

Net Exchange's

POLICY ANALYSIS MARKET

Market Mechanisms for Policy Decision Support

Final Report to DARPA

Phase I of SBIR DAAH01-02-C-R0030

July 24, 2002

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SBIR Final Report
Net Exchange's Policy Analysis Market
Market Mechanisms for Policy Decision Support

In Phase I of Small Business Innovative Research (SBIR) effort DAAH01-02-C-R030, Net Exchange examined the use of futures markets as decision support tools for U.S. foreign, military, and intelligence policy analysis. The existing body of experience on Information Markets motivated this examination. However, the nature of policy analysis requires a new implementation of information market principles – a realization that formed the starting point for Net Exchange's efforts during Phase I. From this starting point, Net Exchange set out to describe, design, and component test a Policy Analysis Market (PAM) that could realize the promise of applying market mechanisms in support of policy analysis.

BASIC INTUITION AND PROMISE

Futures markets are, in essence, information markets through which parties with different glimpses of the future coalesce those glimpses into predictions, the predictions taking the form of prices. The U.S. policy analysis establishments for intelligence, foreign, and military matters do not lack information as critically as they lack efficient means to coalesce information into quality predictions. The lack of efficient means is not just a matter of independent computer database systems that cannot talk to each other. Quality analysis comes about from a mix of data and expertise – access to more data does not necessarily yield the best analysis.

Effectively pooling expertise is as critical a problem as technically providing for seamless data sharing. And, when various entities wish to conceal specific data and/or sources, pooling expertise may be the only approach available. In discovering prices that establish the flows of mutually beneficial commerce, markets pool the informed, if incomplete, views of many entities while keeping the private knowledge of those entities private. If clear signals of policy-relevant trends and events can be “discovered” through market-like functions, then policy analysis can be improved because expertise is being aided.

PERSPECTIVE ON INFORMATION MARKETS

Any market that informs its participants about something they did not all know prior to going-to-market can be thought of as an information market. By this definition, any market that stays in business for very long is an information market – if the market participants can get better information elsewhere on price, availability, and term structure, then they will go elsewhere. However, “Information Market” usually refers to a market that trades in pure information contracts. A generalized example of such a contract is:

Bob pays \$N for a contract on the future of X. If, at a particular time in the future, X is greater than 4, then Bob will receive \$M.

Because Bob was willing to pay it, the price \$N, in relation to the payoff \$M, indicates Bob's belief of the likelihood that X is greater than 4. If this sort of contract is traded in a process that includes the participation of others who are interested in X, then the price \$N can be thought of as market-derived information.

A number of Information Market types, which trade contracts like the one above, have become quite popular over the past twenty years.¹ Examples include credit derivatives markets and many of the hedging practices used in petrochemicals and electricity.

To the extent that the reinsurance industry now uses market functions to spread the risks of insurance policies, then these actions are also carried out on Information Markets as the basic tradeable, an insurance policy, has the form of an information contract. Then, of course, there is the ancient practice of gambling – any major Sports Book can be thought of as an Information Market.

Recently, the Non-Economic Information Market has gained in notoriety. In this type of market, the tradeable is a pure information contract that is not directly connected with any economic activity. The Iowa Political Stock Market is the best known example of this type. However, the economic significance of sporting events may be far lower than that of a Presidential Election – which is to suggest that markets like the Iowa Political Stock Market are new applications of very old market mechanisms.

INFORMATION MARKETS APPLIED TO POLICY ANALYSIS

In the aftermath of September 11th, there is a desire to predict specific events of great import, and the conventional information market contract would seem to fit the purpose:

“I will take 1:3 odds that Streaking Stallion will win in today's second race at Santa Anita,”

is equivalent to,

“I will pay Lloyds of London 33% of the replacement cost in return for ship and cargo insurance for a single transit to-and-fro, and anchorage in, Kuwait during March of 1987,”

is equivalent to,

“I will pay 33¢ in July 2002 for a security that pays \$1.00 if terrorists attack one or more NFL games in September 2002.”

In the context of a Policy Analysis Market (PAM), a security on a specific event requires that an interest in a potential event be known far enough ahead of time for trading in that

¹ Classic commodities futures markets are not Information Markets by the definition used here since the contracts traded, e.g., wheat futures, can actually result in the delivery of physical items.

security to constructively impact policy analysis. Policy analysis has a time horizon of years. Focusing on specific potential events jumps to the end of policy analysis without engaging in decision support along the way.²

Using the horse racing analogy, a PAM that relied on conventional information market securities would require specific securities for each possible combination of racetrack, day, race, track condition, horse, and competing horses. Further, these securities would need to be defined years in advance – long before many of the relevant horses had been identified or, in the case of 2-year olds, before they even had been born.

A fundamental tenet and five subordinate tenets frame the nature of a worthwhile PAM:

Tenet 0: Augment Current Processes. Markets are not ends-in-themselves; rather, they are one of several means through which the participants in a commerce do business. The basic liquidity that makes a market a dependable place for information discovery comes from the use of the market as a day-to-day business tool. Thus, PAM must be designed to fit into the process of policy analysis

Tenet 1: From General to Specific. Policy analysis is built up from the observation of underlying fundamentals and the expert consideration of interrelationships among these fundamentals. PAM must begin to engage the policy analysis business from the general perspective of predicting the evolution and interaction of fundamentals. As trends and interactions coalesce into perceptions of specific relevant events, PAM must facilitate the inclusion and further refinement of these.

Tenet 2: Consistent Applicability. A functioning market is not like a card game – you do not get to reshuffle the deck each time a group of users decides to engage the process. The nature, issuance, maturity, and transaction of securities in PAM must be based on publicly-understood rules and procedures that change rarely, if at all.

Tenet 3: Involve a Wide Range of Participants. The purpose of PAM is to aggregate expertise across U. S. Government agencies and throughout non-Government centers of expertise. Therefore, PAM must fit the operational modes, deal with the topics of interest, guard the information privacy, and accommodate the concerns of a wide range of participants.

Tenet 4: Being Right must be Valuable. Markets are group processes that function effectively if participants provide valuable insight in the form

² The prediction of specific events is one desired outcome of policy analysis, as are prevention of such events and cause investigation, should prevention fail. Even a James Bond movie contains a bit of investigation before the identity of the potential event is even known, let alone prevented.

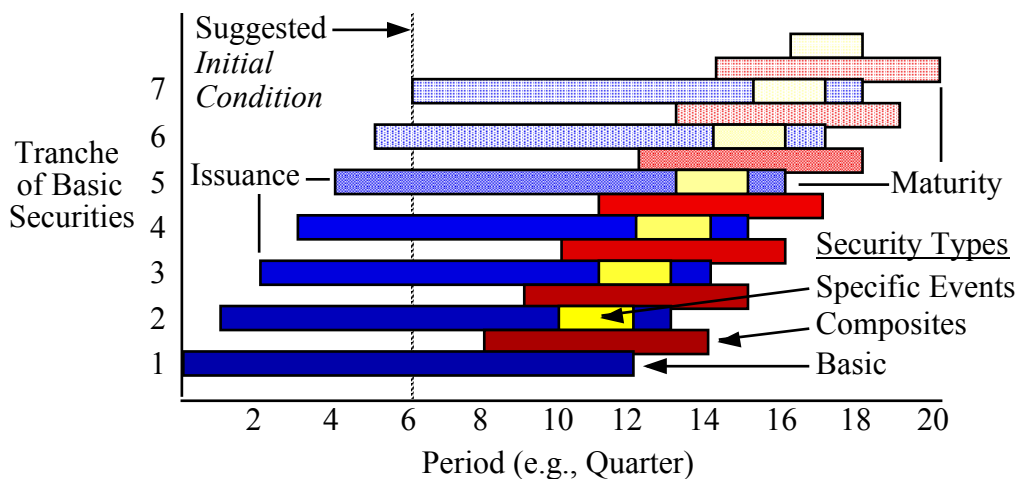
of orders. In return, all participants in the market receive information that is of higher quality than they could have attained through some other process. Free riding will render a market useless if the private gain from providing insightful orders is not greater than the private gain of just watching. Thus, to get participants to provide orders that reflect valuable insight, the participants must know that they will profit from the orders if the future substantiates their insight.

Tenet 5: Specialization must not deter Participation. Policy analysts are specialists (e.g., Jill knows A). Quality analysis requires pooling of special insight (C is likely to happen if A and B happen). PAM must reward special insight without deterring its expression (Jill must be able to profit from stating C given A contingent on B).

The intuition that information markets can be constructively applied to policy analysis seems sound. However, the standard mechanisms and security types do not fulfill these tenets, which is the starting point for Net Exchange’s PAM efforts under SBIR Phase I.

NET EXCHANGE’S PAM DESIGN

Policy analysis is built up from the observation of underlying fundamentals and the expert consideration of interrelationships among these fundamentals. Perceptions of relevant specific events evolve from such analysis. During SBIR Phase I, Net Exchange designed and component tested a PAM capable of implementing a security structure that is in tune with the nature and intent of policy analysis. This security structure evolves from general fundamentals to specific events.



