

EXAMINING TRADER BEHAVIOR IN IDEA MARKETS: AN IMPLEMENTATION OF GE'S IMAGINATION MARKETS

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ABSTRACT

We present the outcome of an idea market run for one of GE Energy's sub-businesses in July and August of 2006. GE Energy used this market to elicit and rank-order technology and product ideas from across the sub-business. In this experiment, we examine the behavior of traders that have submitted the ideas on the market and their influence on the market's outcome. An idea's submitter is clearly motivated to have his idea valued highly by the market, both by the funding given to the top idea as well as smaller prizes given to the top three ideas. In general, founders tended to buy their suggested ideas at prices above the volume-weighted-average-price (VWAP) in significant volumes. We discuss the implications and mitigation strategies. A survey of market participants yielded mixed results regarding the market's effectiveness at ranking ideas but very positive results regarding the quality of ideas proposed.

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KEYWORDS

Idea market, prediction market, idea generation, brainstorming, group support system.

1. INTRODUCTION

General Electric has been experimenting with idea markets for the purposes of collaborative brainstorming and idea ranking. Our specific implementation of idea markets is called Imagination Markets.¹

Idea markets, also called preference markets, are a special form of prediction markets specifically designed to aggregate preferences; participants buy and sell securities based on their preferences. Unlike prediction markets, the underlying objective value of the securities is not known at the close of the market. Instead, the securities' value is based on the opinions of the participants. Chan, et al. has done important work on idea markets. Chan demonstrates that idea markets used to aggregate opinions are consistent with opinions collected via web surveys. He asserts that markets may improve upon traditional survey methods by encouraging greater honesty from the participants, providing participants with valuable feedback from other participants, and offering participants “the joy of competitive play.”³

GE's Imagination Markets help us answer tough business questions such as “What new technology ideas should we be investing in?” and “What new products should we be developing?” Market participants can submit their own ideas for entry into the market, and they can buy and sell shares of any idea in the market based on how well they believe the idea will contribute to the market's (and the GE business's) objectives. Example objectives include contributing the most to growth or developing new revenue streams. At the end of the market, shares are valued using the volume weighted average price over the last 5 days of trading.

GE's interest in idea markets stem from our belief that innovative new product and service ideas can come from anywhere within an organization. Since innovation is a key component of General Electric, the generation of new ideas is one of the first steps in the planning of research projects and allocation of research funding. Similar to most companies, GE utilizes a variety of methods to generate and down-select new ideas. While the process varies from business to business, new ideas are typically generated by traditional means, including suggestion boxes and brainstorming sessions. These traditional means of encouraging new ideas within businesses have

considerable limitations. Suggestion boxes often go unused because contributors receive little or no feedback about their idea or visibility into others' ideas. Brainstorming sessions are often infeasible for soliciting ideas from large, globally distributed teams with potentially thousands of contributors. A small team, usually management, through their expert evaluation of the ideas' viability, typically performs the ranking and down-selection of ideas. By extending a traditional information market to allow participants to contribute ideas throughout the course of the market, we have created a tool that leverages the participants' expertise to identify ideas, as well as to effectively rank them. This tool was developed to augment the existing methods for idea generation and ranking, providing another data point in the overall idea generation and ranking process.

A discussion of our initial Imagination Market, justification for design choices, and early results are presented in LaComb, Barnett, and Pan (2007). This paper presents an idea market executed in 2006 for a sub-business of GE's Energy business and was the fourth of ten Imagination Markets we have run thus far. In this market, we changed several design aspects from our original Imagination Market. Specifically, we removed short selling since earlier participants had found it to be confusing. Instead, in this market, we allocated initial shares of every idea to every participant at the time the idea entered the market. We also changed our original design to value the portfolio during the course of the market based on the volume-weighted average price of the last five days of trading, instead of the last trading price. Further information regarding these design changes are outlined in the section below titled "Design of the Market and Securities".

