

# Autonomous Agents for Supply-Chain Management

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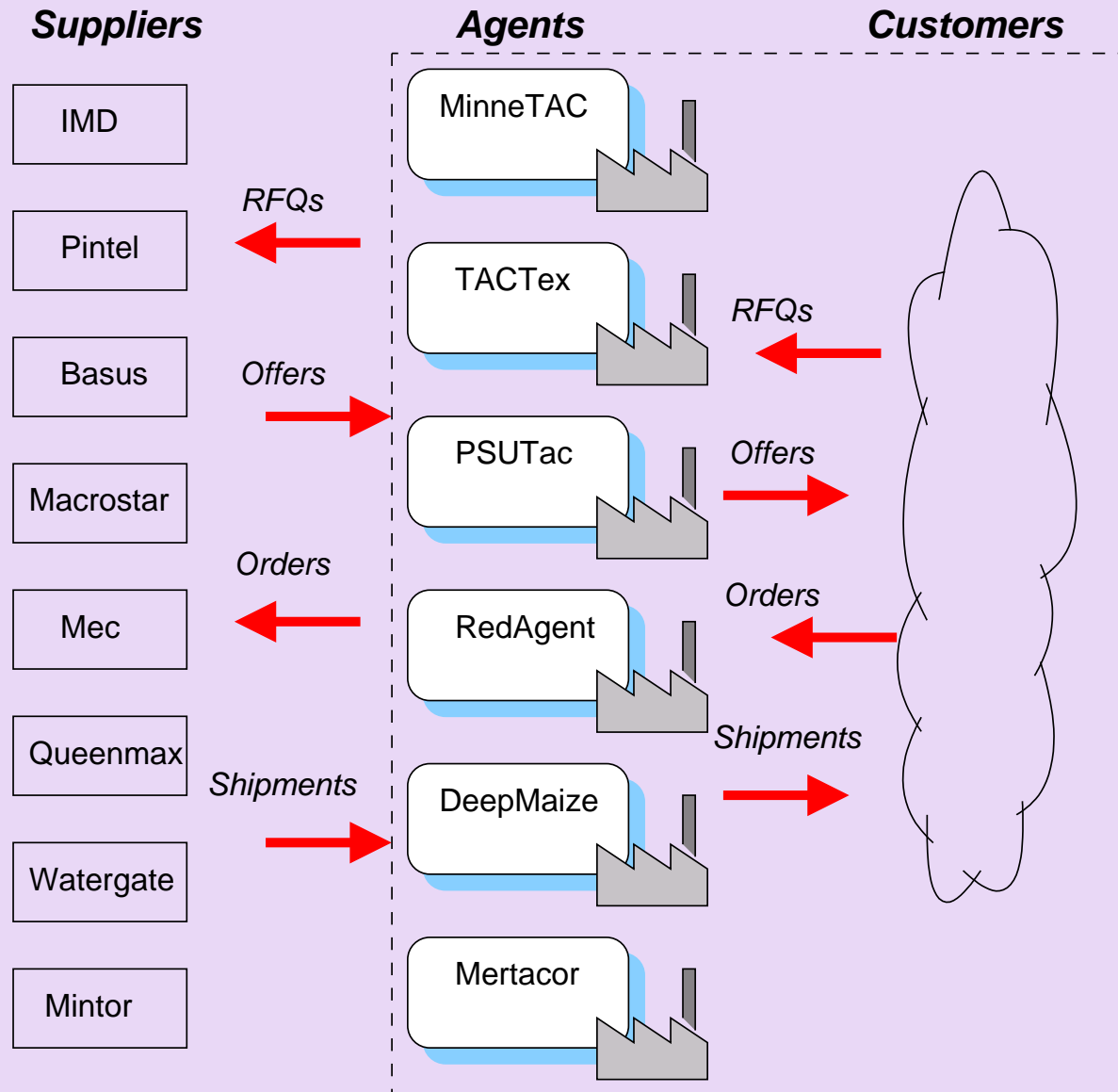
Department of Decision and Information Sciences  
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Department Meeting  
Rotterdam - March 26th 2007

# Overview

- Trading Agent Competition for Supply Chain Management (TAC SCM)
- MinneTAC
- Economic Regimes
- Future Work and Conclusions

# TAC SCM - Scenario



# Static vs. Dynamic Practices

- Today's supply chains are mostly static, relying on fixed, long-term trading partners. Not always optimal!
- Dynamic management allows for finding better matches between suppliers and customers as market conditions change.
- This is the goal of the Supply-Chain Management Trading Agent Competition (TAC SCM).