A tranche³ of basic securities is made available at the start of each period, where a period represents the time granularity of PAM. Each tranche is made up of securities that are tied to data series representing economic, civil, and military fundamentals in the countries

³ “Tranche” is a term from the financial industry that identifies a group of securities that have a common purpose, are issued at the same time, and will mature at the same future date.

covered by PAM. Each basic security matures, or pays off, at a time certain in the future – the time horizon of PAM is the lifetime of a basic security.

Each basic security has three discrete states, one of which will pay at the face value of the security and the other two of which will pay nothing. For example, an Egyptian GDP security issued at the beginning of period 2 will mature at the end of period 13. The specific definition of the security is that it tracks the change in GDP between periods 12 and 13. Its three states are neutral (within a band), up (above the band), and down (below the band). The face value of a basic security is the amount of money a trader can pay the market operator for one of each state of the basic security at any time prior to maturity.⁴

Composite securities are derived from basic securities. Future events involve actions that affect data series that underlie more than one basic security. The purpose of the composite type of security is to provide a PAM participant, who has insight into interrelations among basic securities, with a means of expressing this insight and benefiting from the expression if correct. A simple composite is an intersection between two basic securities; e.g., the probability that a decrease in Country X GDP will coincide with an increase in Country X civil unrest. Given an intersection composite, beliefs about conditional probability can be expressed in PAM, which allows for various types of options as composite securities.⁵

To focus the attention of PAM participants, composite securities will not become available for trade until the basic securities on which they are derived are close to maturity. Note also that a composite may mature after a basic security from which it is derived has matured. This is the case for a composite that is also derived from a basic security that matures later; for example, an intersection of one security that matures in period 15 with another that matures in period 16.

As trading activity becomes focused approaching the maturity of a basic security tranche, and focused further by trading in composites derived from these basic securities, specific event securities can be directly included in PAM. These take the form: Event C will or will not happen during period T. Trading throughout the tranche's life has supported the policy analysis that goes into nominating specific event securities. By introducing event securities later, rather than at the earliest point in the time horizon of a PAM, it is much more likely that the events available for trade will be relevant.

As an illustration of how the movement of several PAM securities can suggest a specific event of interest, consider the following question posed by an MSNBC reporter to former Defense Secretary Cohen on July 15, 2002:

⁴ The face value for all basic securities (the state-triplet of neutral, up, & down) is the same; e.g., \$1.00.

⁵ An example of a classic option supportable as a PAM composite security: A Country X analyst knows that civil stability in X is affected by the difference in economic performance between X and Country Y. However, this analyst does not have any special insight into the economic fundamentals of Y. PAM allows this analyst to buy an option that pays off if Y's economy performs at or above a certain level and X experiences an increase in civil unrest while insuring the analyst against lower Y economic performance.

"Earlier this year, military aid to Jordan was increased by \$100,000,000 and we have reports that the U.S. Air Force is assisting in the expansion of several Jordanian airfields in eastern Jordan. Isn't this an indication that Jordan has decided to side with the U.S. in any upcoming campaign against Iraq? Further, isn't this an indication that such a campaign is close at hand?"

To see how this fits into the PAM framework, assume that the following securities are part of basic security tranches:

Security&State	Description of the Security&State in Bold	Matures	Issued
USJ102+ USJ102= USJ102-	A greater than \$25M increase in the flow of funds between the U.S. and Jordan from Q4 2001 to Q1 2002.	Q1 2002	Q2 1999
UjdJ302+ UjdJ302= UjdJ302-	A greater than 10% increase in the number of U.S. military personnel deployed for joint defense activities with Jordan	Q3 2002	Q4 1999
JmaI103+ JmaI103= JmaI103-	A greater than 10% increase in the number of Jordanian military personnel deployed in opposition to Iraq.	Q1 2003	Q2 2000
ImaJ402+ ImaJ402= ImaJ402-	A greater than 10% increase in the number of Iraqi military personnel deployed in opposition to Jordan.	Q4 2002	Q1 2000
UmaI103+ UmaI103= UmaI103-	A greater than 10% increase in the number of U.S. military personnel deployed in opposition to Iraq.	Q1 2003	Q2 2000

Now, consider the specific events suggested by the following intersection securities, (the most basic type of composite securities):

Composite Security	Suggested Meaning	Period Traded
$(USJ102+) \cap (UmaI103+)$	Jordan compensated to not oppose U.S. attack on Iraq in Q1/03	Before Q1/02
$(UjdJ302+) \cap (JmaI103+)$	Jordan to support attack on Iraq from Jordanian territory in Q1/03	Before Q3/02
$(UmaI103+) \cap (JmaI103+)$	Allied attack on Iraq in Q1/03	Before Q1/03
$(UjdJ302+) \cap (ImaJ402+)$	Iraqi preemptive strike U.S. in Jordan	Before Q3/02

Once intersection composite securities exist, more targeted composites can be fashioned, such as a fully insured option on the last of these which might be of great interest to an Iraqi policy expert who does not have any special knowledge of U.S. military plans:

"I will pay $p\epsilon$ for each option that pays \$1.00 if Iraq launches a preemptive strike in the 4th quarter of 2002 against a U.S. build up in Jordan the previous quarter. If the U.S. build up does not occur, I will get my $p\epsilon$ back."

By buying this option in several consecutive quarters, the Iraqi expert has the opportunity to profit from his special insight without facing the downside risk associated with matters about which he has no special insight.

None of the preceding justifications for trading the illustrated composites has required specific event securities. However, all of the preceding justifications might represent only one of several underlying meanings of the composites. If several meanings have attracted interest, then specific event securities can be added to PAM.

The proposed security structure does have an initial condition problem – if PAM begins at the inception of its first tranche of basic securities, then it will be a long while before PAM's participating traders have many interesting things to trade. Since this could undermine the buildup and maintenance of liquidity that would be critical to the worthwhileness of PAM, PAM should be started midway into the life of tranche #1, as illustrated.

PAM is designed to operate at the country level of detail; namely, civil, economic, and military matters are incorporated for separate countries. Data series are required for each country, series that accurately reflect civil affairs (political, social, insurgencies, etc...), economic performance, and interstate military preparation and/or operations. Similarly, U.S. policy involvement is resolved at the country level; so, data series are required for U.S. military and economic involvement with each country.

The 3-state security model designed for PAM has several advantages, among which are:

1. Defining the security with a discrete number of states, rather than as a continuous item, makes it much easier to construct composite securities from different states of the basic securities.
2. The very broad range of conceivable paths for a data series need not be considered explicitly, only the period-to-period movement.
3. If a participant is interested in a path, then an intersection that explicitly represents the path can be constructed from these states.

The security structure that is central to the PAM design is responsive to four of the six tenets described earlier: augment the current processes (0), from general to specific (1), consistent applicability (2), and specialization must not deter participation (5). The remaining two tenets are outside of security design, rather they are programmatic matters: the reward structure for participants who are correct (5) and a broad scope of participation (3) – the latter constrains the former.

Within the U.S. government, there are numerous department sections and independent agencies with policy experts whose participation would be valuable to PAM and who would value participation in PAM. These include the FBI, CIA, DIA, NSA, Foreign Service, Commerce Dept., Homeland Defense, NSC, and many others. Outside the U.S. government, there are substantial and varied reservoirs of policy analyst talent (broadly defined), including the press, academia, think tanks, insurance companies, trade

associations, various NGOs, and, potentially, agencies of other governments. The best PAM would include all such participants, so long as information source privacy is maintained and PAM is not susceptible to manipulation by any collusive group of participants.⁶

It is intended that PAM securities be worth real money and that PAM participants directly receive the payoffs from their security holdings as these mature. However, there are clear prohibitions against the transfer of money to-and-fro government and non-government entities. Therefore, PAM will be operated as two separate instantiations – the same base securities covering the same countries will form the foundation of twin-PAMS, one for the U. S. government (PAM #1) and one for everyone else (PAM #2). But just as with twins that start out identical, PAM #1 and PAM #2 will diverge in the composite and specific event securities that are traded.

PAM #1 would have to be operated so that it does not violate congressional laws preventing the transfer of money between government agencies that are funded through different authorization/appropriation acts. The most direct approach would seem to be for the Dept. of Homeland Defense to operate PAM #1 and to provide all PAM #1 participants with the means to buy into PAM. Each participant would be able to keep all of its winnings. The entire PAM #1 budget would be authorized and appropriated for expenditure. All inter-agency net money flow would be from the Dept. of Homeland Defense to individuals in other departments and agencies. The *winnings* kept by employees of the Department of Homeland Defense would be booked as bonuses and would be so authorized in the funding legislation for PAM #1.⁷

PHASE I WORK TOWARD REALIZING NET EXCHANGE'S PAM DESIGN

Realizing a PAM that can effectively trade the security structure described requires a system that can operate consistently for many years and service the trading interests of a population that is quite small relative to the number of securities in the market.

