PROJECT MANAGEMENT
CENTER FOR EXCELLENCE
A.J. CLARK SCHOOL OF ENGINEERING
Civil & Environmental Engineering Department

STRATEGIC DECISION-MAKING FOR SUPPLY CHAIN DESIGN AND EXPANSION:
THE CASE OF DRINKING WATER AND IRRIGATION SYSTEMS

Hakob Avetisyan, Mirosław J. Skibniewski, Abhinandh Ramasami, Niranjan Mahamuni

2018 Project Management Symposium

http://pmsymposium.umd.edu/pm2018/

Overview

- Supply Chain Traditional Approaches
- Strategic Modelling and Success Potential
- Leader-Follower Setup
  - Stackelberg Games
- Modelling for Success
  - Mathematical formulation
  - Case Study and Preliminary Results
  - Questions

Hakob Avetisyan

Supply Chain Traditional Approaches

WHAT WAS THE APPROACH?

Supply Chain Traditional Approaches

- In any industry the importance of supply chain management (SCM) has grown over time and got more attention
- Initially it was thought as a flow of goods
  - from supplier that gets the goods from the manufacturer and distributor who is responsible for delivering the goods to the final user

Supply Chain Traditional Approaches

- Along with technological advancement the vision of SCM got modified and took more organized and strategic perspective
  - The systemic, strategic coordination of the traditional business … within a particular company and across businesses … long-term performance of the individual companies and the supply chain as a whole.

Hakob Avetisyan

Strategic Modelling and Success Potential

WHAT IS IT?
WHAT IS SO DIFFERENT AND SPECIAL IN IT?

Strategic Modelling and Success Potential

- Strategic modeling is approach that addresses the multifaceted perspectives of analysis.
- As an example Oracle has a financial functionality in its Enterprise Planning and Budgeting Cloud.
  - Based on the available information it seems that it is missing the game-theoretic approach and the consideration of other players existence in the market
    - It can be limiting factor in the analyses for success

Strategic Modelling and Success Potential

- To prove the point in previous research the relationship of countries for natural gas supply was analyzed and very non-intuitive findings were reported
  - More importantly the results were proven over time (see the reference Avetisyan, 2013. in the paper for more details).

Strategic Modelling and Success Potential

- In 2010-2013 analysis it was found that the supply network for natural gas for China from Russia would be beneficial to proceed only after year 2015
- Proposed capacities would not be enough and there will be need for installation of additional capacities for supply between 2020 and 2025.

Strategic Modelling and Success Potential

Leader and Followers	*Scenario 1 and 3*			*Scenario 2*			*Scenario 4*		
Data by Year	2015	2020	2025	2015	2020	2025	2015	2020	2025
Q_{ijt} (Tcf/y)	*0.788*	*2.202*	*3.530*	*2.830*	*7.06*	*7.06*	*2.352*	*5.983*	*5.983*
LNG_{ijt} (Tcf/y)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$PLNG_{ijt}$ (Tcf/y)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
qf_{ijt} from Turkmenistan (Tcf/y)	0.005	0.028	0.024	0.000	0.000	0.000	0.400	0.550	1.077
$lngf_{ijt}$ from Turkmenistan (Tcf/y)	1.048	2.508	0.000	0.000	0.000	0.000	0.078	0.527	0.000
q_{fijt} from Uzbekistan (Tcf/y)	0.000	0.074	0.000	0.000	0.000	0.000	0.000	0.000	0.000
lng_{fijt} from Uzbekistan (Tcf/y)	0.989	2.248	3.506	0.000	0.000	0.000	0.000	0.000	0.000
Total (Tcf/y)	*2.83*	*7.06*	*7.060*	*2.83*	*7.06*	*7.060*	*2.83*	*7.06*	*7.06*

