict crop yield.
- Inputs for SIMPLE model includes crop-specific parameters, daily weather data, and water availability.
- Following Zhao et al. (2019), daily biomass growth rate $(Biomass_{rate})$ is estimated as:

$$Biomass_{rate} = Radition \times fSolar \times RUE \times f(CO_2) \times f(Temp) \times \min(f(Heat), f(Water))$$

- $fSolar$ is the fraction of solar radiation ($Radition$) intercepted by a crop canopy.
- RUE is the radiation use efficiency. [=1]
- $f(CO_2)$ measures the CO2 impact on biomass growth. [=1]
- $f(Temp)$ measures the temperature impact on biomass growth.
- $f(Heat)$ measures the heat stress on biomass growth.
- $f(Water)$ measures the heat stress on biomass growth. [=1]

SIMPLE Model Parameters and Inputs

$$Biomass_{rate} = Radition \times fSolar \times RUE \times f(CO_2) \times f(Temp) \times \min(f(Heat), f(Water))$$

$$Solar = \begin{cases} \frac{fSolar\_max}{1+e^{-0.01\times(TT-I50A)}}, & leaf\ growth\ period \\ \frac{fSolar\_max}{1+e^{0.01\times(TT-(Tsum-I50B))}}, & leaf\ senescence\ period \end{cases}$$

- I_{50A} is the cumulative temperature required to intercept 50% of solar radiation during canopy closure [=520].
- I_{50A} is the cumulative temperature required to 50% of radiation interception during canopy senescence [=400].

$$f(Temp) = \begin{cases} 0 & T < T_{base} \\ \frac{T-T_{base}}{T_{opt}-T_{base}} & T_{base} \le T < T_{opt} \\ 1 & T \ge T_{opt} \end{cases}$$

$$f(heat) = \begin{cases} 1 & T_{max} \le T_{heat} \\ 1 - \frac{T_{max}-T_{heat}}{T_{extreme}-T_{heat}} & T_{heat} < T_{max} \le T_{extreme} \\ 0 & T_{max} > T_{extreme} \end{cases}$$

Crop Name	Harvest Index	T_base	T_opt	T_heat	T_extreme	Dry Matter
Tomato	0.68	6	26	32	45	6%
Lettuce	0.68	6	26	32	45	10%
Celery	0.68	11	31	37	50	6%
Bell Pepper	0.68	11	31	37	50	8%
Carrot	0.7	6	26	32	45	12%
Cucumber	0.68	11	31	37	50	4%
Onion	0.85	6	26	32	45	10%
Green Bean	0.4	11	31	37	50	10%
Cauliflower	0.68	6	26	32	45	8%

- T_{base} and T_{opt} are the base and optimal temperature for biomass growth.
- T_{max}, T_{heat} and $T_{extreme}$ respectively represents daily maximum temperature, temperature threshold when biomass growth rate starts to reduced by heat stress, and temperature threshold when biomass growth rate rate reaches 0 due to heat stress.

Estimating Yield using SIMPLE Crop Model

- The cumulative biomass until i^{th} day becomes:

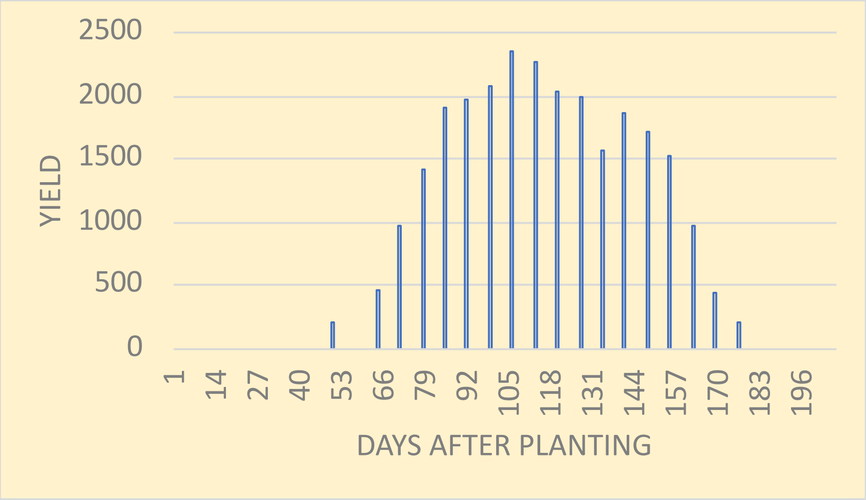
$$Biomass\_cum_{i+1} = Biomass\_cum_i + Biomass\_rate$$