Conventional, human-intermediated markets, such as floor post markets (NYSE), open outcry (CHEM), and over the counter (OTC) brokerage (NASDAQ), have expensive overheads. These systems are not justified for a PAM operation that features small trading populations in a context that is not directly connected with any valuable stocks, commodities, or other commerce. From a practical perspective, therefore, PAM must operate as an automated market with very little day-to-day human oversight of operations.

⁶ Information privacy is provided by the general nature of the basic securities and the fact that the nomination of specific securities is voluntary; so, if a participant wishes to keep a specific insight private, then he or she can just stay quiet. Regarding manipulation, Appendix D reviews a manipulation study performed at George Mason University as part of this SBIR Phase I effort.

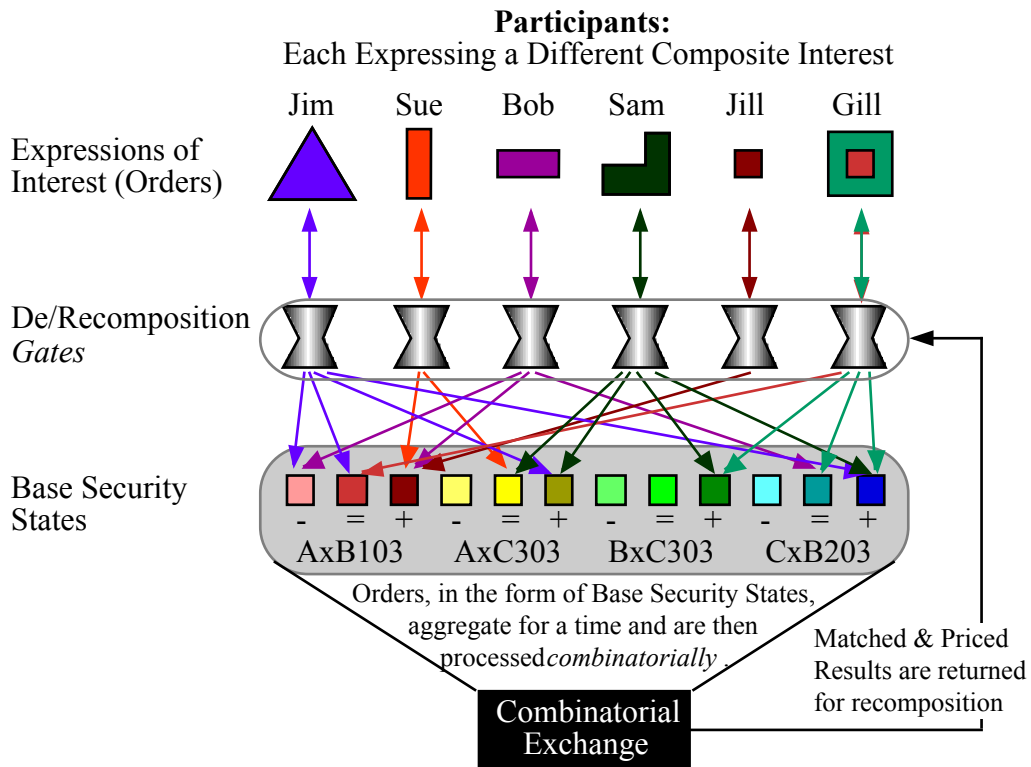
⁷ The size of funding required for PAM #1 security allotments is never likely to exceed more than \$5,000,000 per year for a full-scale PAM.

Thinness is the critical condition affecting a trading process when the trading population is small relative to the number of securities available for trade. To get a handle on the significance of thinness, consider first something called Fundamental Liquidity:

Fundamental Liquidity. The trades that could be identified among a group of interested parties during a period of time if each party expressed its true interests and all possible trades among these interests could be examined to determine the group-wide most valuable set of trades.

Any trading system, in any trading environment, is unlikely to attain the fundamental liquidity for that environment. The shortfall between realized and fundamental liquidity is exacerbated when the market is thin. In the case of PAM, the shortfall can be worsened by the fact that a participant's true trading interests may most often be for composite securities rather than base securities. These composites are made up of the base securities, so PAM's fundamental liquidity is defined relative to the base securities. However, it may be quite rare that in any given trading phase more than one participant is interested in the same exact composite as is another participant.

It is common that participants in a market have composite interests. A number of trading and commerce systems have evolved to explicitly process composite trades when the underlying liquidity is too low for serial trading to support the fulfillment of composite interests. Deal Making – often called brokering – is a classic human-intermediated system for processing composite trades. Computer-intermediated processes designed to make deals among composite interests are called *combinatorial*. The figure below illustrates the basics of a combinatorial process in the context of PAM.



Most expressions of interest involve composite securities. Composite securities define relationships among base securities (buying and/or selling). A combinatorial exchange process identifies multilateral deals among orders that require specific combinations of securities, or packages. With the addition of Gates that serve to decompose orders into base security packages and then recombine matched trades back into composites, a combinatorial exchange process is a natural choice for PAM. Since trades are found at the base security level and are identified multilaterally, a combinatorial exchange process can bring realized PAM liquidity much closer to its fundamental liquidity than could a process that focused on bilaterally matching orders for composite securities.⁸

During SBIR Phase I, Net Exchange built a simple combinatorial market process to demonstrate the application of this technique to the PAM security structure. A two-country (plus the U. S.) model scenario was constructed and eight students at George Mason University (GMU) participated in four days of software debugging and functionality tests. The results were supportive of the basic technique, though the scenario was highly stylized, the participants were novices to the environment, and what was tested was only a piece of the PAM design. This SBIR Phase I test can best be seen as a component test – much was learned for later improvement of the combinatorial component and for its integration into the whole PAM system. This test is described in detail in Appendix A.

A feature of the combinatorial exchange process that might constrain its worth to PAM is the need to aggregate orders over a period of time prior to processing. Aggregating expressions on interest at one point in time, and from among many PAM participants, increases the chance of servicing a high percentage of the fundamental liquidity. However, PAM must provide that the circumstances are right for many PAM participants to submit their earnest expressions of interest during the same Call for Aggregation. Just announcing that such a Call will happen is insufficient to guarantee that orders will be submitted that will result in much trading.

Prior to a Call for Aggregation, it would be helpful for each PAM participant to have some idea about the interests of other PAM participants. It is also reasonable to assume that a PAM participant values the ability to trade on a smaller scale in between these Aggregation Calls. An OTC automated market maker (OTCMM) can provide this inter-Aggregation trading ability, and information from the OTCMM trades can guide the participants' decisions for the Aggregation Calls.⁹ Appendix B describes an OTCMM that was designed by a faculty member at GMU and tested during Phase I.

⁸ Composite securities that involve base security intersections are decomposed into structures that are more involved than just straightforward combinations of base securities, but the principle is, essentially, as illustrated. This is covered in greater detail in Appendix A.

⁹ An OTCMM is probably the best means to introduce, or issue, the base security intersections on which the composite securities rely. In the combinatorial component test, issuance auctions were held for these intersections. Inter-Aggregation OTCMM trading may be a much better means for such issuance.

The table below summarizes the extent of component testing conducted for the Net Exchange PAM design during SBIR Phase I. The details behind this summary can be found in the various Appendices. A conservative conclusion can be stated with high certainty: sufficient research and component testing was performed during SBIR Phase I to indicate that Net Exchange’s PAM design is implementable in the near-term.

Design Component/Issue	Examination during Phase I	Details Reported in
Trading Composite Securities	Combinatorial Exchange demonstrated in the Context of a PAM-Scenario	Appendix A
OTC Automated Market-Maker	Basic Version produced and tested	Appendix B
Inclusion of Specific Event Securities as Time draws Near	Reliance on the body of Research and Experience on Conventional Info. Markets	Public Literature
Data Series Definition, Production, and Judging	The Economist Intelligence Unit identified for Roles – Agreement in Principle	Appendix C
Susceptibility to Manipulation	Comparative Experiments performed at GMU – Info. Mkts. appear robust	Appendix D
Legality, vis-à-vis Securities Regulations, of operating PAM	Survey of Precedents – PAM appears to be either outside of or compliant with existing Regulations	Appendix E

SUMMARY

In Phase I of SBIR effort DAAH01-02-C-R030, Net Exchange established the design and basic components required for a Policy Analysis Market (PAM) that would provide long-term decision support regarding U.S. foreign, military, and intelligence policy concerns. Though the presumed promise for this approach is based from the demonstrated performance of various types of information market, the nature of policy analysis requires a new information market implementation. In its Phase I SBIR efforts, Net Exchange designed such a new implementation, then various components of that design were built and component tested. The results of this Phase I are positive, though not conclusive – the proposed PAM design appears well-founded and tractable in the near-term. Plans for moving forward into a field test of a PAM of useful scope and scale will be dealt with under separate cover.

Appendix A: Combinatorial Exchange Demonstration in a PAM Scenario

On June 4, 2002, eight students at George Mason University began four days of application testing and trading on a demonstration PAM trading system. The system was designed at built by Net Exchange and was operated from the San Diego offices of Net Exchange over the world wide web – the students accessed the application over a web browser. A small scale PAM scenario was constructed to provide context for these efforts.