Hakob Avetisyan

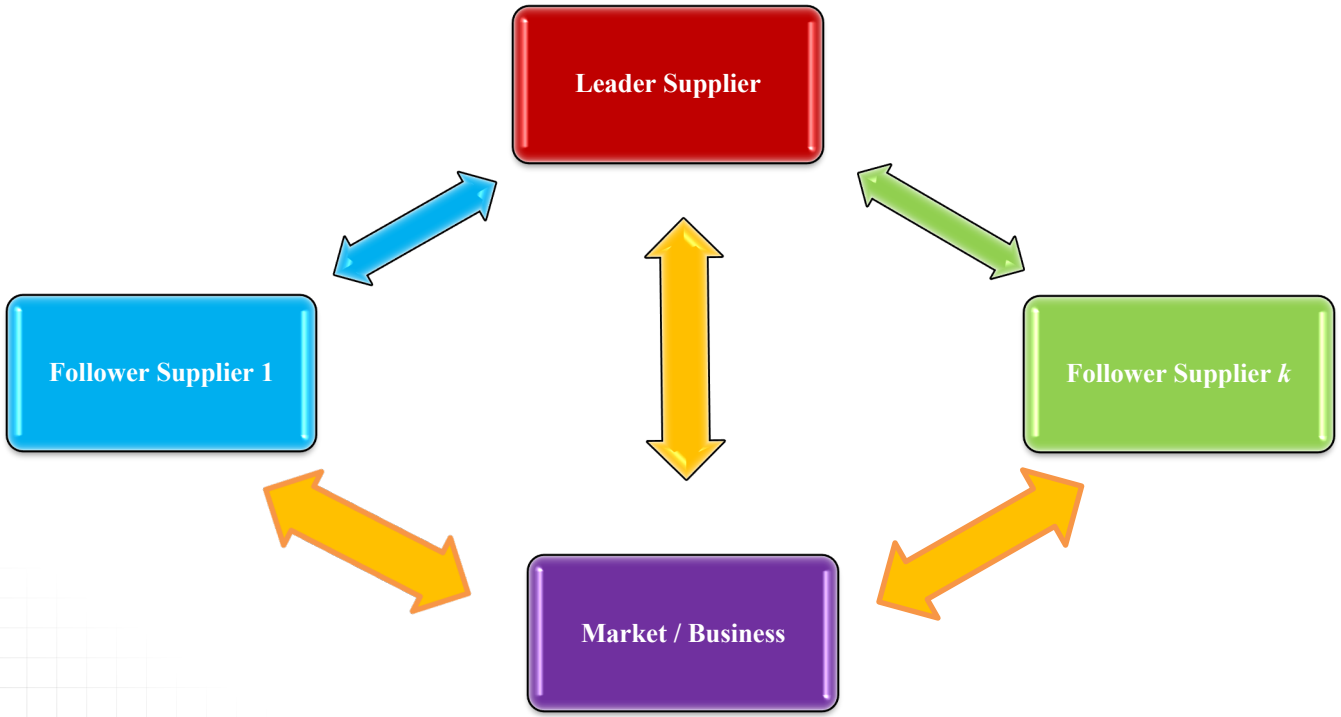
Leader-Follower Setup

STACKELBERG GAMES

Leader-Follower Setup

- Stackelberg game is regarded as a non-cooperative game
  - where the follower makes its move by accepting the leader's choice and the leader, by anticipating that the follower makes its choice, solves for both the upper and lower-level problem variables in order to maximize its own profit or for any other chosen objective.
- Stackleberg games are commonly used by governments for analyzing regulations on the economy as a whole or on particular industry.

