

# Exploration and Exploitation: Managing Knowledge in Turbulent Environments

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# Goals of This Talk

## Exploration, Exploitation, and Knowledge Ecosystems... What Do I Mean?

- provide a background as to my research
- provide definitions and examples

## Discuss an In-Depth Study

## Relate This Research our Distributed Problem-Solving Networks Research

# Background

## Strategist (part-time w/ PhD pursuits)

- Centers for Disease Control (CDC) and U.S. Department of Energy
- focused on “knowledge ecosystems”, 2005-2007

## IT Chief; Associate Director of Informatics w/ CDC

- Bioterrorism Preparedness and Response Program; HIV/AIDS Prevention
- 2000-2005

## Project Manager; Microsoft and Yahoo! Efforts

- 1998-2000

# Background

Turbulent Environments = where knowledge-intensive changes occur rapidly with little warning

- no one individual knows enough to mitigate negative outcomes
- no one individual knows enough to capitalize on positive opportunities

## Examples:

- 9/11, anthrax events in 2001
- West Nile Virus, SARS, monkeypox in 2003
- bioterrorism, national security emergencies

# Turbulent Environments

Turbulent Environments = inter-individual knowledge exchanges must transcend boundaries

- of group proximity
- of individual institutions and social networks

How can human organizations better adapt to turbulent environments?

# Turbulent Environments

Exchanges of knowledge allow humans to

- relay thoughts
- relay perceptions of the environment
- adapt

How can human organizations better adapt to turbulent environments?

How can we employ knowledge technologies to improve organizational responsiveness?

# Exploration and Exploitation

## Seminal article on organizational learning

- written by James G. March (Professor Emeritus, Stanford) in 1991
- his article resulted in over 2,800+ citations

Exploration = organizational use of new knowledge, with an uncertain return

Exploitation = organizational reuse of existing knowledge, with a certain return

# Exploration and Exploitation

Knowledge = defined as “justified true belief”

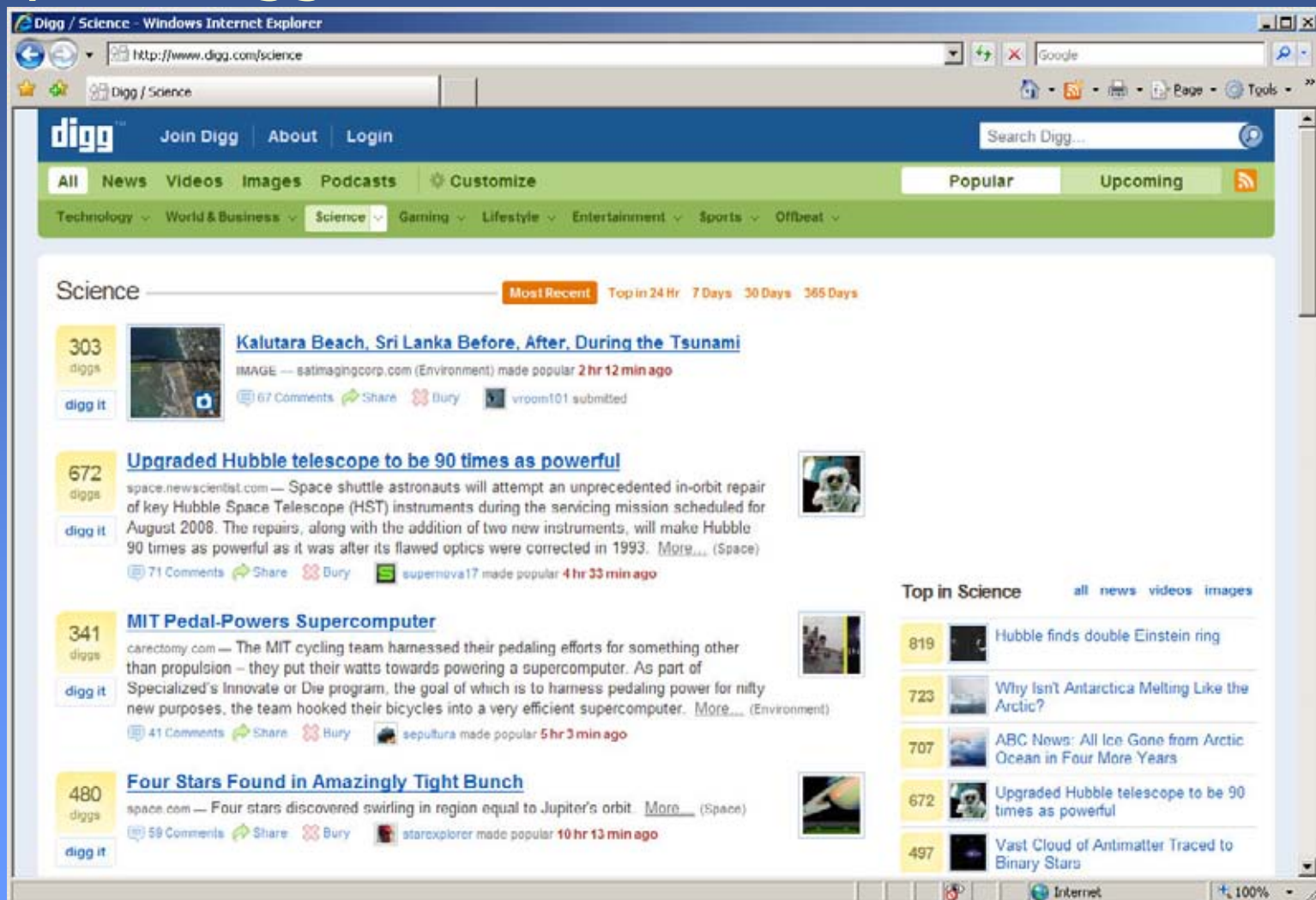
- about external reality (in organizational science literature)
- represents the most strategically valuable resource of any organization

Knowledge Technologies = interfaces and systems that enable knowledge exchanges among humans