- Finally, the total crop yield can be predicted as:

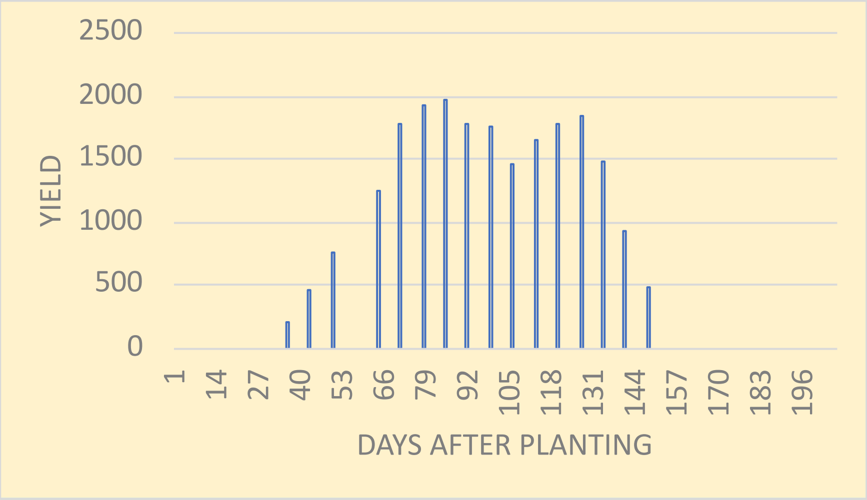
$$Yield = Biomass\_cum_{maturity} \times Harvest\ Index$$

Predicted Yields for Tomato in Las Cruces

Planting Date : Feb 4 (Total Yield: 26,347)

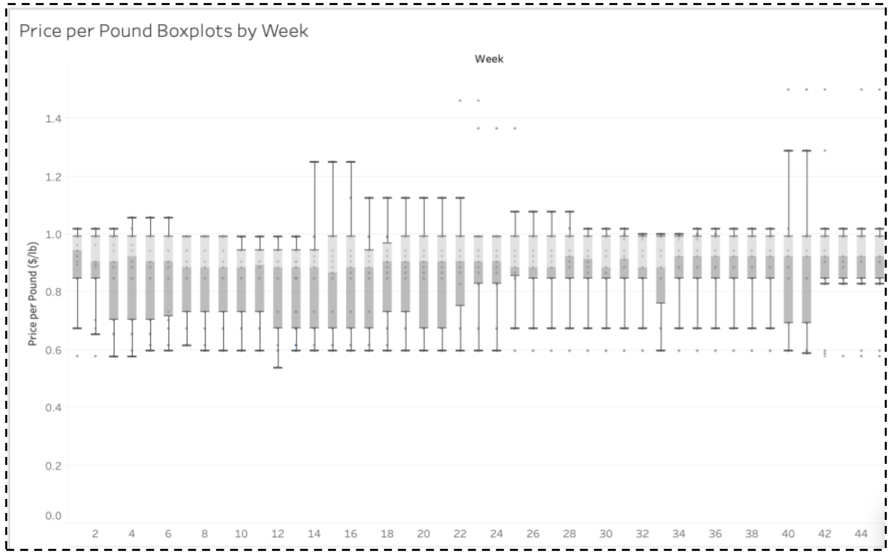


Planting Date : March 3 (Total Yield: 22,850)