Our objectives for the Imagination Market technology are to: 1) generate more ideas than are obtained through other traditional mechanisms, 2) make everyone within the organization a part of the idea generation process, and 3) identify the best idea. The ideas selected through the Imagination Market process may be directly funded or the outcome of the Imagination Market may be another data point in the ranking and down-selection process.

In earlier markets, we noticed the tendency of the individual who submitted an idea to be over-exuberant in the trading of their own idea. We analyze the behavior of the idea submitter in the trading of his own idea and discuss impact and mitigation strategies.

DESIGN OF THE MARKET AND SECURITIES

There are many choices for market design. Duration, participants, incentives, anonymity, and financial structure are just a few of the many

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Design	Reason
Participant community	All salaried employees in the US and Europe in one of GE Energy's sub-business were invited to participate. Those invited did not participate in earlier markets.
Initial seed securities	The market was seeded with eight ideas generated before the market opened so there would be securities to trade at the start of the market.
Addition of new ideas (securities)	We accepted new ideas for the first two weeks of the three-week market. A cross-functional team from the business reviewed ideas and chose which ones to include in the market based on how well they fit the idea criteria presented to traders prior to market start. Ideas were also selected to represent a wide breadth of business areas in the market. Members of the review committee did not otherwise participate in the market.
Initial allocation of shares for each security	Each participant was given 15 shares of each security at no cost. Participants also received \$3000 in play money to invest. At the end of each week, registered participants received an additional \$1000 play money with which to trade. This was unlike the design of our first Imagination market, where participants were given only cash and were allowed to take short positions on securities. We removed the short selling option because many traders were confused by the short selling implementation. We then chose to provide everyone with initial shares, which they could sell to express their opinion that the value of the security was lower than the current price.
Pricing of shares	In the creation of limit orders, traders were allowed to set any price they wanted from 1 to 99 dollars per share. Ideas' "current" prices were simply their last traded price. But unlike the design of our first Imagination Market, we used the volume-weighted average price from the last five trading days when calculating an ideas' relative worth in the portfolio during the course of the market. Use of the last trading price as the method of valuing securities throughout the course of the market had two limitations: 1) it resulted in a tendency of traders to trade a small number of shares in order to see a short-term improvement in their portfolio value; 2) valuing based on the last trading price did not accurately reflect the final payout, which was based on the volume weighted average price.
Final payout to participants (and determination of the best idea)	The best idea was the security with the highest volume-weighted average price (VWAP) during the 5 business days prior to market close.
Market duration: 2 weeks, 5 days	We did not publicize a specific market close date to mitigate the risk of manipulation and tournament behavior as the close date approached.

Design	Reason
Anonymity	Whether suggesting a new idea or trading, all participants were only known to each other through their trader ids when interacting through the Imagination Market application. This allowed traders to express their true opinion about ideas without fear of retribution from other participants. We did not forbid traders from disclosing their identity outside of the market.
Discussion forums available for sharing information	We wanted participants to share opinions about the securities in an online format so we provided a discussion forum for each security.
Incentive for best idea: research funding	The reward for the best idea was \$50,000 of research funding to pursue the idea. While the research funding represents a significant dollar amount, unlike the other incentives, this is money that is not directly provided to the employee. Instead it is allocated as internal time and resources that can be spent on the idea's development. An Apple iPod ⁴ was also awarded for the top idea. ¹ Second and third place ideas received \$100 and \$50 gift cards, respectively.
Portfolio value-based incentives	The top trader (based on portfolio value) received an Apple iPod. The second place trader received a \$100 gift card. The third received a \$50 gift card. Although performance-based rewards have been proven to encourage tournament behavior, we felt that these incentives were necessary to encourage participation. ⁵
Lottery incentive	Two \$50 gift cards were awarded by random drawing (lottery). Lottery entries were created for each trade so the more a participant traded, the better chances they would have. The inclusion of this lottery incentive may mitigate the risk of tournament behavior. However, in future markets we may wish to include a lottery aspect to the performance based incentives by allocating a number of lottery tickets to the trader or idea in proportion to the performance of the trader/idea. However, since all traders face the same incentives on this market (even if they are in a tournament which encourages risk-seeking trading) our comparison of founder/non-founder results will still be insightful.