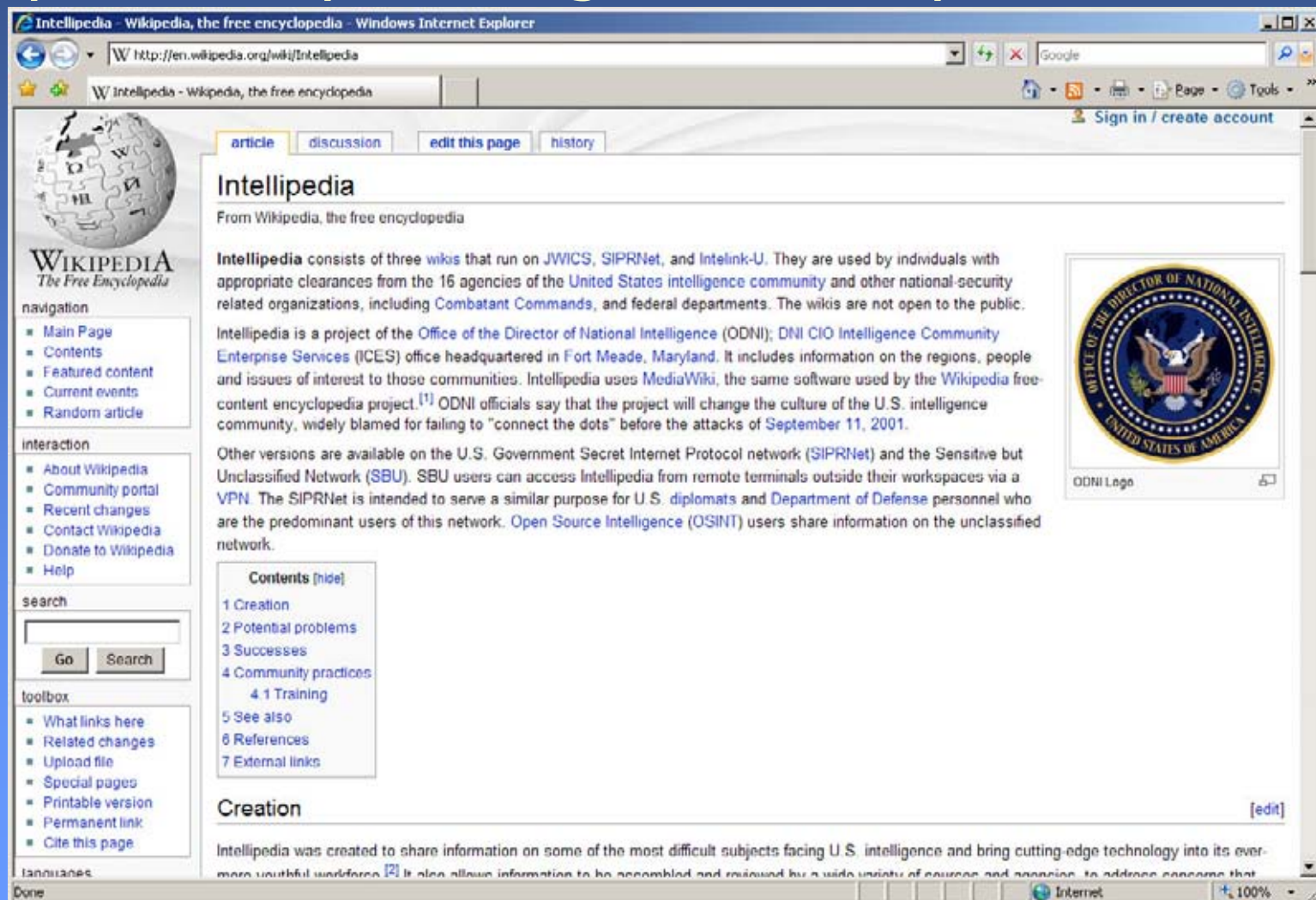
# Knowledge Technologies

## Examples: Digg.com



# Knowledge Technologies

## Examples: Wikipedia.org and Intellipedia



# Knowledge Technologies

## Examples: Sermo.com



# Knowledge Technologies

Knowledge Management Strategy = facilitation of inter-individual knowledge creation and transfer to best “connect the dots”

Organizational Stimuli = include incentives, values, and trust elements to motivate human actors

Knowledge Exchange Processes = knowledge creation, transfer, and protection activities

# Knowledge Ecosystems

Knowledge Ecosystems = embody a “bottom-up”, grassroots approach to cultivating knowledge

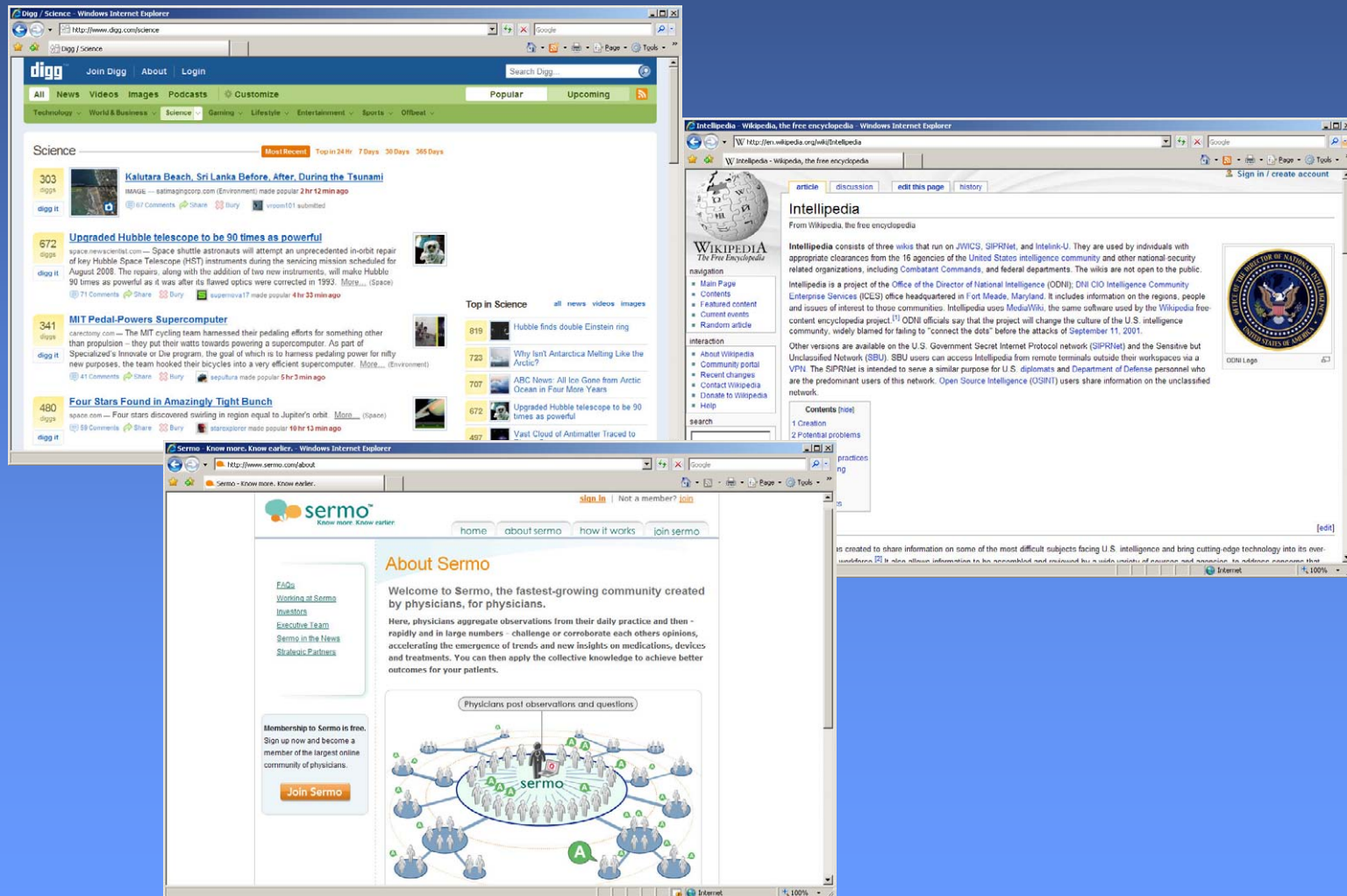
Ultimately influence organizational performance, to include responsiveness and efficiency

- comprise technologies, stimuli, and processes
- studying performance represents my PhD research, 3 empirical papers



# Knowledge Ecosystems

## Examples:



An In-Depth Study

# Managing Knowledge in Turbulent Environments

# An In-Depth Study

Recall March's (1991) seminal paper, organizational learning modeled as a collective tension:

- exploitation (p1) = refinement of old certainties
- exploration (p2) = experimentation of new alternatives

Organizations that engage purely in exploration suffer experimentation costs with little benefit; pure exploitation may become trapped in a "rut"



# An In-Depth Study

Recall March's (1991) seminal paper, organizational learning modeled as a balance:

- exploitation (p1) = reuse of existing knowledge, with a certain return
- exploration (p2) = use of new knowledge, with an uncertain return

Regarding org performance, March predicted exploitation (p1) to be positive in the short-term

...but negative in the long-term...