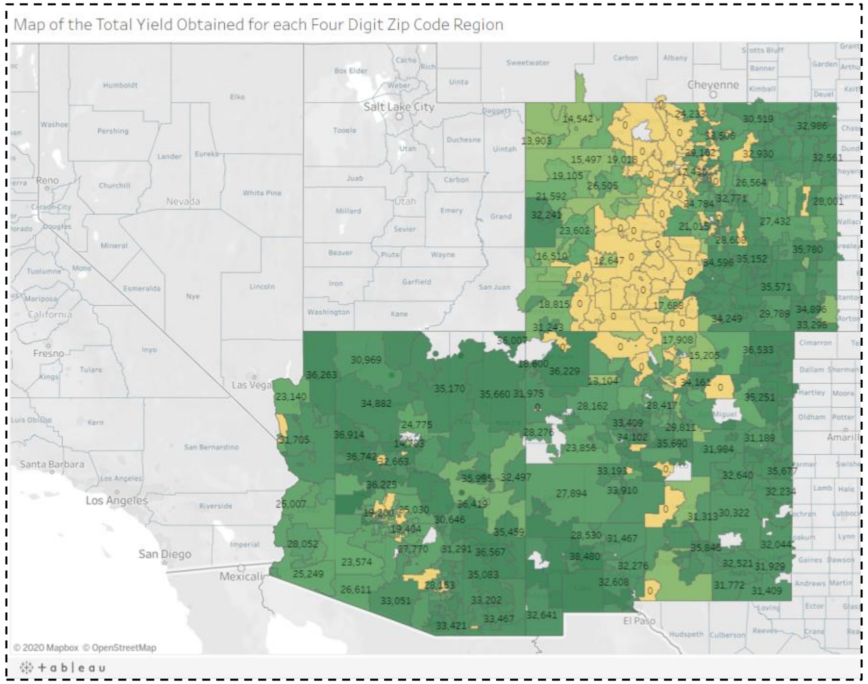


Visualization

- Provide access to relevant information regarding crop market prices, product interest and trends, and .
- Present data and analyses in a visual manner that conveys important information without needing data analytics expertise.
- The information presented in the visualization is developed to aid in decision making for agricultural business and planning.
- The information we have includes data on terminal market crop prices, crop imports, google trends interest, weather and radiation, predicted yield, and region clustering.



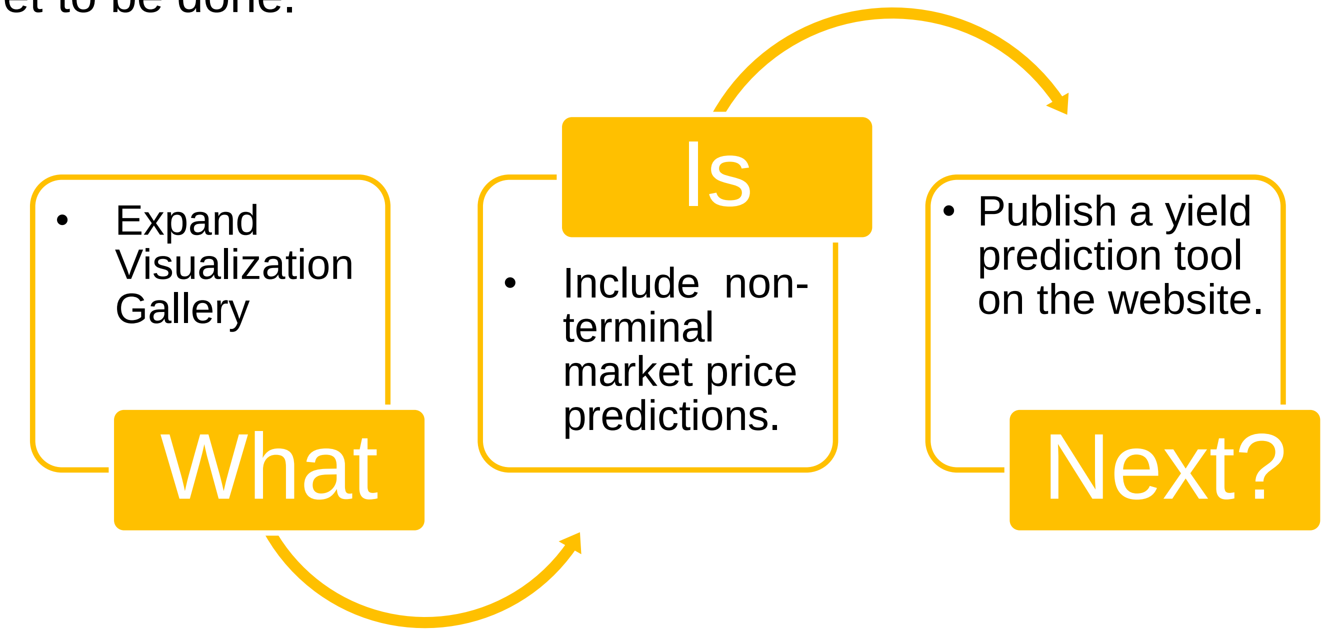
Price per pound of carrots



Yield prediction for 4-digit zip code regions

Conclusion

- Market Intelligence is an essential component in agricultural planning.
- With the use of data and analytics we can better understand the emerging market and take action to be able to respond to opportunities.
- The examples, analysis, and tools presented in the workshop are not exhaustive. More work is yet to be done.



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- Hector Flores, M.S. Thesis
- Nicholas Mason, Ph.D.
- Christopher Wishon, Ph.D.
- Hector Flores, Ph.D.

In Progress:

- Rodrigo Ulloa, Ph.D.
- Xaimarie Hernández Cruz, Ph.D.
- Grace Neal, B.S.

Thank you.