Table 1: Market Design

market attributes to consider. A thorough discussion and justification of our design choices is presented in LaComb, Barnett, and Pan (2007).

Table 1 describes some of our Imagination Market design decisions along with brief explanations of why the design choice was employed. In cases where specific design choices have changed since our first implementation, the reason for the change is provided.

Participants were given a set of criteria against which to evaluate the market ideas. We asked participants to set the price at which they were willing to buy or sell shares (minimum 1 dollar per share, maximum 99 dollars per share) based on how closely the idea fit the criteria. This allowed participants to not only evaluate ideas in a similar manner to each other, but to use criteria that management would ordinarily use to evaluate ideas. The criteria were:

- Ideas our customers will value, and
- Ideas that will produce the best return on investment, and
- Ideas that should be included for funding next year.

RESULTS

a. Participation

The sub-business was self selected based on their own knowledge of the Imagination Market program from GE's Global Research Organization. All salaried employees within the GE Energy sub-business were invited to participate. The sub-business is relatively small in size compared to the overall organization, which made coordination of the market somewhat easier. On the other hand, the sub-business is large enough and responsible for a fairly large breadth of product lines in the Energy industry to provide a relatively diverse base of participants. Of the 1,236 employees invited to participate, 186 (15%) registered for the market and 110 (9%) made trades. The trader population was reasonably diverse and represented all functional groups within the business, roughly in proportion with the functional and geographic distribution of the business as a whole. Traders were located in multiple locations across North America and Europe.

Forty of the traders served in Engineering roles and accounted for 25% of the total trade volume. The balance of the trading population served in roles such as project management, finance, marketing, sales, legal and human resources. Nineteen of the traders were in management positions and accounted for 6.5% of total trade volume. Total daily participation rates are shown in Figure 1.

Eight ideas were seeded in the market in order to get trading started. During the first two weeks of the market, we invited participants to suggest new ideas to be added as securities. Fifty-four new ideas were submitted; each idea was considered for entry into the market by a cross-functional

review team. If the review team approved the idea, it was added to the market and trading could begin immediately.

Thirty-two new ideas were approved and placed into the market for trading during the first two weeks, resulting in a total of forty ideas on the market. The cross-functional review team screened out twenty-two suggested ideas. Figure 2 illustrates the points in the market at which new securities were entered.