# An In-Depth Study

## Individual reality

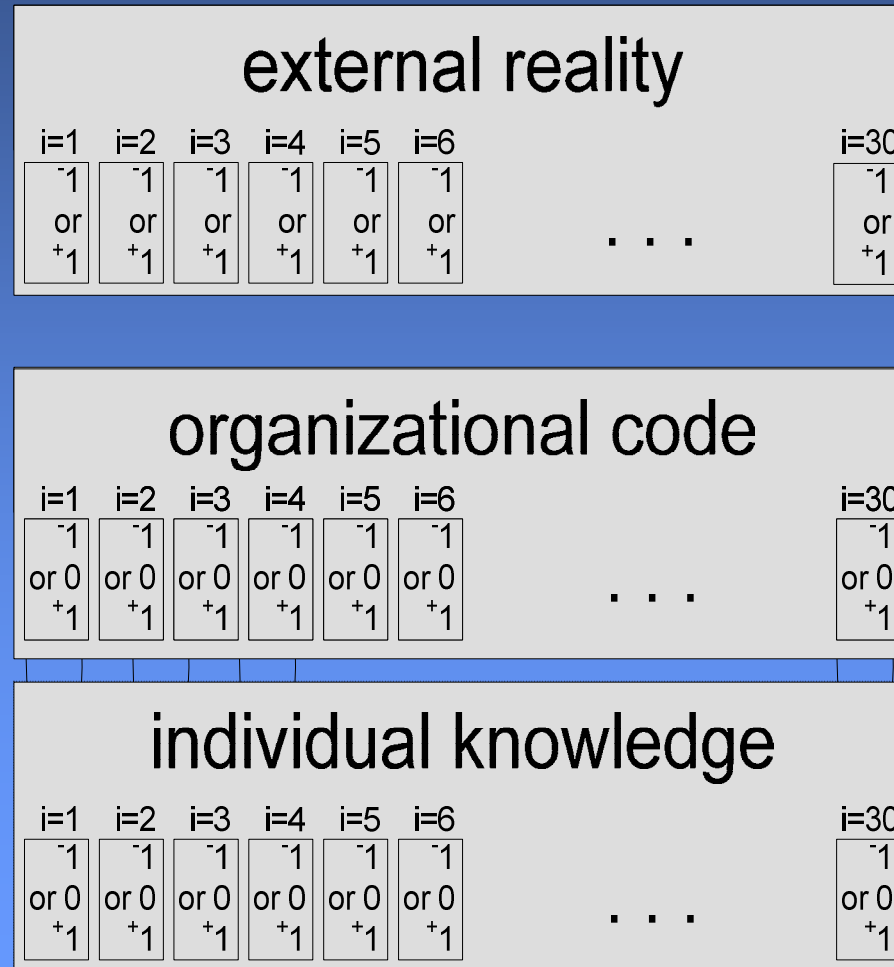
- m dimensions, each independent of one another
- can be either  $\{-1\}$ ,  $\{0\}$ ,  $\{+1\}$ , with  $\{0\}$  as neutral or no opinion
- n individuals in org, each initially with random values

## Organizational code

- m dimensions, each independent of one another
- can be either  $\{-1\}$ ,  $\{0\}$ ,  $\{+1\}$
- code represents collective knowledge of the org, initially all  $\{0\}$

# The Seminal Model

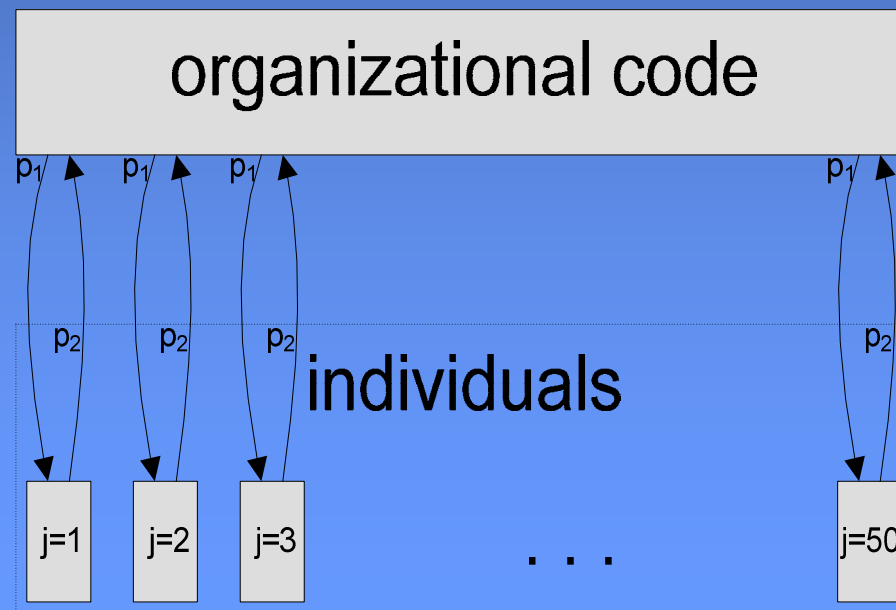
Org code and individual knowledge can learn



# The Seminal Model

## Organizational learning

- neither org code nor individuals directly see true external reality
- org code can only change belief to match best (expert) individual
- yet org may adopt an incorrect dimension from an expert in err



# The Seminal Model

## Turnover

- revolution or significant deviation in an individual's beliefs regarding reality
- March considers both “no” and “moderate” levels of turnover

## Environmental Turbulence

- allows examination of how well the org maintains situational awareness
- theatres of operation can change

# The Seminal Model

## Turnover

- for each iteration, probability ( $p_3$ ) individual will be replaced
- new individual has a random collection of knowledge (i.e., beliefs)

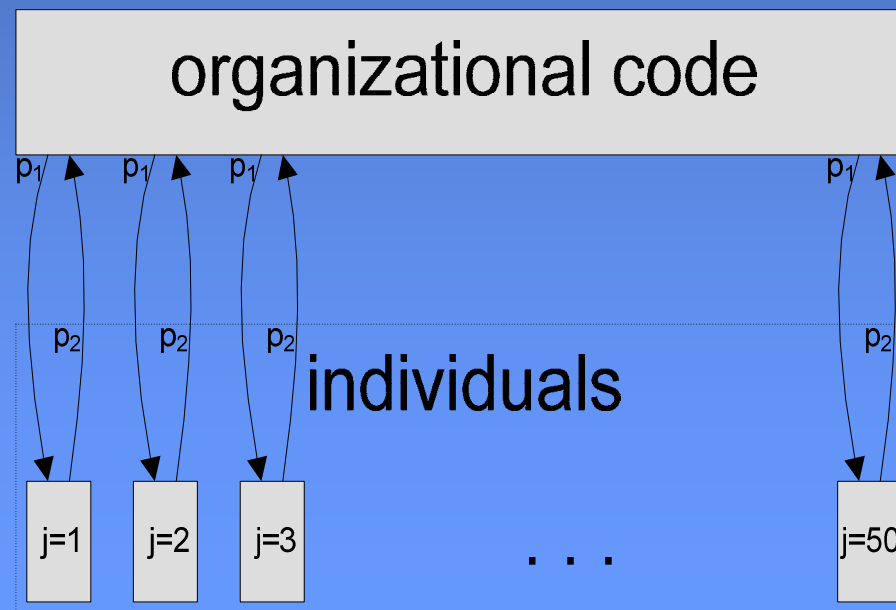
## Environmental Turbulence

- for each iteration, probability ( $p_4$ ) a dimension of reality will “flip”
- each flip can be from either  $\{-1\} \rightarrow \{+1\}$  or from  $\{+1\} \rightarrow \{-1\}$