Leader-Follower Setup



Hakob Avetisyan

Modelling for Success

- MATHEMATICAL FORMULATION
- CASE STUDY AND PRELIMINARY RESULTS

Modelling for Success

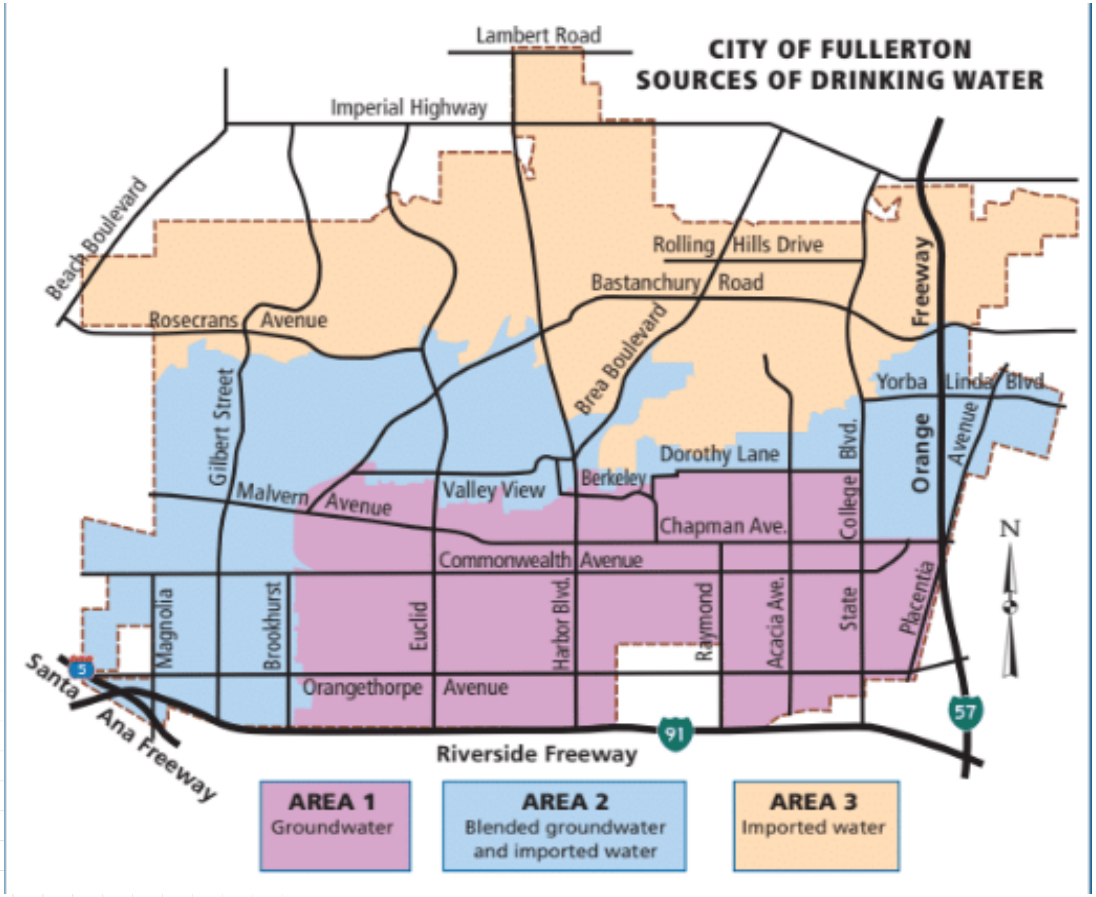
- In short it is simple!

$$\min_{x \in X} F(x,y)$$
s.t.
$$G(x,y) \le 0$$
$$\min_{y \in Y} f(x,y)$$
s.t.
$$g(x,y) \le 0$$
$$x, y \ge 0$$