Included in this appendix are four items:

1. The dossier handed out to each participant (this has been modified to include the private information supplied to each of the eight): “Introduction and Participant Dossier: Policy Analysis Market for the Defense and Intelligence Communities”
2. A high-level, helpful hints accompaniment to the Dossier: “PAM Demonstration, 4 June 2002: Explanations and Helpful Hints.”
3. A more in depth and technical description: “A Quick Guide to PAM.”
4. Three screen shots of the demonstration application.

The demonstration served as a component test for the use of combinatorial processes to express interests and pursue trades based on conditional probabilities. Though the scenario was highly stylized, the trading behavior of the students indicates that they understood how to interface with the system based on the private insight contained in their dossier and the public information available through the demonstration market.

Introduction and Participant Dossier

Policy Analysis Market for the Defense and Intelligence Communities

Net Exchange, 4 June 2002

Net Exchange is producing an experimental futures market for the Defense Advanced Research Projects Administration (DARPA). Futures markets are, in essence, information markets through which parties with different glimpses of the future can coalesce those glimpses into predictions, the predictions taking the form of prices. The U.S. intelligence and security establishments do not lack information as critically as they lack efficient means to coalesce information into quality predictions from which policy can be directed. To this end, Net Exchange is engaged in a project to harness market mechanisms in the service of national security policy analysis. A project we are calling PAM (Policy Analysis Market).

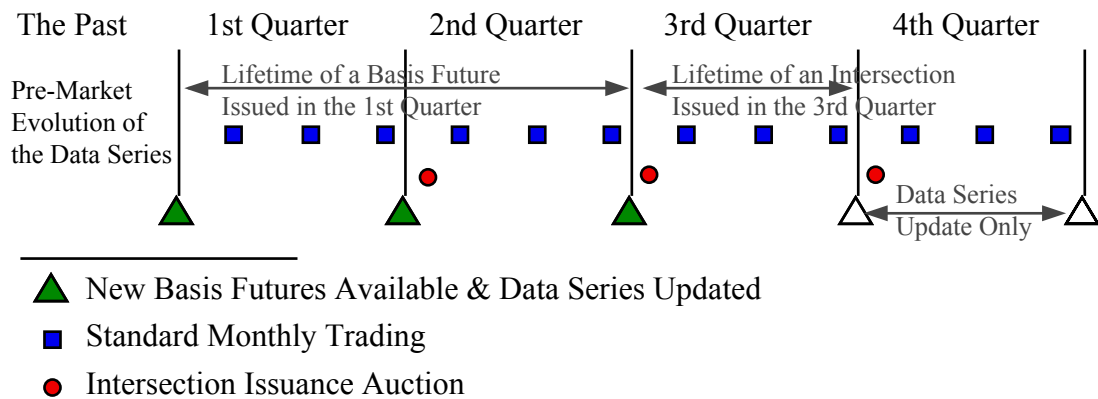
What you are about to participate in is the demonstration of a highly-stylized version of PAM. Developments in and between two fictitious countries, Bobland and Sueland, and the interaction of U.S. policies with these developments, will be simulated over the course of a year. Trading will be monthly, with twelve standard trading sessions and three issuance auctions, which will be described shortly. There are eleven data series, reported quarterly, that form the basis for the futures you may trade in PAM:

4. **Beh** – Bobland Economic Health
5. **Seh** – Sueland Economic Health
6. **Ueh** – U.S. Economic Health
7. **Bcv** – Bobland civil unrest
8. **Scv** – Sueland civil unrest
9. **Bma** – Bobland military actions against Sueland
10. **Sma** – Sueland military actions against Bobland
11. **USb** – Total flow of funds from the U.S. to Bobland
12. **USs** – Total flow of funds from the U.S. to Sueland
13. **Umb** – U.S. military deployments in support of Bobland
14. **Ums** – U.S. military deployments in support of Sueland

It should be apparent that these data series need not be independent; e.g., civil unrest can impact economic health. Predicting these interdependencies is the main intent of PAM, or, more to the point, predicting such interdependencies more effectively than conventional means of information analysis. The demonstration you are about to participate in is a first step on this hoped-for path to improved information analysis – and you will be paid rather well if you effectively exploit the specialized glimpse of information you are provided.

Market Structure and Operations

There are three types of market operations in this demonstration: (i) availability of new futures based on the eleven data series (basis futures), (ii) standard trading, and (iii) intersection issuance auctions. These operations will be scheduled as illustrated.



Prior to the beginning of the demonstration, each participant's account will be credited with £5,000. In trading actions, short selling is allowed; so, issuance of futures occurs through transactions that are *made good* when the system debits the seller's funds account in exchange for a number of *Market Baskets* sufficient to supply the buyer with the futures purchased.

A Market Basket is the set of three futures associated with a particular quarter of maturity and data series. There are eleven Market Baskets for each quarter of maturity; e.g., for futures that become available at the start of the 1st Quarter:

- For **Beh**: Beh2-, Beh2=, Beh2+
- For **Seh**: Seh2-, Seh2=, Seh2+
- For **Ueh**: Ueh2-, Ueh2=, Ueh2+
- For **Bcv**: Bcv2-, Bcv2= and so on for the 33 *states* of the 11 data series.

Each future that becomes available at the start of the 1st Quarter matures at the end of the 2nd Quarter; hence the "2" in the name of each future listed above. Each future is defined relative to the evolution of its data series; e.g., Beh2- means that between the end of the 1st Quarter and the end of the 2nd Quarter the economic health of Bobland decreased. Thus, the three possible states of quarter-to-quarter evolution are covered; i.e., decrease, neutral, and increase. Similar futures, differing only in their period of maturity, will be issued at the start of the 2nd and 3rd Quarters, these will mature at the end of the 3rd and 4th Quarters, respectively. *When a future matures, it pays off £1 or nothing.*

As an example: Two participants transact 100 of **Scv2+**, at £0.40 per future (£40.00 total). The buyer's funds account is debited £40.00 and his/her futures account is credited with 100 **Scv2+**. The seller automatically buys 100 **Scv2** Market Baskets from the market for £100.00. The seller's funds account is debited £100.00 and his/her futures account is credited with 100 **Scv2-** and 100 **Scv2=**. A subsequent sale by this seller involving either of the futures it now has in his/her account will be filled from these exiting balances before any additional Market Basket operations are required.

These basis futures are traded in the standard monthly trading sessions. The market mechanism used for these sessions will be a two-sided combinatorial process, which will be described by the laboratory proctor separate from this dossier. Simple trading of these futures might not, however, allow for the likelihood of suspected interdependencies to be *tested* in the market.

To coax out suspected interdependencies among the events and policies that underlie data series, you will be allowed to have the market issue futures composed of intersections between individual futures. Intersection issuance auctions will be held at the start of the 2nd, 3rd, and 4th Quarters. Unlike the basis futures, the intersection future matures at the end of the quarter of its issuance. An intersection future may involve any two basis futures in existence when its issuance auction is held so long as at least one of the two matures at the end of the current Quarter and they are not from the same series.

The market mechanism used for these intersection future issuance auctions is a multi-round sealed bid auction, which will be described by the laboratory proctor separate from this dossier. One critical restriction of these auctions is that only four intersection futures may be issued from any one auction.

General Information Environment

Each of the eleven data series will evolve based on a random process that is somewhat dependent on the series' history. At the start of a demonstration, each participant will be able to examine the recent past history of all eleven data series. During a demonstration, the updated values for each data series will be posted.

Your “Player” and your Specialized Information

There are eight players in a demonstration, distributed as; two Bobland Experts, two Sueland Experts, two Regional Experts, and two United States Policy Experts. Each player has specialized knowledge of three relationships, each of which involves the evolution of two or more basis futures. These three are unique to each participant; i.e., there are 24 such relationships.

Each special relationship informs of an *almost* certain consequence of a pattern among the involved basis futures. The *almost* here covers the possibility that two or more of the 24 might be in conflict during a quarter. Such a possibility is highly unlikely and, if it occurs, will be resolved as either a *push* or by the randomly determined deactivation, for that quarter, of a subset of the conflicting relationships. Even under this *almost* caveat, the specialized information will provide its holder with a far-clearer glimpse of part of the future than would reliance on the generally available information.

You are a Bobland Expert

Special Insight #1: Bobland is prone to civil unrest when economic times are hard. If **Beh** should fall to or below 97, then **Bcv** will increase. There is no lead or lag in this relationship – it is caused by what Bobs are experiencing rather than their watching the quarterly statistics.

Special Insight #2: Bobland military posturing versus Sueland can be affected by U.S. military deployment to Sueland. For any quarter in which **Ums** reaches or exceeds 103, Bobland will react *in the next quarter* by decreasing **Bma**.

Special Insight #3: Sueland military actions can damage the Bobland economy. In any quarter that **Sma** reaches or exceeds 103, **Beh** in the same quarter will decrease.