# This Study: Extending the Model

March's model only considered a flat organization

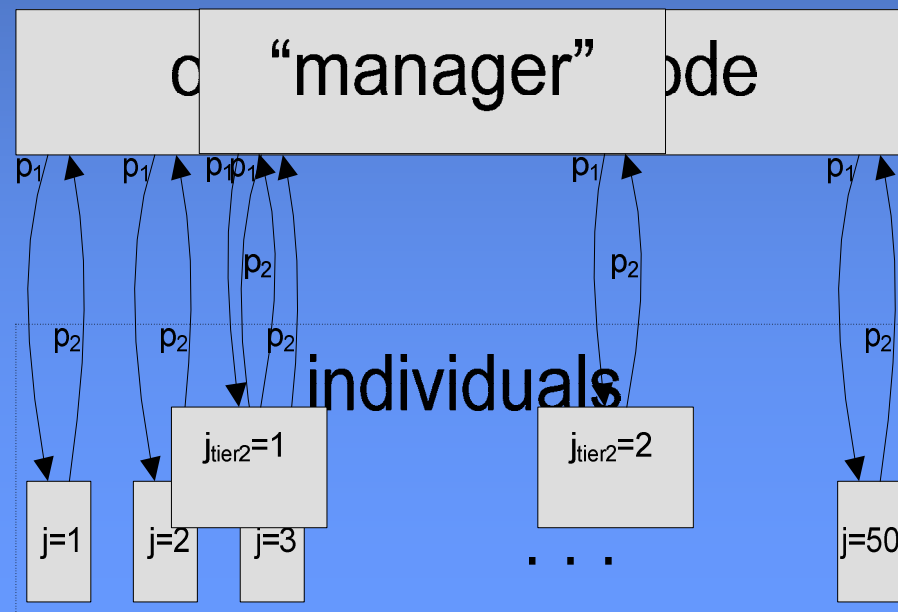
- no reporting structure between individuals
- no use of technology to try and manage knowledge



# This Study: Extending the Model

## Consider a reporting structure

- org code becomes a manager to a set of (b) reporting individuals
- each direct report still has a probability ( $p_1$ ) of learning from their manager
- each manager has a probability ( $p_2$ ) of learning from expert report

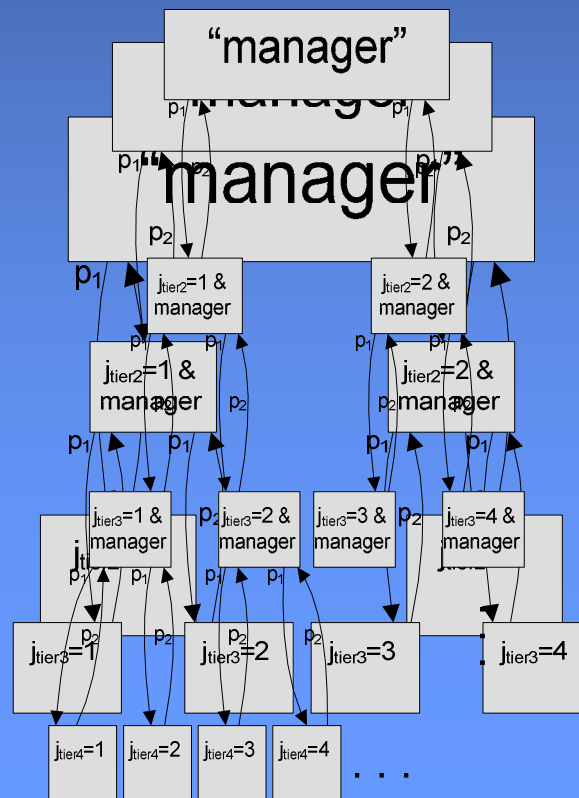




# This Study: Extending the Model

## Consider a reporting structure

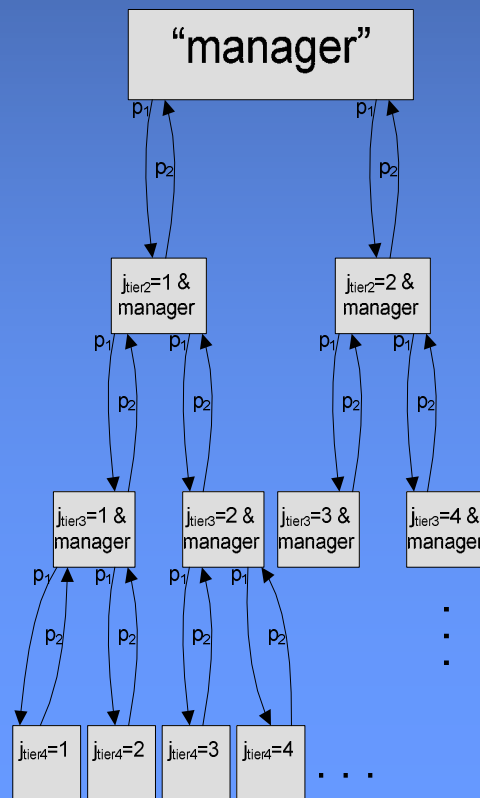
- a report can in turn become a manager to other reporting individuals
- each direct report still has a probability ( $p_1$ ) = exploitation
- each manager has a probability ( $p_2$ ) = exploration from direct reports



# This Study: Extending the Model

## Allows for multi-tier organizational hierarchies

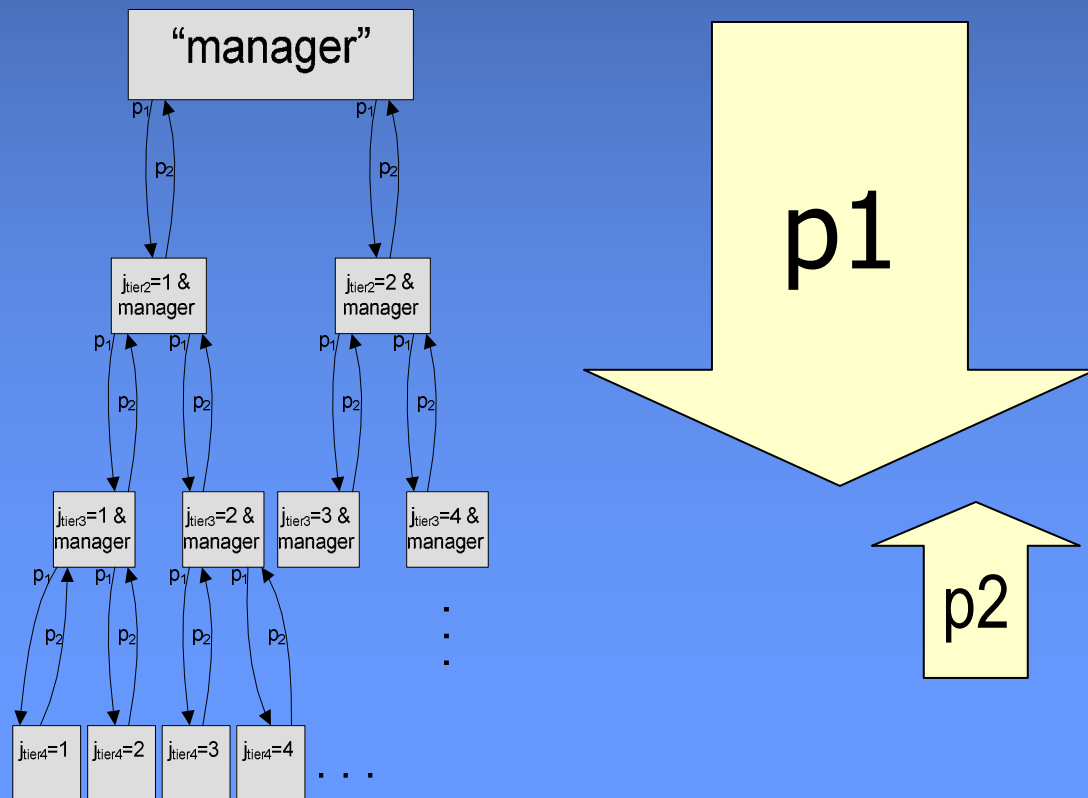
- what effect does increasing the depth of a hierarchy (d) have?
- what effects do turnover ( $p_3$ ) and turbulence ( $p_4$ ) now have?