# TAC SCM - Implications in the Real Business World

- Markets are changing quickly - Organizations that have the ability to meet changing market demands in a timely and cost-effective manner will prosper.
- Decreased cost and performance improvement can be provided through new algorithms for procurement of components, production, and sales management.
- The algorithms can be used to provide information to a human decision maker.

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# MinneTAC - Design Challenges

- Clean separation of infrastructure from decision processes.
- The design must support multiple independent developers pursuing their own lines of research.
- We need to be able to configure agents with different combinations of decision process implementations.
- Controllable generation of experimental data.

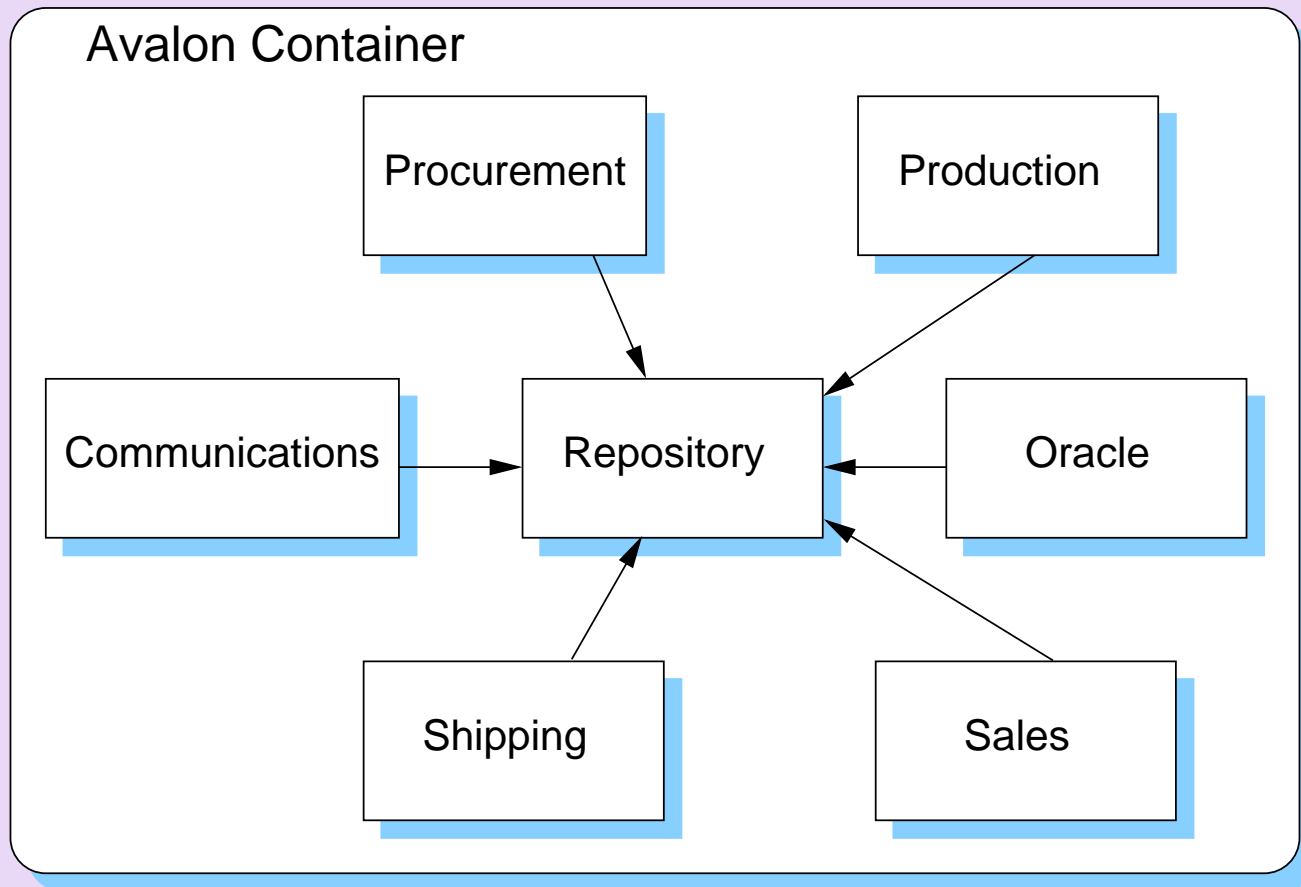
# MinneTAC - The Design

We chose an component-oriented approach.  
Two pieces form the foundation of MinneTAC:

- Apache Excalibur component framework
- “Dummy agent” distributed by the TAC SCM game organizers

J. Collins, W. Ketter, M. Gini, and A. Agovic. “Software architecture of the MinneTAC supply-chain trading agent” submitted to Journal of Brazilian Computer Society, 2007.