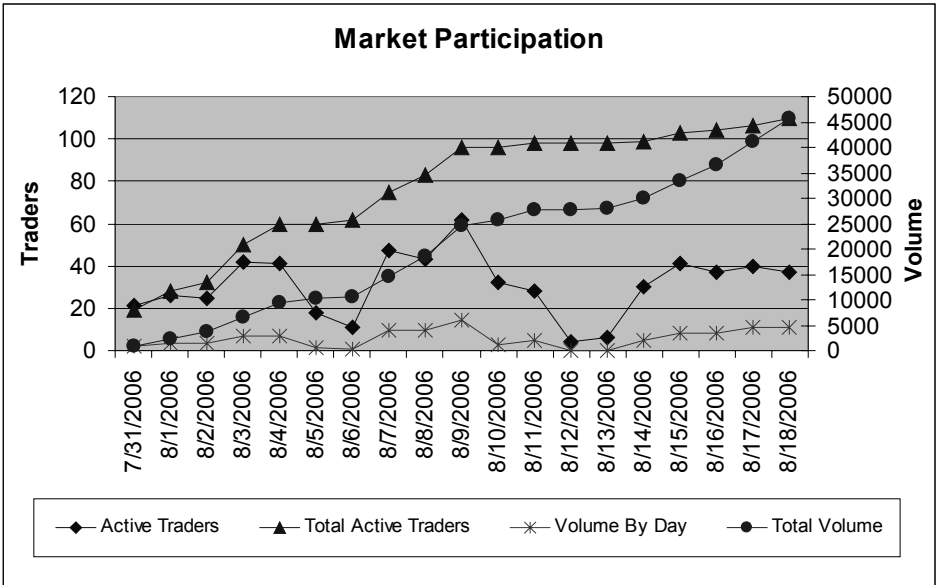


Figure 1: Participation Throughout the Market

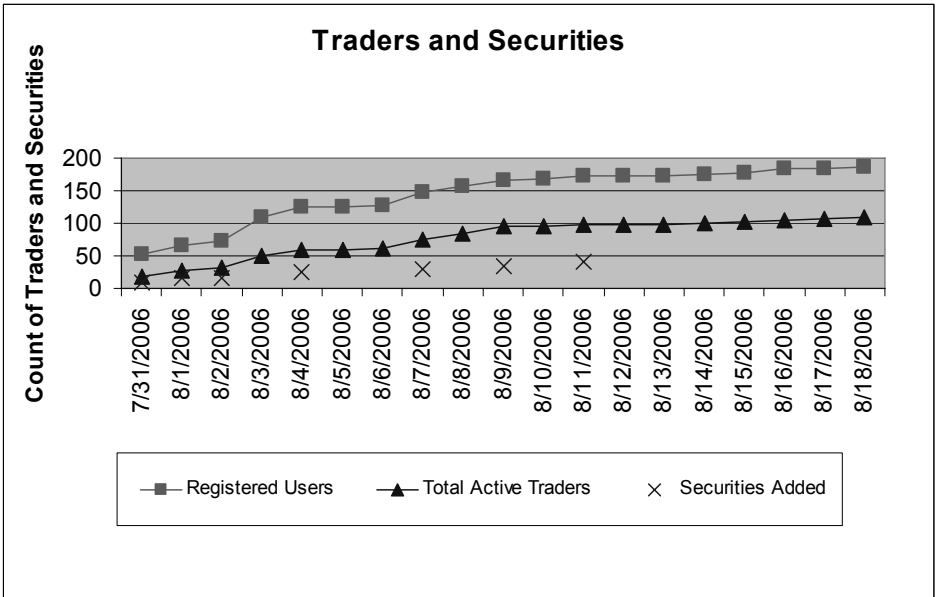


Figure 2: Security versus Trader Totals

b. Security Ranking

The final market results are shown in Table 2. Final price, total volume traded, and the number of individual traders who bought or sold the security are shown. The Initial Seed column indicates whether the idea was present at the start of the market (as indicated by a "Y"). Through the course of the market, a total of 45,652 shares were traded in 2,939 separate transactions.

Symbol	Final Price	Volume	Total Individual Traders	Initial Seed
D	98	2324	72	
FF	98	1910	64	y
H	89	2113	58	
Q	81	1082	57	
JJ	80	2144	48	
II	77	1614	50	
F	73	1178	57	
HH	69	712	43	
R	54	1071	54	
C	53	1042	54	
S	52	1165	56	y
KK	50	705	34	
O	50	1010	49	
EE	49	1350	52	y
NN	45	1358	59	y
MM	44	980	55	
Z	44	475	30	
E	42	931	50	
A	41	1215	53	
P	40	1453	58	
DD	36	1265	59	y
LL	36	710	39	
W	36	1367	53	
BB	35	1691	57	
I	35	741	37	
J	34	780	46	
N	34	689	41	
T	34	735	34	
G	33	819	54	y
X	32	974	52	y
Y	32	1205	50	
CC	29	1035	54	y
AA	28	876	48	
V	26	1120	48	
K	25	1655	58	
M	24	832	43	
B	23	987	37	
U	23	827	44	
L	22	857	47	
GG	21	655	40	

Table 2: Market Results - All traded ideas and final prices

Figure 3 displays the daily volume weighted average price (VWAP) for the top 5 securities based on VWAP over the last five days of the market. Although there were considerable fluctuations in pricing even at the end of the market, most of the top priced securities stayed consistently high throughout the course of the market. Most noteworthy, the two securities that tied for first place were in stiff competition throughout the duration of the market.