# This Study: Extending the Model

Can now evaluate a “top-down” knowledge management strategy

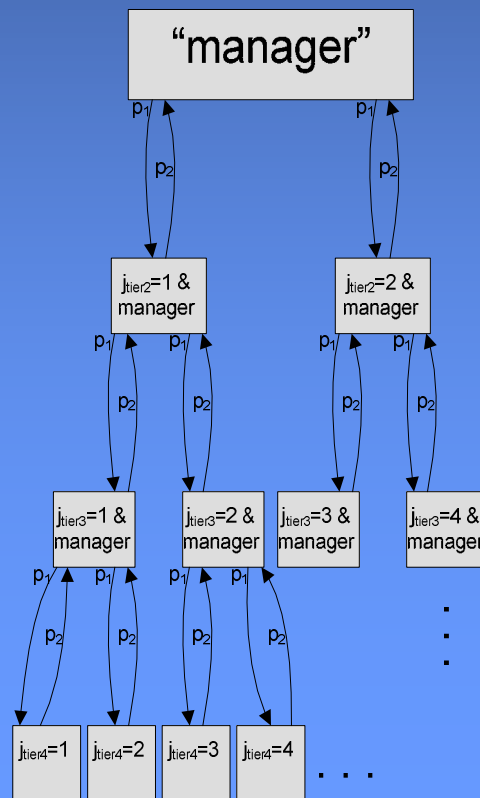
- high exploitation (p1)
- low exploration (p2)



# This Study: Extending the Model

Can now evaluate a “bottom-up” knowledge management strategy

- low exploitation (p1)
- high exploration (p2)



# What About Knowledge Technologies?

March's model excludes consideration of knowledge technologies to help with organizational learning and situational awareness

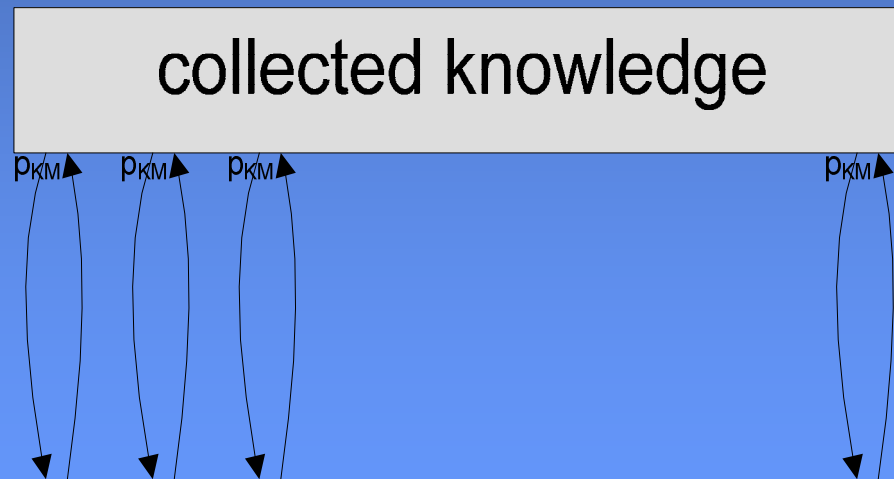
Consider the impact of knowledge technologies

- what effect does increased frequency of use have?
- what effect does including the knowledge of more experts have?

# What About Knowledge Technologies?

Extend model to consider norms of use of knowledge technologies in an organization

- collect the average knowledge of the top (rEX)% expert individuals
- make this collected knowledge available to all managers in org
- each manager has a probability (pKM) of learning from this resource



# Hypotheses and Methods

## Expect to find

- fragmentation of knowledge in a multi-tier hierarchical organization
- multiple tiers lead to inefficient knowledge exchange
- multiple tiers lead to inefficient knowledge flow delay

## With knowledge technologies

- norms of use will counter environmental turbulence
- best norms of use will not be “heavy” use (incur an over-dependence)
- best norms of use will include “top” 1% experts (vs. 10% or 100% of org)

# Hypotheses and Methods

## Build simulation per stated extensions

- validate that simulation matches March's original results
- then test extensions for a flat and multi-tier hierarchy
- report observed relationships