# MinneTAC - Architecture



Arrows indicate API dependencies.

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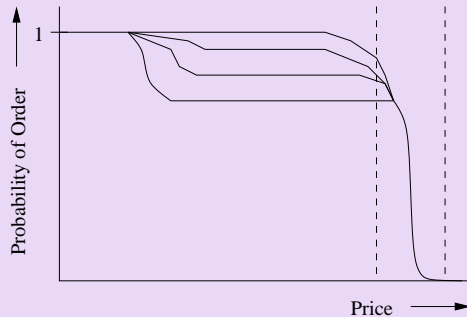
# Motivation Economic Regimes

- Economic theory suggests that economic environments exhibit 3 dominant market patterns: scarcity, balanced, and over-supply.
- We call these distinguishable conditions *economic regimes*.
- The long term objective of our work is to show how knowledge of current and anticipated regimes can enable an agent to make better operational and strategic decisions.

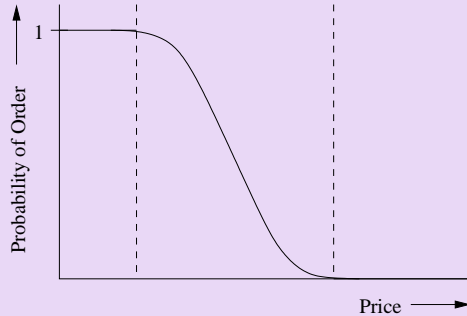
Work done with John Collins, Maria Gini, Alok Gupta, and Paul Schrater.

# Relationship between Prices, Order Probability, and Regimes

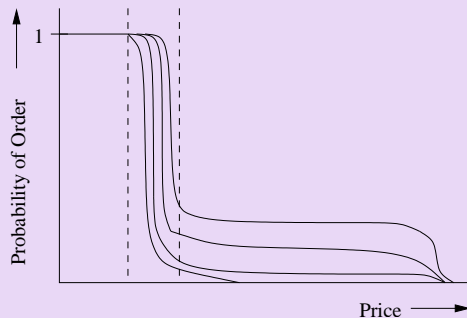
Scarcity:



Balanced:

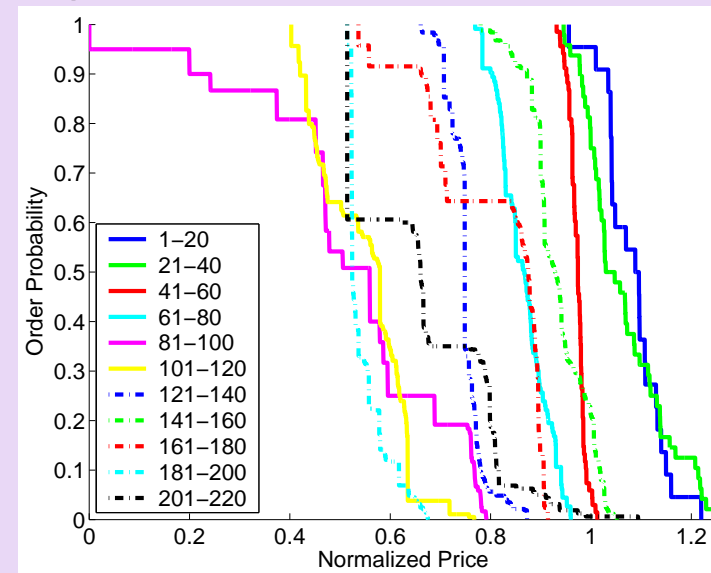


Over-supply:



Reverse cumulative density function represents probability of order.