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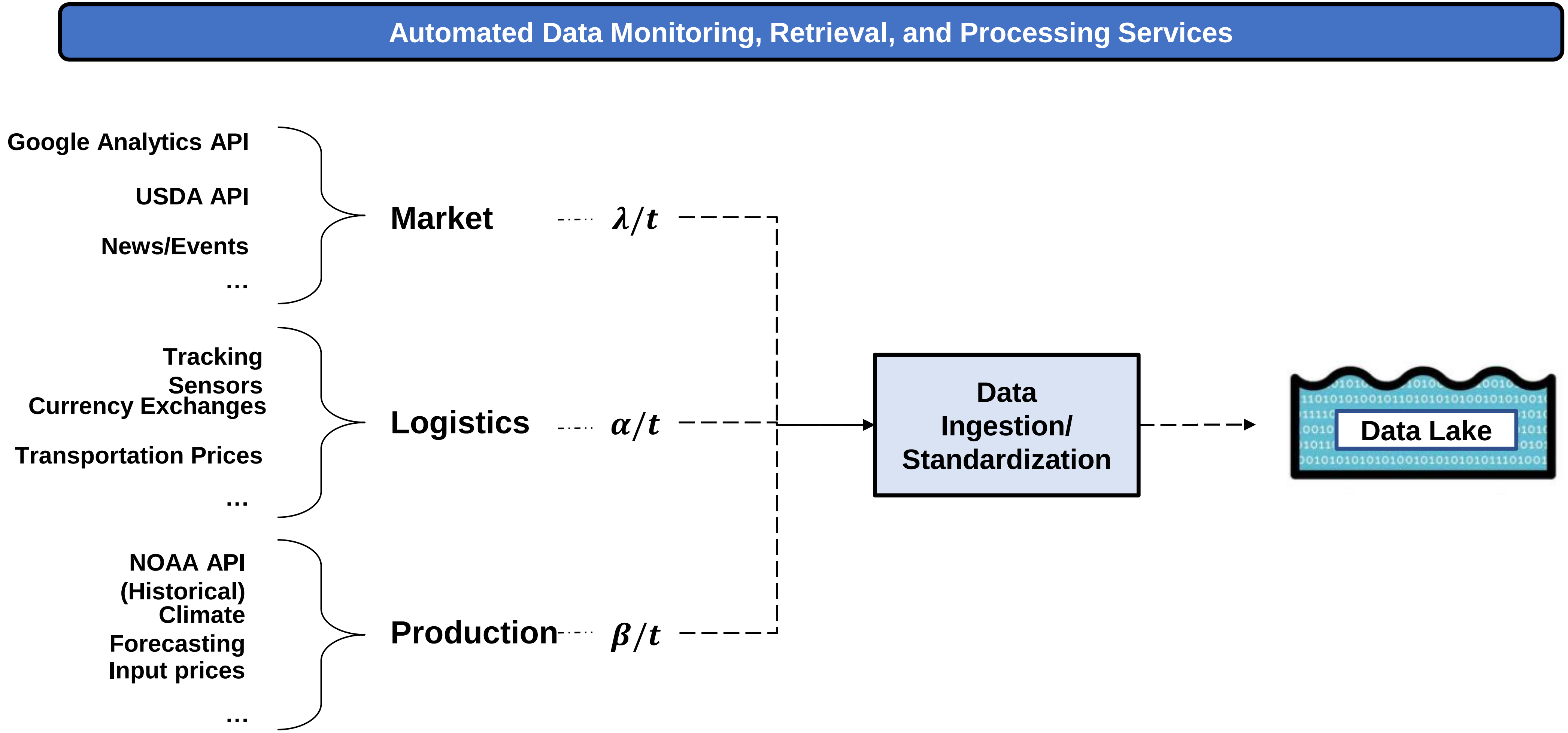
International Logistics and Productivity Improvement Laboratory (http://ilpil.asu.edu/)
School of Computing, Informatics and Decision Systems Engineering

Questions? Comments?