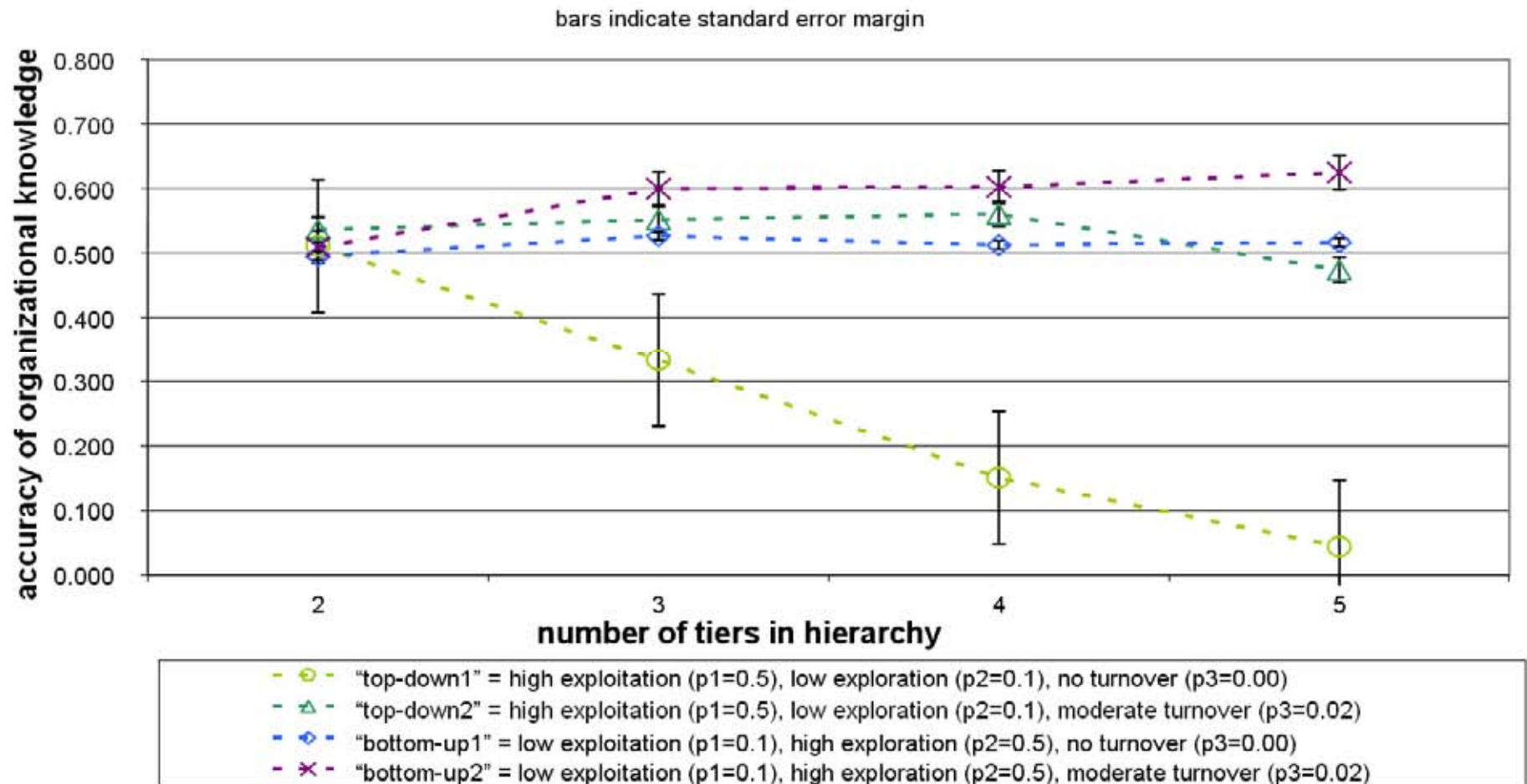
## Simulation coded in Microsoft .NET

- creates model exactly as specified
- outputs results for analysis



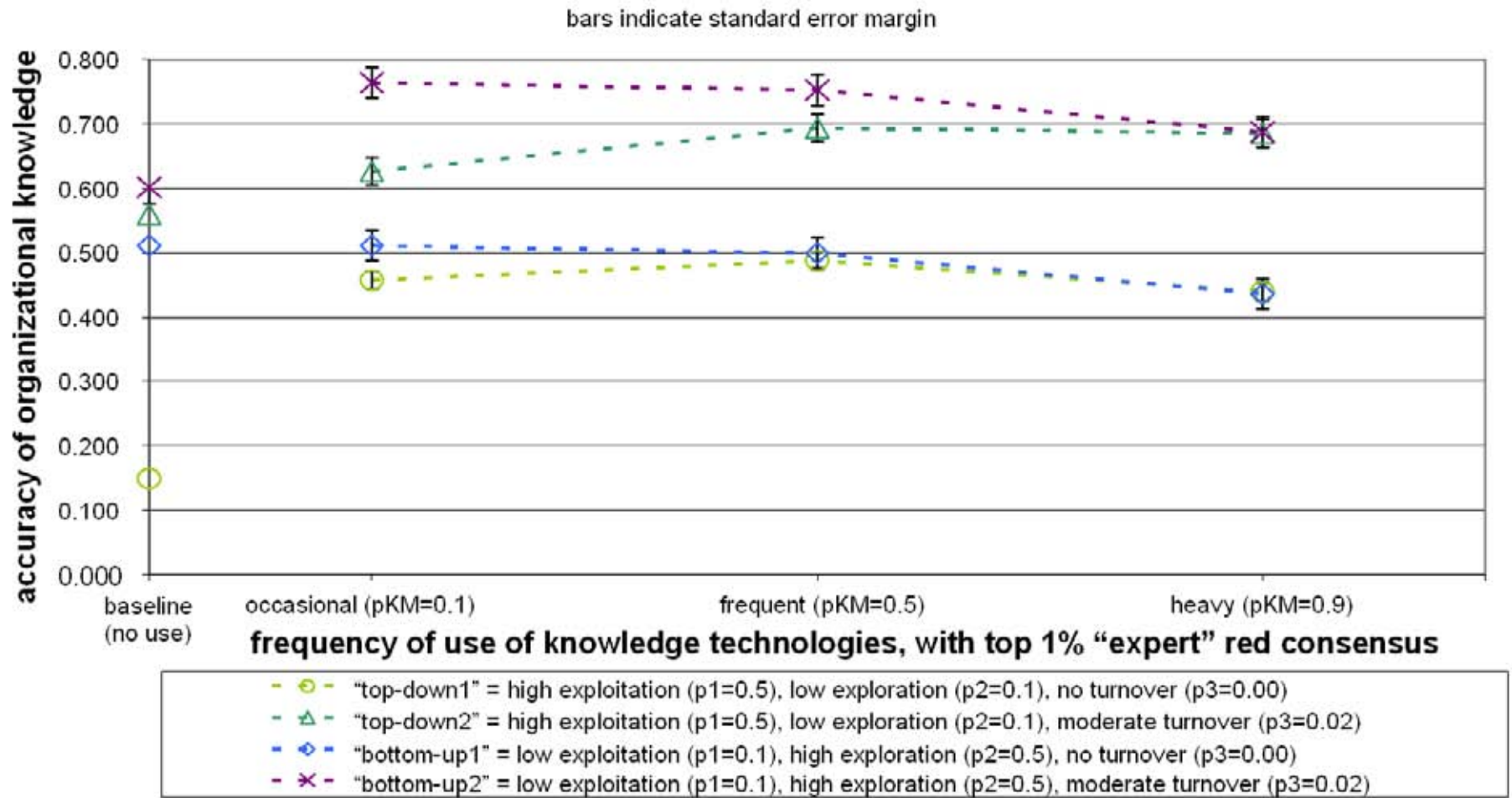
# Results

## Effect of Tiers in Hierarchy on Accuracy of Organizational Knowledge in Response to Environmental Turbulence



# Results

## Effect of Frequency of Use of Knowledge Technologies on Accuracy of Organizational Knowledge in Response to Environmental Turbulence



# Results

## Considered 6,000 possible organizations

- samples drawn from random population of all organizational knowledge management strategies

Coefficients<sup>a,b</sup>

| Model | Unstandardized Coefficients |            | Standardized Coefficients | t       | Sig. | Collinearity Statistics |       |
|-------|-----------------------------|------------|---------------------------|---------|------|-------------------------|-------|
|       | B                           | Std. Error | Beta                      |         |      | Tolerance               | VIF   |
| 1     | (Constant)                  | .658       | .006                      | 117.572 | .000 |                         |       |
|       | probP1                      | .170       | .014                      | .300    | .000 | .176                    | 5.688 |
|       | probP2                      | .124       | .006                      | .215    | .000 | 1.000                   | 1.000 |
|       | probP3                      | 2.118      | .118                      | .182    | .000 | 1.000                   | 1.000 |
|       | probP4                      | -5.646     | .118                      | -.488   | .000 | .999                    | 1.001 |
|       | interactP1Depth             | -.055      | .003                      | -.446   | .000 | .153                    | 6.549 |
|       | countBreadth                | -.001      | .000                      | -.297   | .000 | .520                    | 1.922 |

a. Dependent Variable: corrOrgCMatch

b. Weighted Least Squares Regression - Weighted by countDepth

# Results

## Negative performance impacts

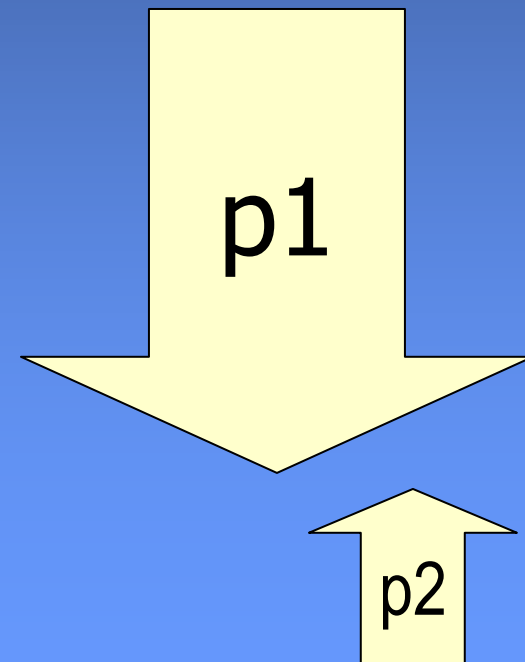
- increasing exploitation has negative consequences for multi-tiered organizations, but not for flat organizations on average
- this reduction in accuracy increases as the number of tiers increase