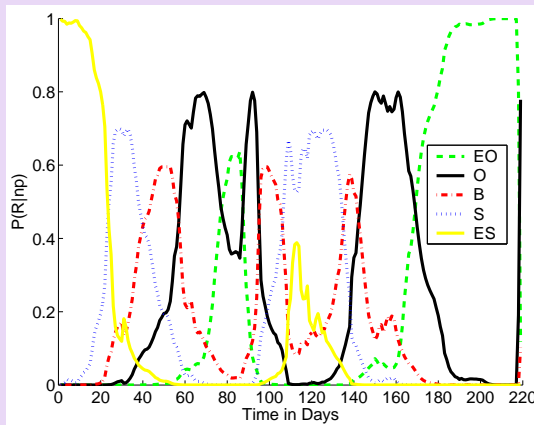
Experimental:



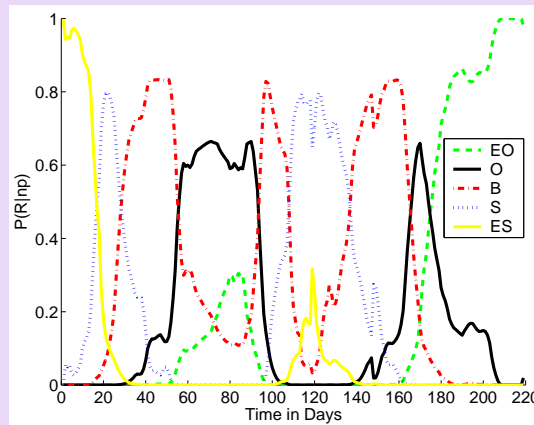
# Use Regime Prediction For Sales Strategies

1. Allocation (Strategic Decision):
  - Optimal product mix, given resource constraints.
  - Allocation of parts, production capacity, and finished goods over time (multiple sales cycles).
2. Pricing (Tactical Decision):
  - Find the best prices to move the desired inventory.