Username: user1

Password:

You are a Bobland Expert

Special Insight #1: Bobland has a fairly active trade with the United States, which, naturally, responds to domestic demand. Whenever **Beh** reaches or exceeds 103, **USb** will increase. There is no lead or lag in this relationship – it is a coincident consequence of domestic demand.

Special Insight #2: The government of Bobland does not like the prospect of a military alliance between the United States and its old adversary, Sueland. Bobland cannot confront the United States directly; however, if it judges conditions to be bad enough, the Bobland government will result to state sponsored terrorism against the U.S. Whenever **Ums** reaches or exceeds 106, Bobland-backed terrorist activities in the U.S. will cause **Ueh** to decrease **in the same quarter**.

Special Insight #3: A severe economic crisis in Bobland concerns the United States for various reasons. Whenever **Beh** decreases to or below 95, foreign aid from the United States causes **USb** to **increase in the next quarter**.

Username: user2

Password:

You are a Sueland Expert

Special Insight #1: Sueland is prone to civil unrest when economic times are hard. If **Seh** should fall to or below 97, then **Scv** will increase. There is no lead or lag in this relationship – it is caused by what Sues are experiencing rather than their watching the quarterly statistics.

Special Insight #2: Sueland military posturing versus Bobland can be affected by U.S. military deployment to Bobland. For any quarter in which **Umb** reaches or exceeds 103, Sueland will react *in the next quarter* by decreasing **Sma**.

Special Insight #3: Bobland military actions can damage the Sueland economy. In any quarter that **Bma** reaches or exceeds 103, **Seh** in the same quarter will decrease.

Username: user3

Password:

You are a Sueland Expert

Special Insight #1: Sueland has a fairly active trade with the United States, which naturally, responds to domestic demand. Whenever **Seh** reaches or exceeds 103, **USs** will increase. There is no lead or lag in this relationship – it is a coincident consequence of domestic demand.

Special Insight #2: The government of Sueland does not like the prospect of a military alliance between the United States and its old adversary, Bobland. Sueland cannot confront the United States directly; however, if it judges conditions to be bad enough, the Sueland government will resort to state sponsored terrorism against the U.S. Whenever **Umb** reaches or exceeds 106, Sueland-backed terrorist activities in the U.S. will cause **Ueh** to decrease **in the same quarter**.

Special Insight #3: A severe economic crisis in Sueland concerns the United States for various reasons. Whenever **Seh** decreases to or below 95, foreign aid from the United States causes **USs** to **increase in the next quarter**.

Username: user4

Password:

You are a Regional Economics Expert

Special Insight #1: Bobs do not like it when their lot in life declines relative to that of their neighbors, the Sues. Whenever **(Seh – Beh)** reaches or exceeds 3, **Bcv** will increase **in the next quarter**.

Special Insight #2: Sues do not like it when their lot in life declines relative to that of their neighbors, the Bobs. Whenever **(Beh – Seh)** reaches or exceeds 3, **Scv** will increase **in the next quarter**.

Special Insight #3: There are powerful Non-Governmental Organizations (NGOs) that oppose U.S. commercial influence in the region, which they deem Cultural Imperialism. In any quarter that **(USb + USs)** reach or exceeds 210, one or more of these NGOs will commit a terrorist action that decreases **Ueh in the same quarter**.

Username: user5

Password:

You are a Regional Military Expert

Special Insight #1: There is nothing like a little war to justify the sort of Marshal Law that the government of Bobland prefers to employ in the face of heightened civil unrest. Whenever **Bcv** reaches or exceeds 103, **Bma** will be increased **in the next quarter**.

Special Insight #2: There is nothing like a little war to justify the sort of Marshal Law that the government of Sueland prefers to employ in the face of heightened civil unrest. Whenever **Scv** reaches or exceeds 103, **Sma** will be increased **in the next quarter**.

Special Insight #3: There are powerful Non-Governmental Organizations (NGOs) that oppose U.S. military influence in the region. In any quarter that (**Umb + Ums**) reach or exceeds 210, one or more of these NGOs will commit a terrorist action that decreases **Ueh in the same quarter**.

Username: user6

Password:

You are a United States Policy Expert

Special Insight #1: The United States values stability in the Bob/Sue Region; thus, approximate military parity between Bobland and Sueland is preferred. Whenever (**Bma – Sma**) reaches or exceeds 3, **Ums** will increase **in the next quarter**.

Special Insight #2: The United States values stability in the Bob/Sue Region; thus, approximate military parity between Bobland and Sueland is preferred. Whenever (**Sma – Bma**) reaches or exceeds 3, **Umb** will increase **in the next quarter**.

Special Insight #3: If the U.S. economy weakens, so does the flow of trade and aid to Sueland. Whenever **Ueh** decreases to or below 97, **USs** will decrease **in the same quarter**.

Username: user7

Password:

You are a United States Policy Expert

Special Insight #1: It may come to pass that the United States wishes to destabilize the government of Bobland. This can be best accomplished through backing a Bob insurgency movement, but this requires access through the neighboring country of

Sueland. U.S. support to the Bob insurgency is thus disguised as aid to Sueland. Whenever ($U\$s - U\b) reaches or exceeds 3, Bcv will increase **in the next quarter**.

Special Insight #2: It may come to pass that the United States wishes to destabilize the government of Sueland. This can be best accomplished through backing a Sue insurgency movement, but this requires access through the neighboring country of Bobland. U.S. support to the Sue insurgency is thus disguised as aid to Bobland. Whenever ($U\$b - U\s) reaches or exceeds 3, Scv will increase **in the next quarter**.

Special Insight #3: If the U.S. economy weakens, so does the flow of trade and aid to Bodland. Whenever Ueh decreases to or below 97, $U\$b$ will decrease **in the same quarter**.

Username: user8

Password:

PAM Demonstration, 4 June 2002

Explanations and Helpful Hints

PAM operates off of eleven data series that describe certain conditions and policies in the hypothetical Bobland/Sueland Region. These events and policies tend to progress from quarter to quarter within bounds that the governments and populaces of Bobland, Sueland, and the United States (an involved party from outside the region) have come to expect and with which they are comfortable. However, specific events, policy shifts, or other changes occasionally result in one or more of these data series diverging from the expected and comfortable bounds. Predicting these divergences and their consequences is the point of PAM and the means through which you, as a participant can make a fair bit of money.

Overview of your Specialized Information

Each participant is provided with three pieces of specialized information – information known only to him or her. Each of these pieces deals with a bound defined by one or more of the eleven data series; e.g., if series **A** meets or exceeds 104, then series **B** will decrease.¹⁰ While the triggering series is within its bounds, the value of the insight is still *in expectation* – the trigger may not occur. A participant who has special insight regarding **B conditional on A exceeding a bound** simply has the ability to make a more educated guess than does any other participant.

Standard Trading – Estimating the future of the Data Series

If a PAM participant has special insight on **B conditional on A exceeding a bound**, then the information will be more valuable if he or she has some understanding of how likely **A** is to exceed the relevant bound. At the beginning of a demonstration, you are provided with five quarters of data series statistics. These values have been produced through the following random process:

15. All eleven series start at a normalized value of 100
16. A random process is applied to each series to determine whether it increases, stays the same, or decreases in the next quarter.
17. If the result of (2) is for the series to stay the same, then (2) is repeated in the next quarter.
18. If the result of (2) is for the series to increase, then the series will be updated through another random process that favors a further increase. If a further sequential increase occurs, then subsequent updates will favor leveling off or declining.

¹⁰ It is possible that some other relationship, known of by another participant, is set to trigger series **B** differently (an increase, in this case). In such a case, the conflicting possibilities will either cancel each other out (a *push*) or be decided between through the flip of a coin or some other random process.

19. If the result of (2) is for the series to decrease, then the series will be updated through another random process that favors a further decrease. If a further sequential decrease occurs, then subsequent updates will favor leveling off or increasing.
20. All data series continue to evolve using extensions of (3), (4), and (5).
21. The only exception to (6) is that all of the bounds become effective starting with the series determinations at the 1st Quarter end/2nd Quarter start.

Due to step (7) above, all of the specialized information remains ineffective throughout the five quarters of historical statistics. Because this part of the data series cannot be affected by the bounds, examination of the data series by the participants can provide estimates of how the series evolve independently – estimates that are not biased by concerns that bounds have been exceeded and the series have thus become interdependent.

By estimating how the data series evolve, participants can have a better idea of how to value and when to use their specialized information. Trading securities based on the future evolution of these series provides a means of aggregating different participant's estimates and resolving a better estimate through price discovery. For example, if your insight includes a bound on **A** at 104 and the current level of **A** is 103, you should value a good estimate of the likelihood that **A** will reach 104 in the next quarter (in the nomenclature of PAM, if the current quarter is 2, you are interested in the price of **A3+**).

The initial purpose of the quarterly standard trading operations is to assist the participants in estimating the future of the data series.