Coefficients<sup>a,b</sup>

| Model |                 | Unstandardized Coefficients |            | Standardized Coefficients |
|-------|-----------------|-----------------------------|------------|---------------------------|
|       |                 | B                           | Std. Error | Beta                      |
| 1     | (Constant)      | .658                        | .006       |                           |
|       | probP1          | .170                        | .014       | .300                      |
|       | probP2          | .124                        | .006       | .215                      |
|       | probP3          | 2.118                       | .118       | .182                      |
|       | probP4          | -5.646                      | .118       | -.488                     |
|       | interactP1Depth | -.055                       | .003       | -.446                     |
|       | countBreadth    | -.001                       | .000       | -.297                     |

a. Dependent Variable: corrOrgCMatch

b. Weighted Least Squares Regression - Weighted by countDepth



# Results

## Positive performance impacts

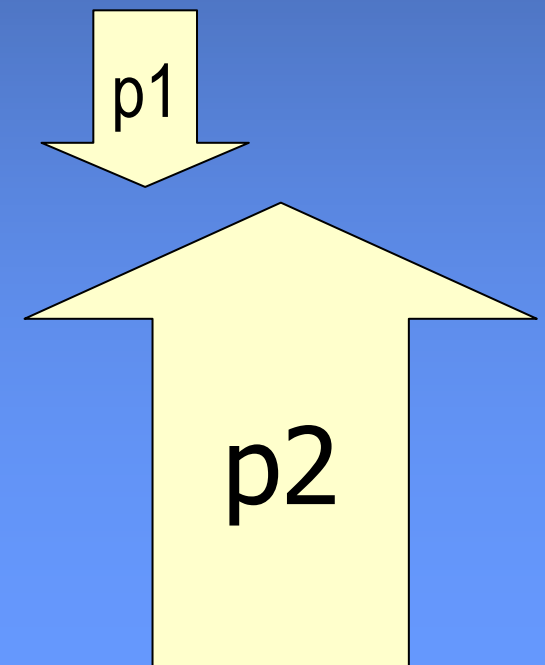
- a moderate level of turnover is beneficial
- across the board, a “bottom-up” strategy of low exploitation and high exploration best counters environmental turbulence

Coefficients<sup>a,b</sup>

| Model |                 | Unstandardized Coefficients |            | Standardized Coefficients |
|-------|-----------------|-----------------------------|------------|---------------------------|
|       |                 | B                           | Std. Error | Beta                      |
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|       | probP3          | 2.118                       | .118       | .182                      |
|       | probP4          | -5.646                      | .118       | -.488                     |
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a. Dependent Variable: corrOrgCMatch

b. Weighted Least Squares Regression - Weighted by countDepth



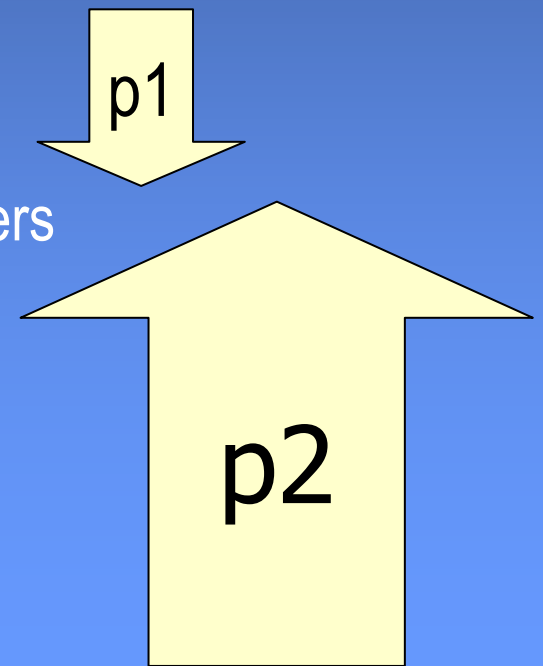
# Results

Constraints on successfully employing knowledge to best adapt is mediated by

- organizational design
- use of knowledge technologies

Organizations need to balance

- fast and slow (less likely to conform to org code) learners
- less about management per se, more about cultivation



Relating This to Research at OII

Managing Knowledge in Turbulent  
Environments

# Relating This to Research at OII

## Global Trends 2015 Report

“The networked global economy  
will be driven by rapid  
and largely unrestricted flows of  
information, ideas...”



# Relating This to Research at OII

## Global Trends 2015 Report

“Less and less control over flows of information, technology, diseases, migrants, arms, and financial transactions...”

# Relating This to Research at OII

## Global Trends 2015 Report

“Effective governance will increasingly be determined by the ability and agility... to exploit increased information flows, new technologies...”

# Relating This to Research at OII

## Increasing fragmentation leads to knowledge gaps

- with bioterrorism response = more 90 different U.S. agencies involved
- with national security = 16 different U.S. intel agencies, spending \$43+ billion
- with energy and environmental security = problems of a global scale

How can our government and business organizations “connect the dots” better?

...top-down strategies are insufficient...

# Relating This to Research at OII

Pioneering bottom-up tools are already present

- reputation systems, prediction markets
- collective intelligence systems, attention economies
- open source collaborations, problem solving forums

Distributed problem-solving networks and knowledge ecosystems to improve intra- and inter-organizational responsiveness

# Knowledge Ecosystems In Action

## Reputation Systems: Y! Answers, Digg.com

The screenshot displays the Yahoo! Answers website. At the top, the "YAHOO! ANSWERS" logo is on the left, and "Sign In" and "New User? Sign Up" links are on the right. Below the logo, there are buttons for "ask." (with a question mark icon), "answer." (with a smiley face icon), and "be a better Genius see Science & Mathematics" (with an exclamation mark icon). A search bar with the placeholder "Search for questions:" is followed by "Search", "Advanced", and "My Profile" buttons. The breadcrumb trail reads "Home > Science & Mathematics > Biology".

On the left sidebar, there is a "Ready to Participate? Get Started!" button with a smiley face icon. Below it, the "Categories" section lists "All Categories", "Science & Mathematics" (expanded), and "Biology" (selected). Under "Science & Mathematics", sub-categories include "Agriculture", "Alternative", and "Astronomy & Space". Under "Biology", sub-categories include "Botany" and "Chemistry".

The main content area is titled "Biology". It features a "Top Biology Answerer" section highlighting "ATP-Man - Level 7 - 1933 Best Answers" with a "Top 10 Answerers" link. Below this are three buttons: "Answer Open Questions", "Discover Resolved Questions", and "Vote Undecided Questions".

The "View by:" section shows "Date" selected and "No. of Answers" as an option. The list of questions includes:

- Which food test is more accurate?**  
★ In [Biology](#) - Asked by [fondls](#) - 0 answers - 5 minutes ago
- What do potatoes use to store energy?**  
★ In [Biology](#) - Asked by [allskittles](#) - 1 answer - 5 minutes ago

# Knowledge Ecosystems In Action

## Prediction Markets: intrade, Foresight Exchange



The Prediction Market

User Name  
Password

[Live Help](#) [Login Help](#) [Log In](#)

[Home](#) [Signup](#) [Markets](#) [Trade](#) [Practice](#) [Forum](#)

**Current Contracts** ?  
Find:  [GO](#)  
[Most Traded](#)  
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[Olympic Games](#)  
[Bird Flu](#)  
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[Climate Change](#)  
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[Financial](#)  
[Legal](#)  
[Politics](#)  
[Weather](#)  
[Show Expired](#)  
[Suggest Contract](#)  
[markets@intrade.com](mailto:markets@intrade.com)

**Current Events - Bird Flu**

| Contract   | Bid | Ask  | Last | Vol  | Chge |
|--|-----|------|------|------|------|
| Asian Bird Flu H5N1 to be confirmed in the U.S (Rule 1.8 Applies)  |     |      |      |      |      |
|  <a href="#">BIRDFLU.USA.MAR08</a><br>Bird Flu (H5N1) to be confirmed in the USA on/before 31 Mar 2008  | 1.5 | 8.5  | 5.5  | 2116 | 0    |
|  <a href="#">BIRDFLU.USA.JUN08</a><br>Bird Flu (H5N1) to be confirmed in the USA on/before 30 Jun 2008  | 3.1 | 16.0 | 12.0 | 1007 | 0    |
|  <a href="#">BIRDFLU.USA.SEP08</a><br>Bird Flu (H5N1) to be confirmed in the USA on/before 30 Sep 2008 | 5.1 | 27.0 | 19.0 | 150  | 0    |