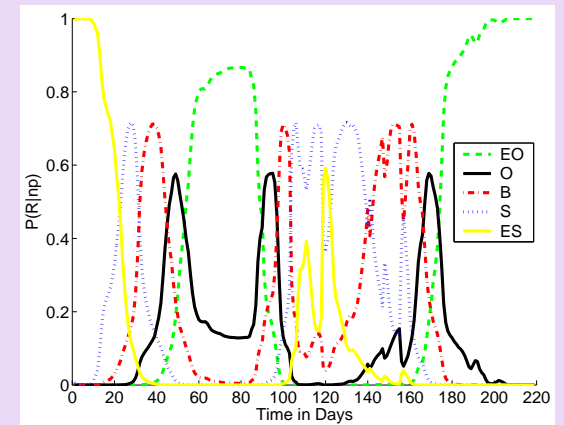
# Regime Probability – Real-time



Low Market



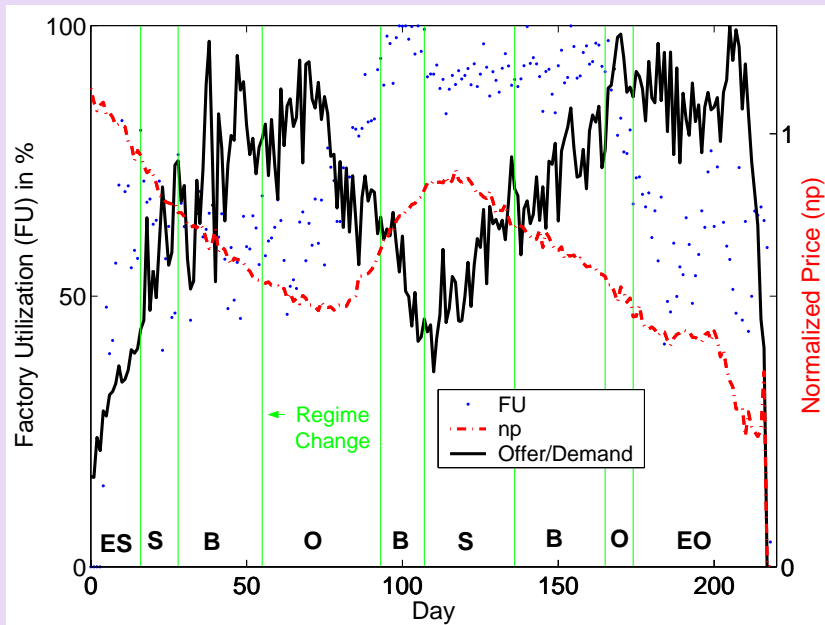
Medium Market



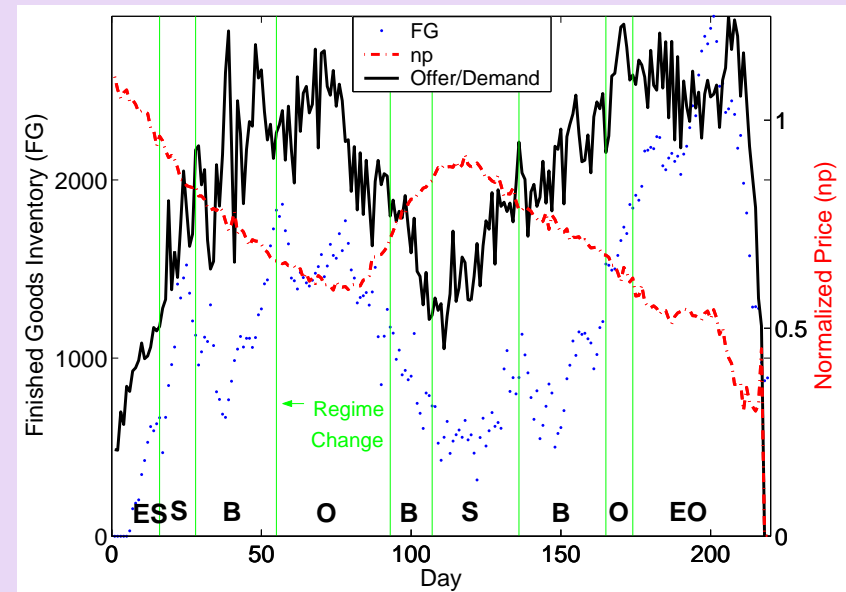
High Market

$\vec{P}(R_k | \widetilde{np}_{day}) \quad \forall k = 1, \dots, M$  calculated online for game 3721 @tac3.

# Regime Market Parameters



Factory Utilization (FU)



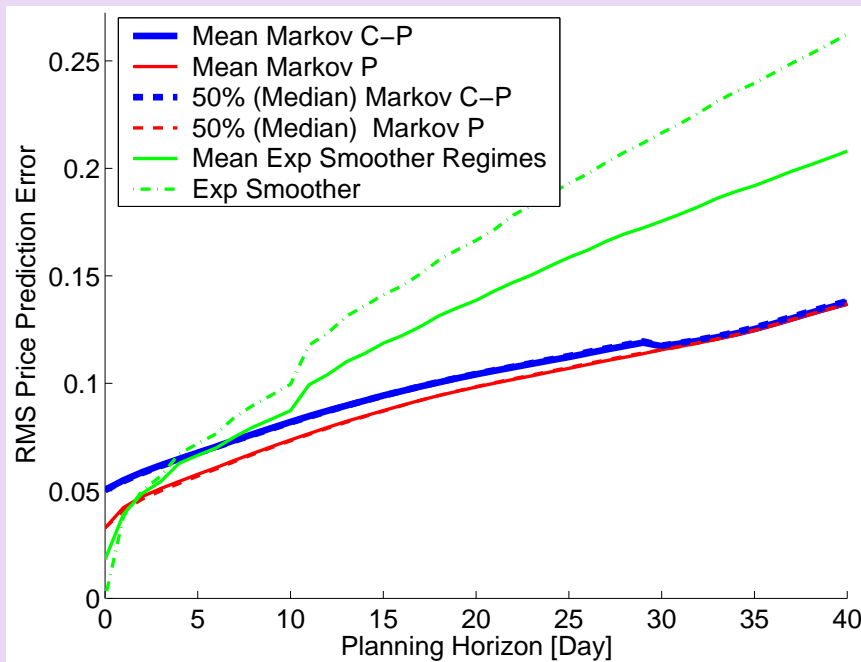
Finished Goods Inventory (FG)

Game 3721tac3 - medium market segment: Ratio offer/demand, **normalized prices**, and **regime transitions**.