Additional Material

How Will It Work (in Design)



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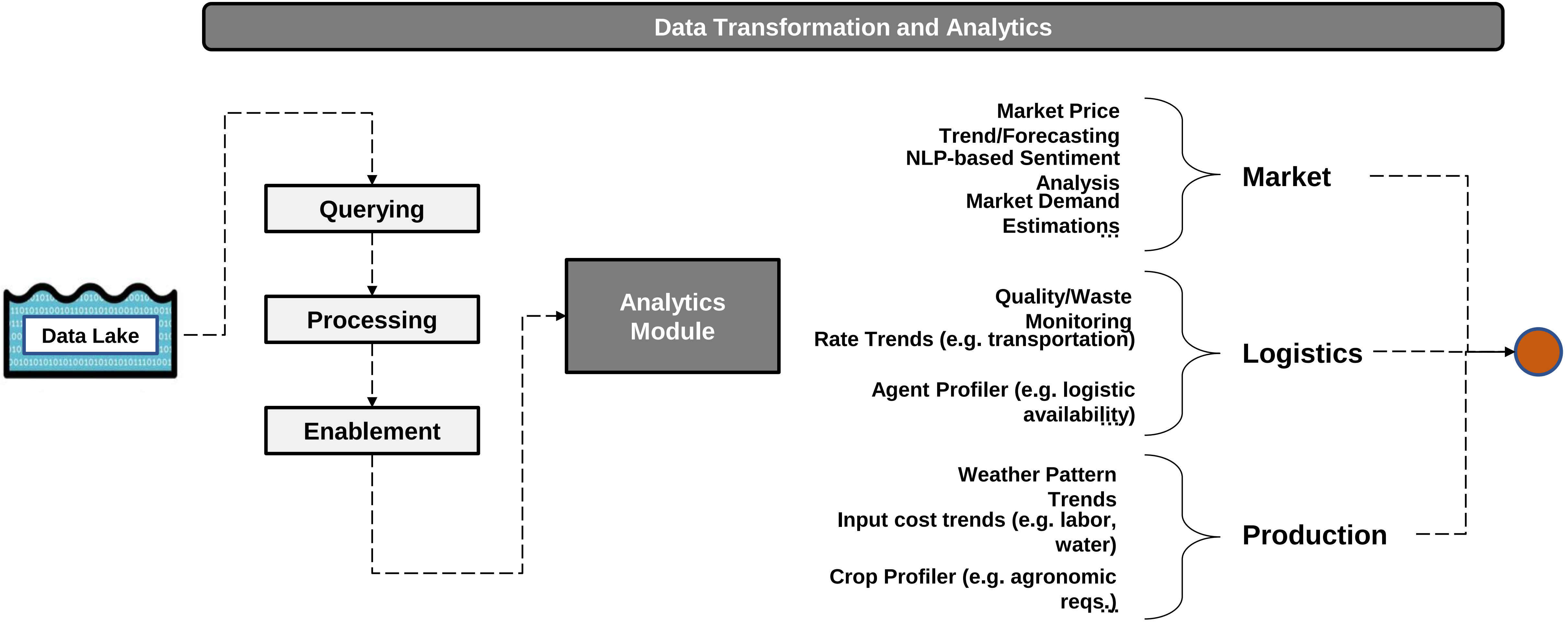

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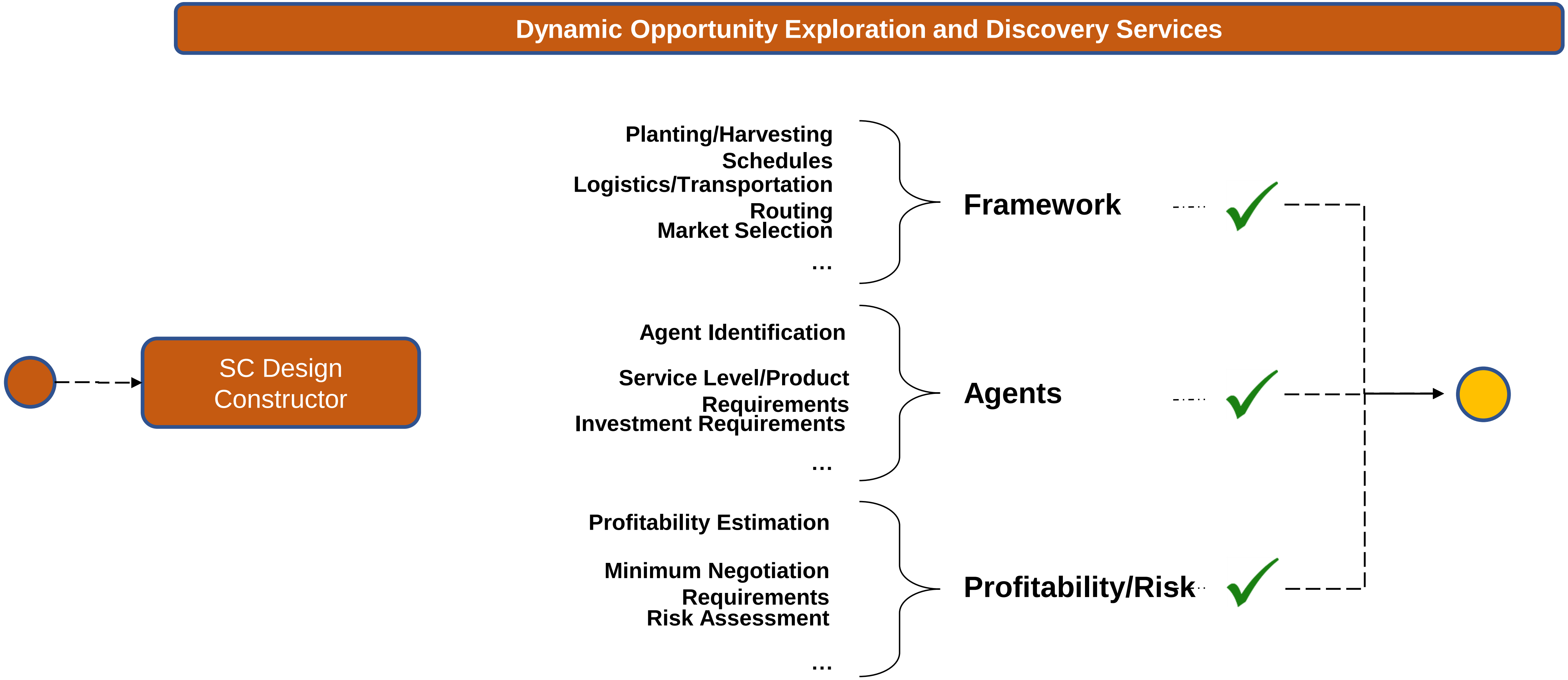