It is reasonable to assume that the first thing a participant will do when a demonstration begins is to examine the most recent value of the statistics on which their insight is based. If one such statistic is just below, at, or just above the bound called out in the insight, then the participant will want information from trades involving the evolution of that statistic. The participant can get the information he or she is interested in by being a buyer or a seller. If the bound is a number above 100 and the statistic has yet to meet the bound, then the participant might most immediately wish to trade the Up state; however, trading the Down and Equal states of the statistic can provide the desired information, as well. If the bound is a number less than 100 and the statistic has yet to meet the bound, this reverses and the participant may most immediately wish to trade the Down state; however, just as before, trading in the other states can provide the desired information.

If none of the statistics on which a participant's insight is based is anywhere close to its bound, then the participant holding such insight has no specific reason to care about "his/her" statistics. In this case, the participant should actively observe the information distributed during order submission and try to make money by picking off the bids and/or asks of participants who are after information on "their" statistics but who, in this participant's mind, have misestimated the evolution of the statistics.

Intersection Issuance and Trading -- Making Money from your Special Insight

In the companion document, “A Quick Guide to PAM,” which you should have received separately, the merit of trading intersections and the technique for trading options based on intersections is explained and illustrated. The use of these *compound futures*, futures composed of two states from different data series, is the most effective way to leverage the potential value of your special insight. But to make use of these intersections, they must first be issued and issuance of these intersections is endogenously determined by the participants competing over the limited number of intersections that can be issued.

Before describing the issuance process, though, it should be made clear that trading these intersections is not a matter of one party who has a *Sure Thing* finding some fool who will take the other side. When the intersections are traded, both at issuance and throughout their one quarter of existence, the value of the data series on which the triggering security is based will quite likely not be certain (in the relationship, **A-** will happen conditional on **B+** happening, **B+** is the trigger). In those cases where the basis data series has diverged so far from 100 that the relationship between the two data series is obvious, the value of the special insight has vanished and no one will want to issue, buy, or sell the intersection. The relationship will not be obvious when the trigger is near its bound, which is precisely when the holder of the information will most highly value the issuance and trading of the intersection – opening up the possibility that he or she will overvalue the intersection due to mis-estimation of the likelihood of the trigger.

An issuance auction will be held at the start of the 2nd, 3rd, and 4th Quarters. In the 2nd Quarter issuance auction, orders may be submitted for intersections containing futures that mature in the 2nd and 3rd Quarters, with the caveat that an intersection issued at the start of a Quarter must contain at least one future that matures at the end of the quarter of issuance. Thus, the intersection (Bcv2+, Beh3-) can be issued in the 2nd Quarter auction but not the intersection (Bcv3+, Beh3-).

As the standard trading system allows short selling, all that a participant has to do in an issuance auction is get some of his or her valued intersection issued, from that point until its earliest-maturing component matures the intersection is *in play*. In an issuance auction, you are allowed to buy from yourself – just submit a buy order at a bid above the ask of a separate sell order that you also submit. So, one might imagine that you just buy/sell all the intersections in which you have an interest, they get issued, and you proceed to standard trading. Not so fast!

From each issuance auction, only four (4) intersections can be issued. The auction system will select the four that maximize the total difference between submitted buy and sell orders. Further, issuance will occur only after three rounds of the auction have been run. After the first two rounds, the *currently winning* intersections will be publicly posted along with the currently submitted but not winning. As certain intersections are bid up, even through self-buy/sell efforts, some participants will conclude that at current

prices they do not want to buy an intersection that they have been bidding. Such a participant may switch and become a seller of intersections if he or she sees an intersection bid at a price that seems too high given the participant's expectation of the evolution of the presumed trigger. Competition for intersection issuance should prevent the self-buy/sell strategy from succeeding.

Once the intersections are issued, they and all the other intersections that make up the possible combinations of the basis series from which the intersections are composed are available for trading in the standard trading periods.

Likely Course of Trading Activity

For any particular PAM scenario run, only a subset of the 24 special insights will be triggered and relevant. This is to be expected given the brief, four quarter duration. Because of this, it is likely that trading will concentrate in basis futures and intersection futures associated with the incidences of special insight that are triggered or might reasonably get triggered. Because of this natural concentration in trading activity, the *Filtering* function on the standard trading interface will substantially assist you in finding the information you need and in forming, submitting, and managing orders. The mechanics of this function are summarized here:

The filter allows you to use basic pattern matching to display only the items you are interested in. Note that in addition to the item information at the top of the page, this will also affect which items are displayed in the dropdown boxes for order entry.

-An asterisk can be used to match any number of characters. So 'B*' will match anything starting with a 'B'. It's not case sensitive, so 'b*' will do the same.

-An underscore will match a single character. 'B____' (B followed by 4 underscores) will match any name with 5 characters starting with B.

-Brackets with characters between them will match any one of those characters. So Beh[23][+|=] will match any state of Beh for periods 2 and 3.

-Multiple patterns can be specified by commas. 'B*, S*' will match anything beginning with a 'B' or an 'S'.

Those participants whose special insight is or might reasonably be triggered during a scenario will tend to be the initiators of activity leading to trading. Those other participants will tend to be *counter-punchers*, responding to indications of interest by trying to assess where an initiator has over-estimated the likelihood of a trigger and then profit from such over-estimation. In either case, money can be made and lost.

Good Luck!

A Quick Guide to PAM
June 4, 2002
Net Exchange

Trading Base Futures

Suppose that Sueland's economic health improved successively for the past five periods. You may think that Sueland is gaining momentum and there is an 80% chance it'll continue improving in the current period, say period t . I may think that the current growth has nearly topped out and that Sueland has about a 30% chance of continued improvement. If we are both risk neutral, then future $Seht^+$ is worth \$0.8 to you and \$0.3 to me. Our difference of opinions makes it possible to make a trade that both of us feel good about relative to our own expectations. When many participants trade $Seht^+$, the market can extract the view of market participants on Sueland's economic health improvement.

Difference of opinions between you and me may be caused because you know how to use other available data to forecast Sueland's economic health that I don't know how. In such a case, you have an advantage over me and you can do even better when you can trade intersection futures as illustrated below.

Why Trade Intersections?

Suppose that you, a regional expert, *know* that an increase in US military deployments in support of Bobland in the current period, say period 2 and thus $Umb2^+$, will result in an increase in Bobland military actions against Sueland in the next period, $Bma3^+$; that is, you know $\text{Prob}\{Umb2^+ \cap Bma3^+\} = \text{Prob}\{Umb2^+\}$.

Also assume that base futures $Umb2^+$ and $Bma3^+$ are trading at \$0.5 and \$0.45 respectively at the last market. If you believe that the price of $Umb2^+$ is right, then you realize that $Bma3^+$ is underpriced; it should be priced at least as high as $Umb2^+$ and possibly higher.¹¹ So you can buy $Bma3^+$ to profit from your knowledge. If the price of $Bma3^+$ remains at \$0.45, your expected gain is at least \$0.05 per share. What is likely to happen is that your willingness to pay higher than \$0.45 for $Bma3^+$ will drive the price up, but nevertheless, you can gain.

If you can trade the intersection future $Umb2^+ \cap Bma3^+$, you may be able to extract greater gains since $\text{Prob}\{Umb2^+ \cap Bma3^+\} \leq \min[\text{Prob}\{Umb2^+\}, \text{Prob}\{Bma3^+\}]$. In an extreme case, if everyone else believes that these two events are independent, then the market price for the intersections is around \$0.225 since they believe $\text{Prob}\{Umb2^+ \cap Bma3^+\} = \text{Prob}\{Umb2^+\} * \text{Prob}\{Bma3^+\}$. Against such a market, if you buy the intersection at \$0.225, your expected gain is at least \$0.275 per share. In a more likely

¹¹ And $\{Bma3^- \cup Bma3^-\}$ is probably over priced.

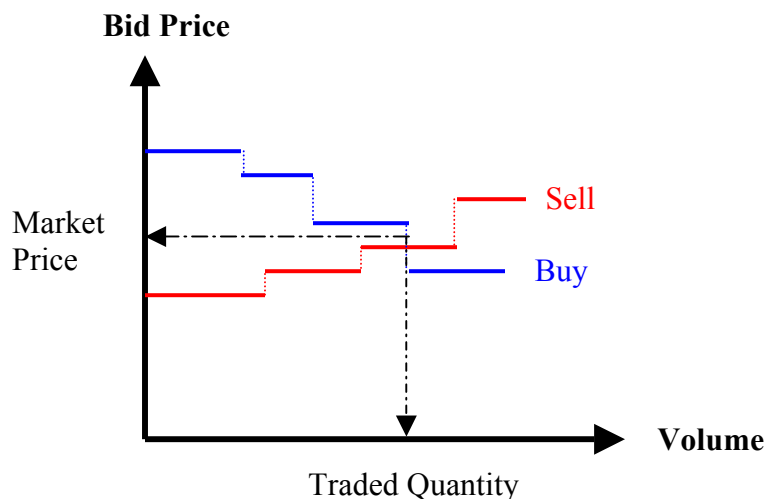
scenario, if the rest of the market think $\text{Prob}\{B_{ma3+} | U_{mb2+}\} = 0.7$, then the market's expectation of $\text{Prob}\{U_{mb2+} \cap B_{ma3+}\}$ is $\text{Prob}\{B_{ma3+} | U_{mb2+}\} * \text{Prob}\{U_{mb2+}\} = 0.5 * 0.7 = 0.35$. Against such a market, if you buy the intersection at \$0.35, your expected gain is at least \$0.15, three times higher than trading future B_{ma3+} . This should motivate you to nominate and trade intersection $\{U_{mb2+} \cap B_{ma3+}\}$ in the issuance auction and later in regular markets.