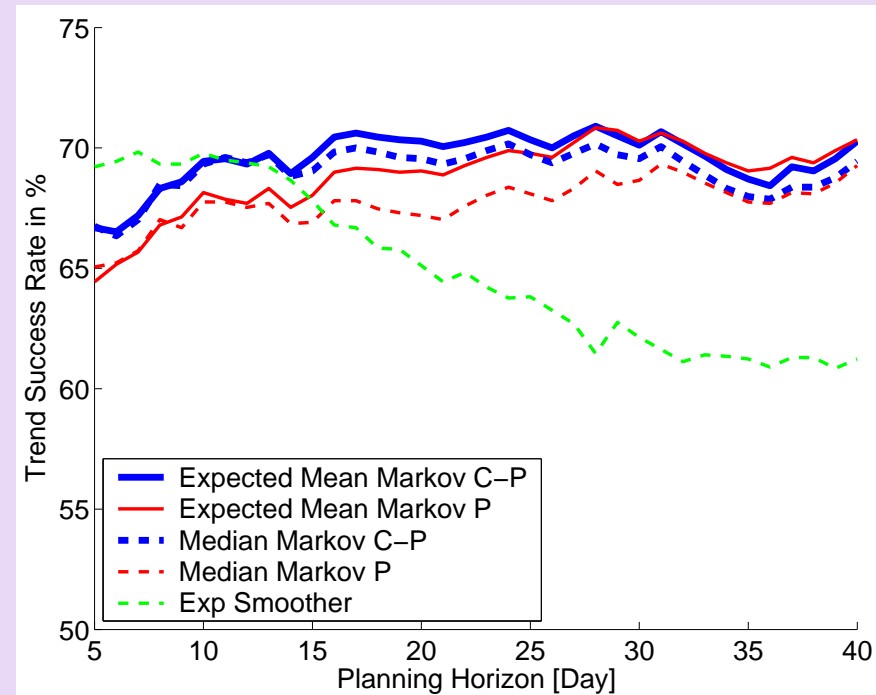
# Online Prediction of Regimes

We model the prediction of the next regime as a Markov prediction process: The posterior regime probabilities are predicted for current and future days based on yesterday's smoothed mid-range normalized price  $\widetilde{np}$ .

# Evaluation of Price and Trend Prediction



Price Prediction



Trend Prediction

# Mean Profit Results using Different Versions of MinneTAC

Strategic: Tactical: Agent:	Mean Profit / Standard deviation (in \$M)			
	Price-Follower	Regimes	Combo	Regimes
	Linear	Linear	Linear	Regimes
MinneTAC	1.347/3.703	1.813/4.017	1.780/4.536	2.117/3.764
TacTex06	8.752/5.682	8.873/5.600	8.399/5.173	9.205/5.385
DeepMaize06F	8.839/4.629	8.713/4.846	8.403/4.710	8.318/4.181
PhantAgent06	8.049/5.422	7.991/5.384	7.895/5.326	8.173/5.437
Maxon06F	4.243/4.516	3.767/4.288	3.808/4.254	4.019/4.181
Rational05	0.739/4.912	0.669/4.692	0.710/4.692	1.305/4.527

Experimental setup with controlled market conditions and different variations of MinneTAC for order probability, price and price trend predictions. Each column is an average of 23 games.

# Application Areas Economic Regimes

- Identification of economic regimes:
  - Strategical decision making
  - Tactical decision making
- Price and price trend forecasting.
- Forecasting of economic regimes shifts:
  - Wholesaler (e.g. book store).
  - Production plant (e.g. Daimler-Chrysler).
- Automated supply-chain management, e.g.,
  - i2
  - SAP

# TAC SCM - Finals 2006

- TacTex - University of Texas, USA - Winner
  - Good Procurement
  - Good Sales
- MinneTAC - Univ. of Minnesota, USA
  - Average Procurement
  - Good Sales
- PhantAgent - Univ. of Bucharest, Romania
- DeepMaize - Univ. of Michigan, USA
- Maxon - Wolfram Conen, Germany
- Botticelli - Brown Univ., USA

# Future Work - Economic Regimes

- Dynamic model selection between the different price prediction approaches.
- Develop procurement strategies that take advantage of regime forecasting.
- Implement and evaluate approach in other application domains, e.g.,
  - Stock market
  - Amazon
  - eBay

# Agent-Mediated Business Networks and Markets Lab

- Interdisciplinary research on decision support tools and advanced technologies aimed at significantly increasing enterprise supply chain agility.
- Highly personalized agents that facilitate information gathering and optimize human decision making.
  - Significantly enhance bounded rationality of humans with the help of multi-agent systems.
- Form an ERIM team to compete in TAC SCM
  - ErasmusTAC
  - RSM-TAC

# Supply-Chain Simulation

- Tease apart subtle interactions and effects that would never be visible among the noise of the real world.
- Try ideas for things like pricing and inventory control that you could never risk in the real world.
- Run a whole year's interactions in an hour, change the setup, and run the year again.
- Provide a real good understanding of challenges that one is likely to face in a real environment.

# Conclusions

- Supply-Chain Simulation TAC SCM.
- Autonomous Trading Agents.
- Identification and Prediction of Economic Regimes.
- New way of predicting prices and price trends.
- Erasmus Agent-Mediated Business Networks and Markets Lab.

## Contact

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