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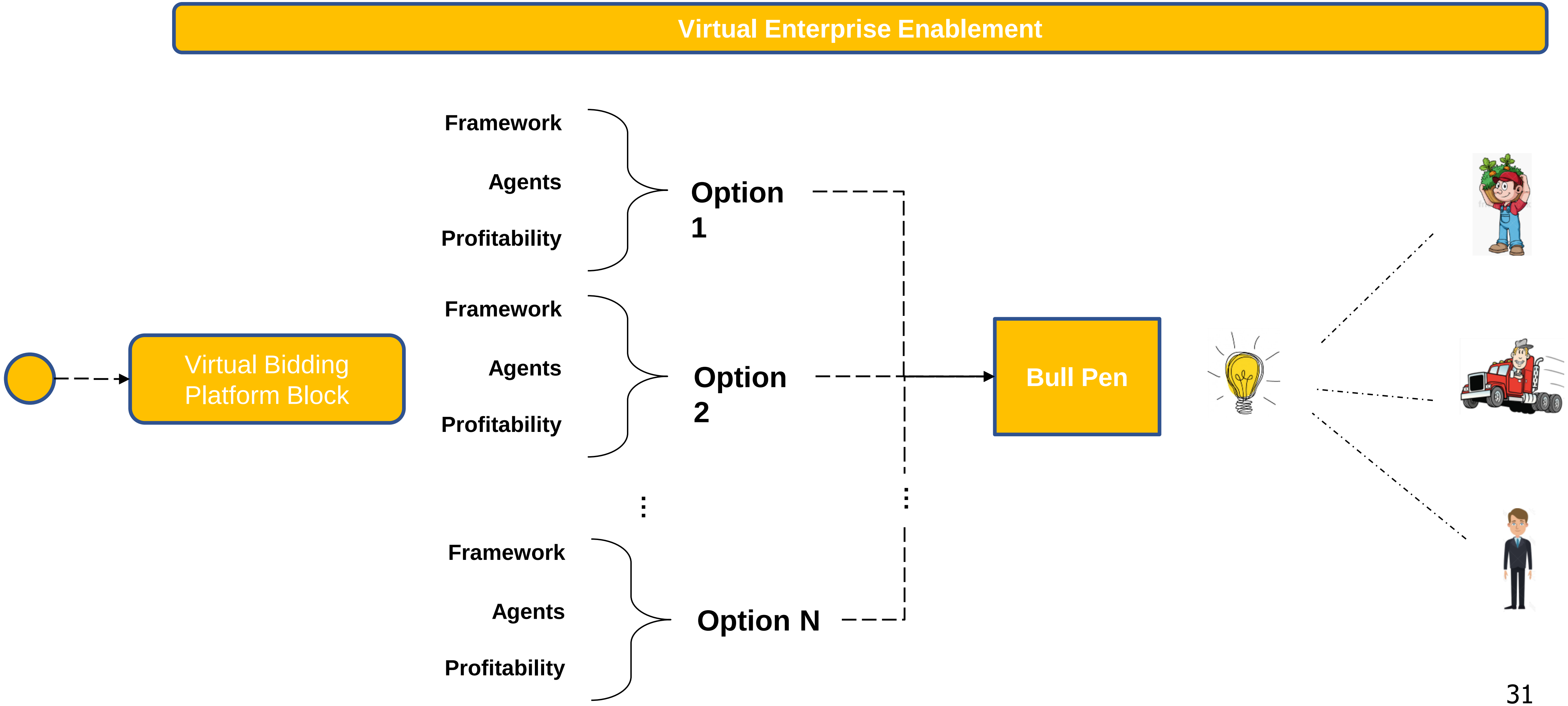