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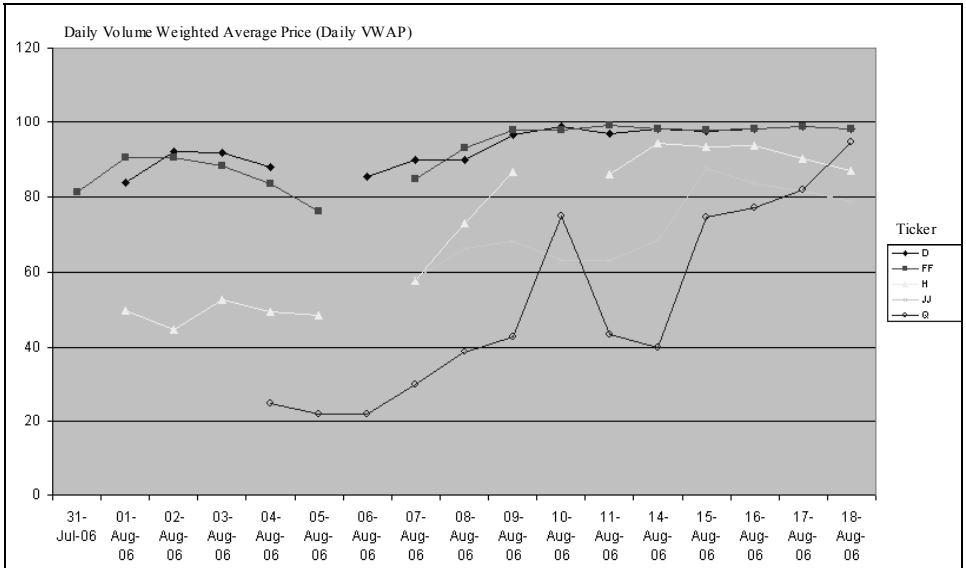


Figure 3: Daily volume weighted average price for each idea on the market

c. Idea Springboarding

The market mechanism allowed for a relatively large number of promising ideas to be generated in a relatively short time period. Further, a springboard effect was noted as ideas in the market tended to trigger submissions of related ideas that, in many cases, built upon the original submissions. Figure 4 shows a qualitative grouping of the ideas in the market by similarity. This grouping represents a subjective assessment by the product line management function of the sub-business, and no distance measures are meant to be conveyed in this graph. Ideas contained within the same circle represent variations of the same product line (for example, a red car versus a blue car). Ideas representing similar, but different product lines are connected by a dotted line, but not encircled (for example, a red sedan may be connected to a red van, but would not be connected to an airplane).

Clear winners were often selected from the similar groupings (shown in figure 4). For example, of the cluster involving securities C, X, DD, I, security C was the market's favorite, ending with a price of \$50 compared to the others ending in the \$30s. Further C had a negative correlation with each of the ideas as the market tended to buy more of C as X, DD and I were sold. Similar market reactions were seen in the JJ, LL, M, BB, O, W, KK cluster; the V, E, II cluster; the Y, HH cluster; and the F, S, R, Z cluster. Many new

ideas, or aspects of existing ideas, were proposed and openly discussed in the market forums.

In contrast to clustering the ideas based on a subjective assessment of the ideas and their relationships within product lines, we could consider grouping the ideas based on the buying patterns of the traders, grouping together those purchased by the same traders. There appeared to be little correlation between these two comparisons as traders tended to favor one idea over another in a given product line. For example, we examined the behavior of the traders as it relates to the ideas in the C, X, DD, I grouping and found only 35%, 40%, and 25% of the traders who purchased shares in ideas X, DD, and I, respectively, also purchased shares of idea C. When comparing C to an idea on the opposite side of our product-line-based cluster, such as idea CC, 30% of the traders who purchased idea CC also purchased shares of the idea C.