In this example, we assumed that you know that $\text{Prob}\{B_{ma3+} | U_{mb2+}\} = 1$. This is an extreme case. However, it should be clear by now that whenever you have special information on a conditional expectation or a correlation of events that the rest of the market do not, there is an opportunity to gain and having the relevant intersection available to trade can only enhance your chance of gaining more.

Pricing and Staircase Order Formation

In the intersection issuance market of this experiment, the order is matched to maximize the gains from trade under the restriction that at most four (or some other fixed number) intersections can be traded. The market price is set to the mid-point of the marginal buy and sell order offers.

When you have special information, it is possible that you may be the only buyer/seller of the intersection future. In the example in §2, you could be the only buyer paying high enough price. By breaking down your buy quantity in several steps and pricing them successively lower prices, you may be able to obtain a better market price for the intersection.



Bidding on Conditional Probability: Option Formation

Let's take a look at the example in §2 again. You know that $\text{Prob}\{B_{ma3+} \mid U_{mb2+}\} = 1$. Suppose that the intersection you wanted, $U_{mb2+} \cap B_{ma3+}$, is added to a regular market and you want to trade it. Suppose that you suspect that $\text{Prob}\{U_{mb2+}\}$, the last market estimate is 0.5, is going to change. Worse, you may suspect that someone has insider information on $\text{Prob}\{U_{mb2+}\}$ and you don't like to be a contra-side of trade to such a person in the intersection trade. What if this someone knows that the $U_{mb2=}$ is going to happen. Then $U_{mb2+} \cap B_{ma3+}$ is worthless and he will be willing to sell this intersection future to you. What you want in this situation is to buy the option whose payoff is as follows:

pays \$1, if $U_{mb2+} \cap B_{ma3+}$,
 pays \$0, if $U_{mb2+} \cap \{B_{ma3=} \cup B_{ma3-}\}$
 money back, if $U_{mb2=} \cup U_{mb2-}$.

With this option, you will be protected against the instance of conditioning event U_{mb2+} not happening and you can safely trade on your knowledge of the conditional probability. Assuming risk neutrality, a trader should be willing to pay up to $\text{Prob}\{B_{ma3+} \mid U_{mb2+}\}$ for this option.¹² You, in particular, should be willing to pay up to \$1. Suppose that the rest of the market thinks $\text{Prob}\{B_{ma3+} \mid U_{mb2+}\} = 0.7$ and you manage to buy this option at \$0.7. Then you can gain \$0.3 from this option if U_{mb2+} happens. Assuming that the $\text{Prob}\{U_{mb2+}\} = 0.5$, the expected gain of the option is \$0.15. Compare this with a similar scenario in §2 where you bought the intersection $U_{mb2+} \cap B_{ma3+}$ at \$0.35. The expected gain is the same \$0.15, however, you hedged away the risk of losing money with the option in case U_{mb2+} does not happen. Of course, you do not gain as much when $U_{mb2+} \cap B_{ma3+}$ happens with the option (\$0.3 compared to \$0.65 for the intersection). You may have a problem finding a contra party to the trade especially if a potential contra party suspects that you know something he doesn't.

In a combinatorial market, such as PAM, where you can bundle futures in a single package in a desired proportion, you can create your own option from futures traded in the market equivalent to what is described above. Suppose a trader thinks that

$$\text{Prob}\{B_{ma3+} \mid U_{mb2+}\} = p.$$

Then she can bundle $U_{mb2+} \cap B_{ma3+}$, $U_{mb2=}$, and U_{mb2-} in proportion of 1:p:p.¹³ Assuming she is risk neutral, this unit bundle is worth \$p to her. She will get \$p back when U_{mb2+} does not happen and \$1 when $U_{mb2+} \cap B_{ma3+}$ happens. She has a chance to trade this package if enough volume of each future in the package is submitted for trading. It is not necessary to have a single contra party to trade this package. If you believe that $\text{Prob}\{B_{ma3+} \mid U_{mb2+}\} = 1$, then you package [$U_{mb2+} \cap B_{ma3+}$, $U_{mb2=}$, U_{mb2-}] in 1:1:1 and you should be willing to pay up to \$1 for the package. If $U_{mb2+} \cap B_{ma3+}$ is priced at \$0.35 and $U_{mb2=}$ and U_{mb2-} together at \$0.5, your expected payoff

¹² Suppose that you pay \$x for this option. Then the expected payoff is

$$\begin{aligned} & \text{Prob}\{U_{mb2+} \cap B_{ma3+}\} + x * (1 - \text{Prob}\{U_{mb2+}\}) \\ &= \text{Prob}\{B_{ma3+} \mid U_{mb2+}\} * \text{Prob}\{U_{mb2+}\} + x - x * \text{Prob}\{U_{mb2+}\} \\ &= x + \text{Prob}\{U_{mb2+}\} * (\text{Prob}\{B_{ma3+} \mid U_{mb2+}\} - x) \end{aligned}$$

So if $\text{Prob}\{B_{ma3+} \mid U_{mb2+}\} - x \geq 0$ then the expected profit is non-negative. The trick is to get the same (conditional) expected payoff on U_{mb2+} and $\{\text{not } U_{mb2+}\}$.

¹³ Again, the trick is to get the same (conditional) expected payoff on U_{mb2+} and $\{\text{not } U_{mb2+}\}$. With this bundle, $E[\text{payoff} \mid U_{mb2+}] = E[\text{payoff} \mid U_{mb2=} \cup U_{mb2-}] = p$.

is \$0.15. Again, you hedged away the risk of losing money by packaging Umb2= and Umb2- to the intersection future.

In the order formation, you are asked to input the unit price for each future in the package. It would be easiest to set the price at the probability of underlying event that you believe and adjust them, probably the probability of the intersection. For example, you can form the package order as follows:

Future	Max Qty	Unit Offer	Buy/Sell
Umb2+ ∩ Bma3+	200	\$0.4	Buy
Umb2=	200	\$0.3	Buy
Umb2-	200	\$0.2	Buy

With this order, you priced the unit package at \$0.9.

If I believe that $\text{Prob}\{\text{Bma3+} \mid \text{Umb2+}\} = 0.8$, then I'd package the futures as follows:

Future	max Qty	Unit Offer	Buy/Sell
Umb2+ ∩ Bma3+	200	\$0.35	Buy
Umb2=	160	\$0.3	Buy
Umb2-	160	\$0.2	Buy

With this order, I priced the unit package at $\$0.35 + 0.8 * (\$0.3 + \$0.2) = \0.75 . The market will make sure that my order is filled in this proportion. So if I manage to buy at this price, my expected profit is \$0.05 per my unit package.

Allocated Quantity Rounding

Although the order matching is done so that the proportion of the futures in a package order is preserved, it may find a matching quantity in a fraction and then round it. For example,

Order	Future	Max Qty	Unit Offer	Buy/Sell
1	Umb2+	4	\$0.5	Buy
	Bma3+	2	\$0.35	Buy
2	Umb2+	6	\$0.4	Sell
	Bma3+	2	\$0.3	Sell
3	Bma3+	10	\$0.35	Sell

If the matching engine enforces that all traded quantities must be integer and all packages trade at respective proportions, there is no match for this example. Rather than returning no match, it computes the allocation in fractions as shown in the table below. Then it rounds the fractions to integers as shown in the same table.

Order	Future	Alloc. Frac. Qty	Alloc. Rounded Qty
1	Umb2+	4	4

	Bma3+	2	2
2	Umb2+	4	4
	Bma3+	4/3	2
3	Bma3+	1/3	0

Because of rounding, the allocated quantities of order 2 are not in the desired proportion. The quantity rounding is limited to plus minus one unit per future. In this example, the allocated quantities are low and the proportion is greatly distorted. However, the discrepancy due to the rounding will usually be small-to-negligible when greater quantities are traded.

The rounding routine attempts to round a fractional quantity in the direction in which the gain of the order (computed from the market price and unit offer) is increased when possible. It generally benefits you if you input unit offers that reflect your estimate of the probability of the underlying event for the future as close as you can in a package order.