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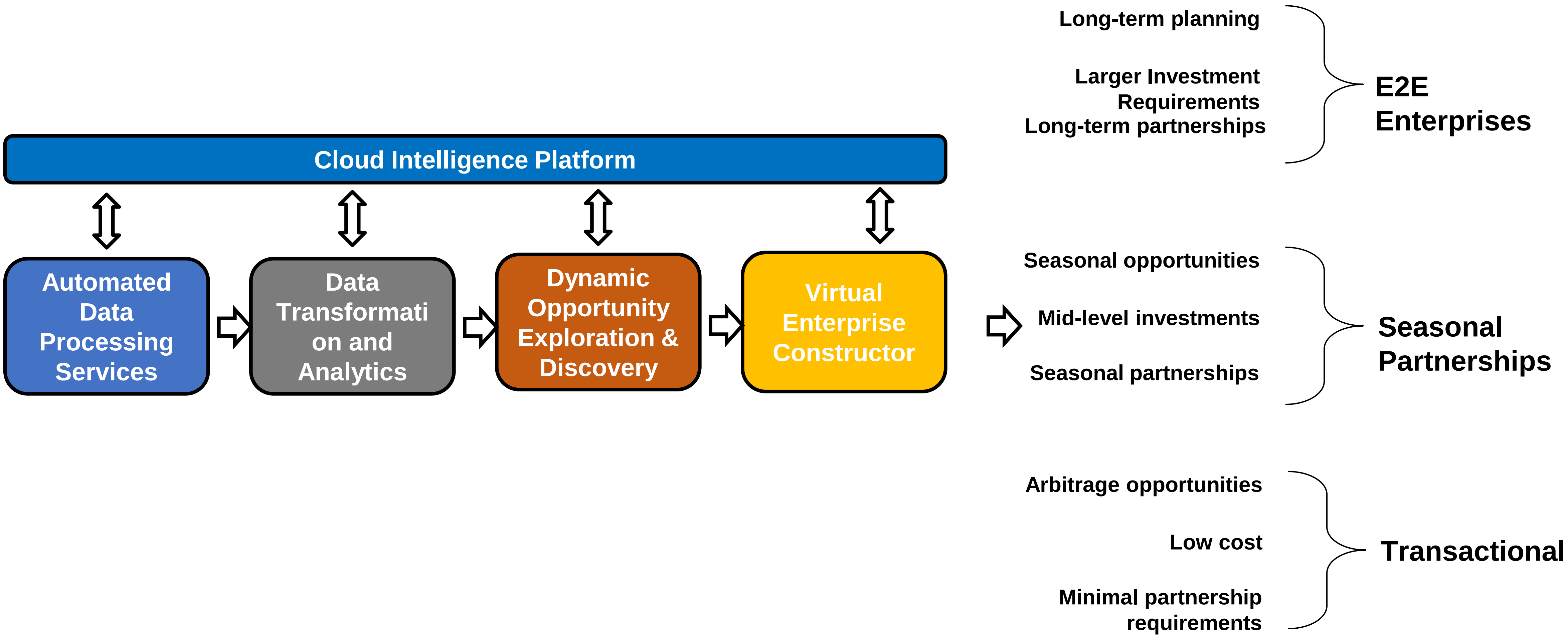
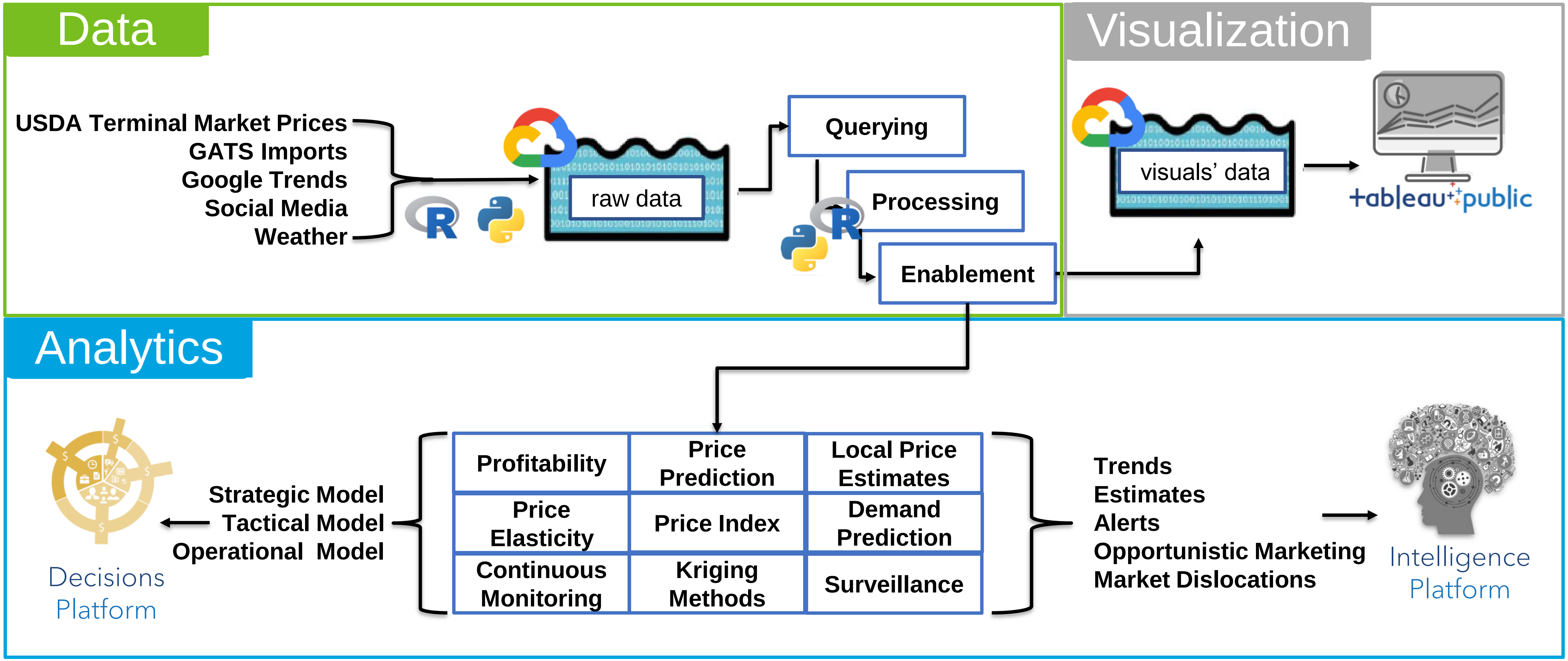