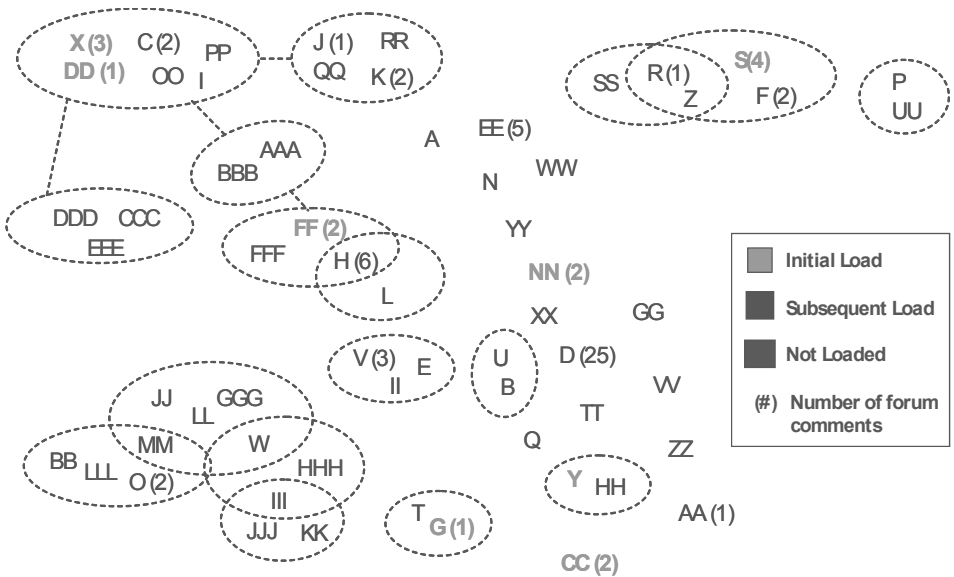


Figure 4: Idea Clustering - Many ideas seemed to be stimulated by existing ideas in the market

The highest overlap of traders was between O and S, where 12 (86%) of the 14 traders who purchased shares of idea S were part of the 30 traders who invested in idea O even though these two ideas were targeted towards very different product lines.

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d. *Founder's Behavior*

One of the most interesting analyses we performed on our market data involved assessing selected participants' behavior. While it is difficult, if not impossible, to discern the intentions of a trader, the idea's submitter (or founder) is clearly motivated to have his idea valued highly by the market, both by the funding given to the top idea as well as the smaller prizes given to the top three ideas. There was also unstated potential for future funding opportunities as the market was run in conjunction with the business's annual budgeting process. The founders' trading activity is summarized in Table 3.