Jan 13 - 4:46PM GMT

# Knowledge Ecosystems In Action

## Collective Intelligence Systems: bigthink, Sermo

The screenshot displays the Big Think website interface, which is organized into several key sections:

- Left Sidebar:**
  - Browse Ideas:** A green header for the navigation menu.
  - Meta:** A list of philosophical and general topics including Faith & Beliefs, Identity, Inspiration, Life & Death, Love & Happiness, Outlook & the Future, Truth & Justice, and Wisdom.
  - Physical:** A list of scientific and cultural topics including Arts & Culture, Business & Economics, History, Media & the Press, Philanthropy, Policy & Politics, Rest & Diversions, Science & Technology, Medicine & Biology, Space & Time, The Environment, The Internet, and The World.
  - You:** A section at the bottom of the sidebar.
- Top Center:** A video player featuring a 'big think' logo, a play button, a progress bar, and a timestamp of 00:00.
- Subtopics:** A section below the video player with a 'SUBTOPICS' header, containing links for Medicine & Biology, Space & Time, The Environment, and The Internet.
- Experts:** A section below subtopics with an 'EXPERTS' header, featuring three expert profiles: Peter Rojas (Co-founder, Engadget), Anthony Fauci (Immunologist; Director, NIAID), and Walt Mossberg (Technology Columnist, The Wall Street Journal).
- Right Sidebar:**
  - IDEAS:** A green header for the ideas section.
  - Re: Is America technologically c...** and **What is the environmental impact...** are two example idea titles.





# Knowledge Ecosystems In Action


## Attention Economies: Seriosity


**Information Overload?**  
**Attack the problem with Attent™**


[→ Try Attent](#) [→ View Demo](#)



 **Attent Is.**


 **Did you know?**


 **How Attent works.**



### Seriosity is Changing the Game

Seriosity's enterprise solutions use psychological and economic principles from multiplayer games to improve collaboration, innovation and productivity. The first use of our innovative approach is a robust solution to address information overload. [more »](#)

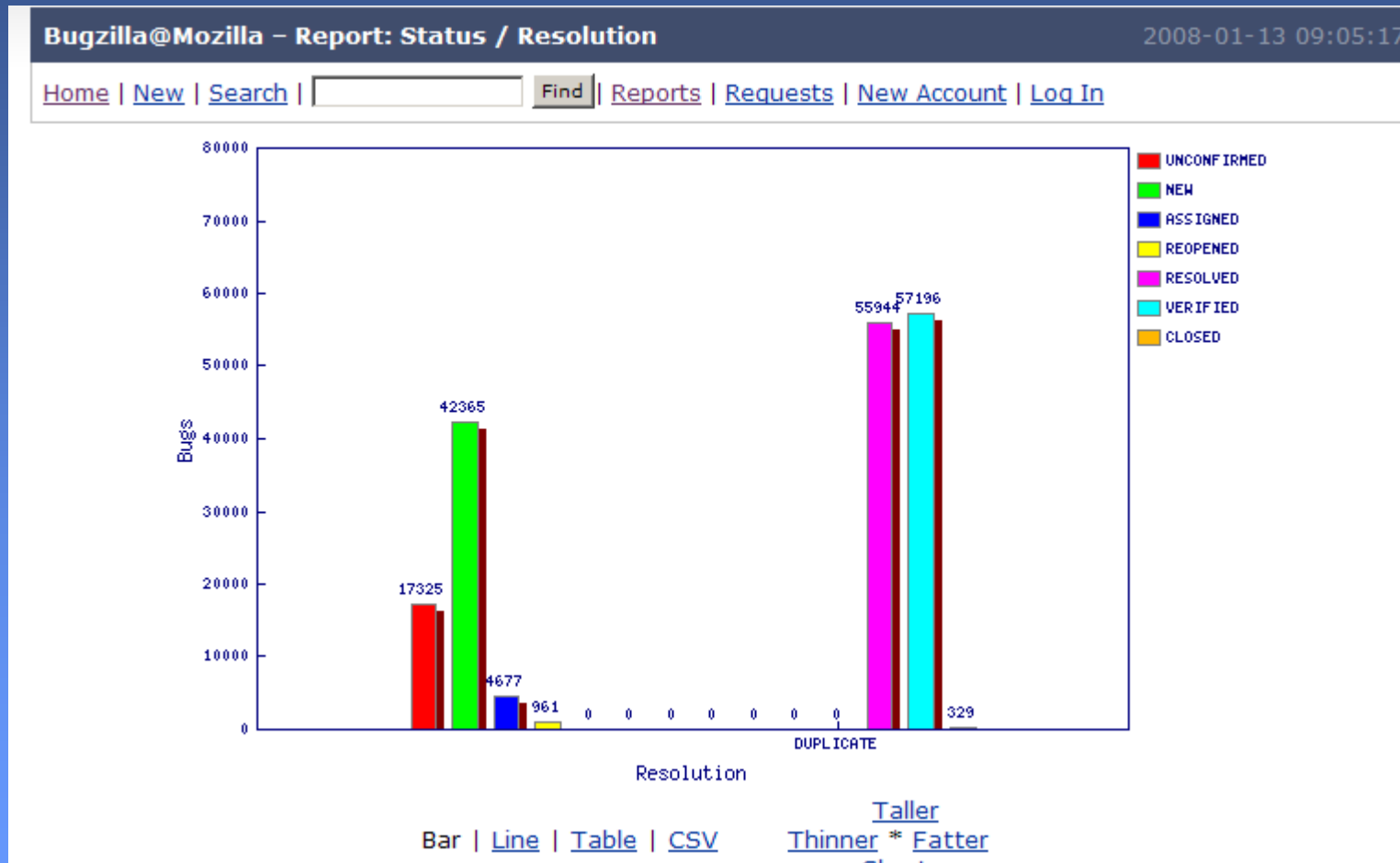
 **IBM Partners with Seriosity**  
Multiplayer games research relevant to enterprise leadership... [»](#)

 **View Demo: Seriosity Attent**  
Quickly learn how Attent solves email overload... [»](#)




# Knowledge Ecosystems In Action

## Open Source Collaborations: Bugzilla, Wikipedia



# Knowledge Ecosystems In Action

## Problem Solving Forums: InnoCentive, SourceForge



Register to be an InnoCentive Solver today.

135,000+ Solvers | 175 Countries | 40 Industry Disciplines and Growing

|                |   |
|----------------|---|
| Seekers        |   |
| Solvers        | + |
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- Business and Entrepreneurship
- Chemistry
- Engineering and Design
- Life Sciences
- Math and Computer Science
- Physical Sciences

Our [Open Innovation Marketplace](#) Challenges are posted by [Seekers](#) (corporations, government agencies, and nonprofit organizations) who are looking for your help with product development and other business and science problems. Each Challenge has a significant cash award associated with it. If your solution is chosen – you win!

# Towards the Future

Consider how our organizations can best leverage technologies, stimuli, and processes to improve

- public health preparedness and outbreak response
- national security and counter-terrorism efforts
- global energy and environmental security
- improved inter-agency collaborations
- strategic intelligence and foresight efforts

# Towards the Future

## Additional references:

- Heckscher, C. and Adler, P. The Firm as a Collaborative Community: Reconstructing Trust in the Knowledge Economy, Oxford, UK: Oxford University Press, 2006.
- Kerr, R., Wolfe, T., Donegan, R., and Pappas, A. “A Holistic Vision for the Analytic Unit,” *Studies in Intelligence* (50:2), 2006, pp. 47-55.
- Majchrzak, A., Jarvenpaa, S., Hollingshead, A. “Coordinating Expertise Among Emergent Groups Responding to Disasters,” *Organization Science* (18:1), 2007, pp. 147-161.

questions? ([dbray@bus.emory.edu](mailto:dbray@bus.emory.edu))