Item Name	Buy Vol	Buy Price	Sell Vol	Sell Price	Current Filter	Last Price	Holdings
Bcv5+	200	n/a	0	n/a		n/a	0
Bcv5-	0	n/a	0	n/a		n/a	0
Bcv5=	150	n/a	0	n/a		n/a	0
Bcv6+	0	n/a	0	n/a		n/a	0
Bcv6-	0	n/a	100	n/a		n/a	0
Bcv6=	0	n/a	0	n/a		n/a	0
Beh5+	0	n/a	0	n/a		n/a	0
Beh5-	0	n/a	0	n/a		n/a	0
Order Group							
Level 1	Order	# of Bids	Total Bid/Ask	Delete	Edit		
<input type="checkbox"/> All				<input type="checkbox"/> All			
<input type="checkbox"/>	order100956	1	108.00	<input type="checkbox"/>	<input type="checkbox"/> edit		
<input type="checkbox"/>	order100958	2	167.50	<input type="checkbox"/>	<input type="checkbox"/> edit		

Current Money: 4,972.50

Financial Items

Item Name	Buy Vol	Buy Price	Sell Vol	Sell Price	Current Filter	Last Price	Holdings	Filter
Bcv5+	200	n/a	0	n/a			0	
Bcv5-	0	n/a	0	n/a			0	
Bcv5=	0	n/a	0	n/a			0	
Bcv6+	0	n/a	0	n/a			0	
Bcv6-	0	n/a	0	n/a			0	
Bcv6=	0	n/a	0	n/a			0	
Beh5+	0	n/a	0	n/a			0	
Beh5-	0	n/a	0	n/a			0	

order100956

Sunshine
vol price

Edit bids for order100956

Add bids for order100956

Save Order Changes

Delete

Buy/Sell	Name	Price	Quantity	All	Buy/Sell	Name	Price	Quantity
buy	Bcv5+	0.54	200	<input type="checkbox"/>	buy	Bcv5+		
					buy	Bcv5+		
					buy	Bcv5+		
					buy	Bcv5+		
					buy	Bcv5+		
					buy	Bcv5+		

New Order

Save Bid Changes

Delete

Add

Clear

Appendix B: OTC Automated Market Maker

The OTC Automated Market Maker is described in the paper, “Combinatorial Information Market Design,” by Prof. Robin Hanson, George Mason University, June 2002.

This paper is reproduced in the printed version of this report. For those accessing this report electronically, this paper may be viewed at:

<http://hanson.gmu.edu/combobet.pdf>

Appendix C: Data Series Definition, Production, and Judging

The practicality of initiating and operating PAM, let alone the chance of gleaning any useful information from PAM, depends critically on defining, producing, and consistently updating the data series that underlie each of the basic securities in PAM. This task will require the participation of an organization that is in the business/practice of defining and gathering such data and that is respected for its ability to do so and to remain unbiased vis-à-vis the operation of PAM.

Net Exchange believes that The Economist Intelligence Unit (EIU) is one such organization, and is perhaps the best possible candidate to perform this critical PAM function. Net Exchange contacted the EIU during Phase I of this SBIR regarding the prospect of their joining a PAM effort should DARPA choose to pursue PAM beyond Phase I. The EIU has expressed an interest in so participating.

Given well-defined and managed data series, the role of Judge is fairly straightforward. The PAM Judge officially certifies the state of each PAM security at some certain time after the maturity date of the security. It is envisioned that the Judge will be the same organization that produces and manages the data series.

Appendix D: Susceptibility of Information Markets to Manipulation

A widespread concern with information markets is the possibility that interested parties will bias market prices in order to gain favorable decisions. Simple theoretical models suggest that desires to bias can add noise to prices, but cannot bias them on average. Human behavior, however, is often at odds with the predictions of simple models. We have therefore begun to explore this issue in the laboratory. We now have only very preliminary results.

All of our experiments included ten subjects, each of who was given a “clue” about whether a “project” would succeed. The project was randomly chosen (at 50/50 odds) to either succeed or fail, and once this was determined, each subject was given a private (and independent) success/fail clue that had a 2/3 chance of agreeing, and a 1/3 chance of disagreeing, with this truth. The subjects then participated in a market that estimated the chance of project success. Finally, we compared this market estimate to a full information benchmark, which what a rational Bayesian with access to all the clues would estimate. Our primary outcome measure was the root-mean-squared-error (RMSE) between the price and the full information estimate.

Subjects always bought and sold assets of the form “Pays \$100 if the project succeeds.” All sales were fully-covered short sales, and so were logically equivalent to purchases of “Pays \$100 if the project fails.” The market institution used for these trades was an automated market maker, who always had a public single-unit \$1 bid-ask spread, and who moved that spread one price unit in response to each trade. For example, if the current bid and ask prices (i.e., buy and sell prices) were \$43 and \$44 respectively, then if a subject purchased one unit at the ask price of \$44, the bid and ask prices would change to \$44 and \$45. If a subject instead sold one unit for \$43, these prices would change to \$42 and \$43.

The prices always started at \$50 and \$51, and each subject had sufficient assets to, by himself, move the price to either extreme. (Going bankrupt, and so owing money to the experimenter, was never possible.) Subjects could trade at any time during roughly 100-second periods, which ended at random times. After each period subjects were told if the project had succeeded. The last sale price in each period was taken as an estimate of the percentage chance of project success. No communication between subjects was allowed, except via market trades. All dollar figures above are experiment dollars, each of which was worth \$0.001 U.S. dollars. Subjects may have participated in other market experiments before, but were inexperienced in this particular experiment.

We have so far compared two treatments, or experimental variations. In the simple treatment, everything was as described above, subjects received an additional \$500 per round, and bids and asks were denominated in experimental dollars. In the complex treatment, there was a possibility that the project might not be tried, in which case it could not succeed. Bids and asks were denominated not in simple “cash” of the form “Pays \$1”, but in cash of the form “Pays \$1 if the project is tried.” The price in this case

was taken to be an estimate of the percentage chance of project success, conditional on the project being tried.

Whether or not the project was tried was determined by whether the last bid price was above or below a randomly drawn integer in the range [0,100]; the higher the price, the more likely the project would be tried. (Subjects were only told at the end whether the project was tried; they were never told this integer.) If the project was tried, then if it was successful each subject got an additional \$1000, and if it failed, each subject got nothing additional. If the project was not tried, each subject received an additional “project not tried” value, or project opportunity cost, which was one of these values: \$0, \$250, \$500, \$750, and \$1000. Each subject was privately informed of his opportunity cost, which was chosen randomly, independently, and uniformly from these possibilities. Subjects thus had differing interests in whether the project was tried, and so often had an interest in biasing the price, in order to induce a more favorable decision.

Always estimating a 50 percent chance of project success would produce a RMSE (root-mean-squared-error) of 40.1 in our environment. We have so far run the simple treatment in two experiments of 20 periods each, and have run the complex treatment in two experiments of 17 and 18 periods. RMSE was 26.7 overall in the simple treatment and 26.6 in the complex treatment. Thus the error rate was lower than chance, and actually lower in the manipulation treatment, though an F-test says that the errors were not significantly different (at a 50% one-tail significance level) between the two treatments.

Thus our experiments so far have not found incentives to bias the price actually biasing the price, or even increasing the error. Of course this must be a very tentative assessment, which might be reversed by further experiments in this or other environments. Also, our ability to draw conclusions here about manipulation is clouded by the fact that the complex treatment differed from the simple treatment in several ways. It used conditional instead of unconditional trades, introduced an additional risk associated with trying the project, and introduced a decision-making function of the price. Further experiments could help us to disentangle these effects.

Appendix E: Legality of PAM vis-à-vis Securities Regulations

PAM #1, operating wholly among U.S. government agencies, will be exempt from securities laws and regulations. So, it is only PAM #2, operating among non-U.S. government entities, that must comply with securities laws and regulations.

Securities laws and regulations are, for the most part, designed to protect investors from fraud. When all of the investors that are allowed to own trade certain securities are classified as “Expert”, or some other designation that classifies them as neither novice nor naïve, then trade in the securities is exempt from most regulations. It is through such exemptions that capital is raised through private offerings (e.g., venture capital). It is also through such exemptions that major firms in an industry participate in risk hedging derivative securities, often organized through OTC intermediaries. In this latter case, the major firms are considered to be experts in the industry for which the hedging is undertaken.

PAM #2 will be organized so that the official participating entities are major institutions and firms; e.g., CNN, Stanford University, the Brookings Institute, the New York Times, Harvard University, the RAND Corporation, etc Each such entity will be authorized to operate a specific number of trading accounts and will assign trading accounts to employees or other agents who the entity selects. The official entity will provide the budget for each trading account; thus, none of the assigned agents can lose any of their own money by participating in PAM #2. So long as each such entity can be legitimately described as “expert” in some aspect or field relevant to Policy Analysis (as used in PAM), then PAM #2 should be exempt from securities regulations.

It is worth noting that most derivatives trading activities are not currently regulated by any U.S. government agency. PAM can easily be described as trading in information derivatives. In this context, PAM #2 might be free from regulation even without requiring that all the official participating entities be “expert.” However, it seems prudent to follow the more stringent course of requiring that only “expert” entities be allowed as participants.

Appendix F: Midterm SBIR Presentation

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Charles Polk
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Appendix G: Final SBIR Presentation

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