Modelling for Success

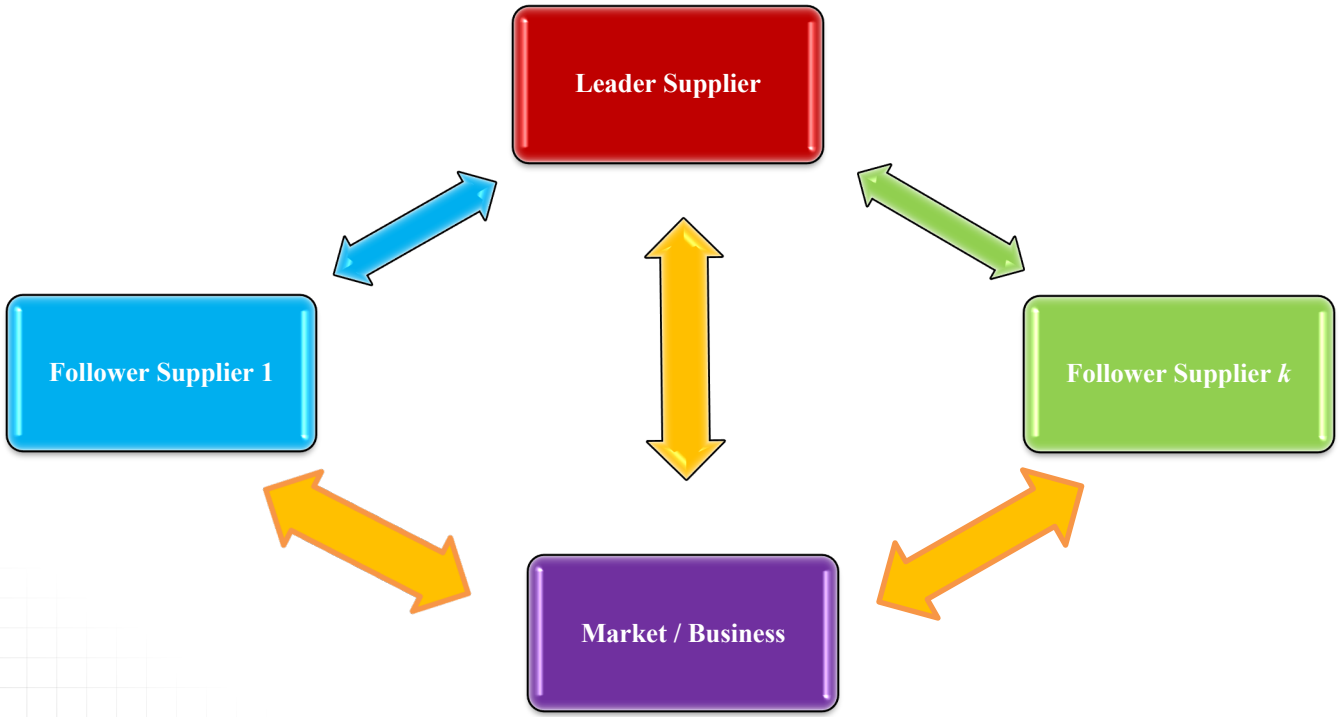
- The case study was decided to be conducted on water supply network as it is a grid of supply and can be interpreted for extended supply chain analysis.
  - Sure there will be changes in the system constraints

Modelling for Success



http://pmsymposium.umd.edu/pm2018/

Leader-Follower Setup



Modelling for Success

- In short, but in extended format -

$$\max_{Q_{ijt}} \sum_i \sum_j \sum_t \Bigg(\Bigg(A_{ijt} - B_{ijt} \Bigg(\sum_f q_{fijt} + \left(Q_{ijt} - Q_{ij(t-5)}\right) \Bigg) \Bigg) \left(Q_{ijt} - Q_{ij(t-5)}\right) + \Bigg(U_{ijt} - W_{ijt} \Bigg(\sum_f q_{fijt} + Q_{ijt} \Bigg) \Bigg) Q_{ijt} - \left(CP_{ijt}(dd)\left(Q_{ijt} - Q_{ij(t-5)}\right)\right) - \left(CQP_{ijt}(dd)Q_{ijt}\right) - \left(CCP_{ijt}(dd)Q_{ijt}\right) - \left(KQ_{ijt} \cdot XP_{ijt}\right) \Bigg) \rho_{ijt} \qquad (1)$$

Modelling for Success

- In extended format - Followers!

$$\max_{q_{fijt}} \sum_i \sum_j \sum_t \left(\left(a_{fijt} - b_{fijt} \left(\sum_f q_{fijt} + Q_{ijt} \right) \right) q_{fijt} - \left(\sum_f \left(\left(cqp_{fijt}(dd) q_{fijt} \right) + \left(ccp_{fijt}(dd) q_{fijt} \right) \right) \right) \rho_{ijt} \right)$$

Modelling for Success

- Conclusive Remarks!
  - The case study is in progress and we hope it will provide valuable insight for SCM
  - It is our expectation that it will be widely adopted by markets as it allows to analyze the market from both the suppliers' and from consumers' perspective.

http://pmsymposium.umd.edu/pm2018/

Contact: havetisyan@fullerton.edu

QUESTIONS?