Market Intelligence Interactions



Data Gathering and Storage

Sources

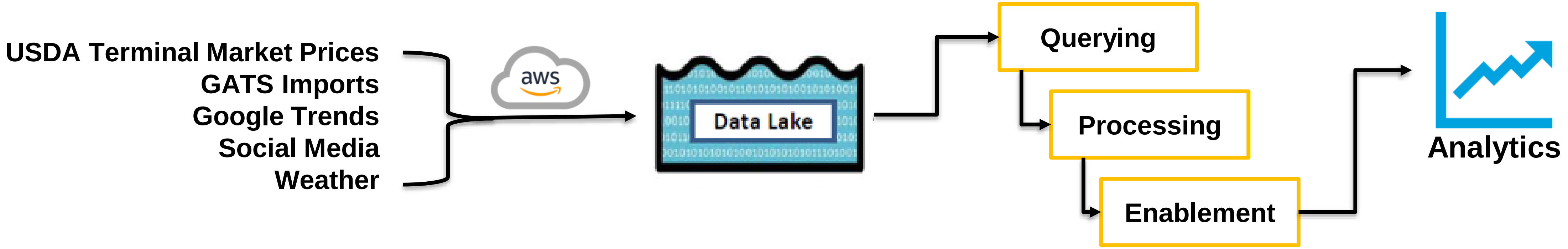
Identify data sources related to crop market prices, imports, demand, interest, transportation costs, among others.

Storage

Creation of a database platform to store relevant data and automatically update it according to a pre-defined frequency.

Processing

Creation of codes or scripts to process raw data and transform it into the needed formats.



Prescriptive Analytics

Yield Prediction

Usage of biological models to predict the total yield and its harvest distribution for each possible planting week.

Planning Unit Definition

Identify yield homogeneous regions.

Farm Planning

Usage of predicted prices and yields as inputs for agricultural planning optimization models.