Symbol	Submitter	Own Idea			Own Idea			Other Ideas (not submitter's)			Other Ideas (not submitter's)		
		Buys			Sells			Buys			Sells		
		Price Prem	Shares	% tot vol	Price Prem	Shares	% tot vol	Price Prem	Shares	% tot vol	Price Prem	Shares	% tot vol
A	125						89.4%	15	0.0%				
B	169	136.7%	311	31.5%	87.5%	40	4.1%	116.3%	131	0.3%	101.4%	250	0.6%
C	51	109.6%	322	30.9%		0	0.0%				113.2%	550	1.2%
D	28	104.4%	648	27.9%	103.5%	450	19.4%	91.9%	171	0.4%	101.1%	734	1.7%
E	73	107.2%	110	11.8%	109.6%	118	12.7%	99.0%	1,608	3.6%	111.7%	1,928	4.4%
F	95	118.9%	68	5.8%							106.4%	60	0.1%
H	19	112.8%	763	36.1%	114.0%	358	16.9%	105.1%	334	0.8%	105.5%	917	2.1%
I	130	99.4%	40	5.4%	98.0%	55	7.4%	108.1%	2,793	6.4%	93.0%	4,458	10.2%
J	15	121.6%	50	6.4%				97.7%	130	0.3%	106.4%	195	0.4%
K	38				60.8%	15	0.9%						
L	146							100.3%	54	0.1%	93.1%	15	0.0%
M	78	143.0%	5	0.6%	195.1%	15	1.8%	107.9%	352	0.8%	125.9%	280	0.6%
N	126	120.4%	237	34.4%				106.8%	598	1.3%	87.3%	1,183	2.6%
O	20	106.2%	261	25.8%				117.6%	240	0.5%	89.5%	623	1.4%
P	45	126.7%	485	33.4%	84.0%	140	9.6%	123.3%	250	0.6%	84.2%	775	1.7%
Q	87												
R	62							91.8%	87	0.2%	97.9%	205	0.5%
T	154	129.5%	105	14.3%				120.7%	195	0.4%	93.8%	240	0.5%
U	48	104.6%	75	9.1%	84.9%	30	3.6%	109.9%	495	1.1%	96.3%	405	0.9%
V	8	87.4%	10	0.9%									
W	105	102.1%	20	1.5%	88.9%	25	1.8%	106.0%	348	0.8%	93.2%	190	0.4%
Z	61							102.8%	74	0.2%			
AA	130	136.3%	101	11.5%	101.1%	116	13.2%	108.1%	2,793	6.4%	93.0%	4,458	10.2%
BB	7							111.1%	25	0.1%	64.9%	43	0.1%
EE	4	122.3%	330	24.4%	96.4%	135	10.0%	125.0%	256	0.6%	91.9%	583	1.3%
GG	145	116.9%	31	4.7%									
HH	159	147.2%	312	43.8%				115.3%	371	0.8%	94.3%	831	1.8%
II	73	115.4%	561	34.8%	106.3%	448	27.8%	99.0%	1,608	3.6%	111.7%	1,928	4.4%
JJ	130	111.3%	865	40.3%	99.8%	671	31.3%	108.1%	2,793	6.4%	93.0%	4,458	10.2%
KK	61	93.8%	15	2.1%				102.8%	74	0.2%			
LL	85	100.8%	15	2.1%				102.0%	265	0.6%	116.0%	188	0.4%
MM	30	88.7%	45	4.6%				103.9%	278	0.6%	98.9%	245	0.5%
Sum			5,785			2,616			16,338			25,742	
Vol Wtd Average		116.8%			102.8%			106.6%			97.2%		

Table 3: Founder Trading Activity

"Price Prem" means price premium, % tot vol is percentage of total shares traded for the idea by the founder.

During the course of the market, a security's contribution to the player's portfolio was calculated as the VWAP over the last five days of trading. The submitter column shows the trader id of the idea's founder. The price premium column shows the percentage of the five-day VWAP at which the founder bought or sold that idea or other ideas and the shares column shows the number of shares of that idea or other ideas that the founder bought or sold. The volume weighted average row shows the volume-weighted average percentage of the five-day VWAP at which each founder bought or sold their

own idea or other ideas; it summarizes the overall price premium all founders as a group gave to their idea or other ideas. Table 3 contains only those securities that were proposed and approved for inclusion in the market.

In general, founders tended to buy their suggested ideas at prices above the VWAP in significant volumes. They tended to sell at lower frequency and volume. Founder activity with regard to other securities tends to fall into two categories: attempts to maximize the value of their own portfolio (buy low - sell high) or attempts to drive the prices of competing securities down at the expense of their overall portfolios' value, often manifesting itself as a buy high - sell low strategy. As an example, trader 130 took significant buy and sell positions in ideas FF (accounting for 11% of total trade volume), H (20% of total trade volume), F (16% of total trade volume) and B (37% of total trade volume) with what largely appeared to be an attempt to drive down the prices of these competing securities. Similarly, trader 19 participated in 19% of trades in security C. Overall, 29% of the traders were founders, and they were involved in 39% of all trades in ideas, including those that were not their own.

A one-tailed two-sample t-test comparing the price premium for a founder's own ideas versus the price premium that founders placed on others' ideas showed that owners' price premium is higher for their own ideas than for that of others' ideas (t-statistic (df=38)=2.17, p=.018). The difference between the founder's price premium when selling their own idea vs others' ideas is not significant (t-statistic (df=15)=0.43, p=0.67).

In Table 4, we examine the behaviors of the top five and bottom five traders. Those traders who were founders of ideas are denoted by the phrase "(founder)". In general, we would expect top ranked traders to trade profitably, i.e., buying low and selling high. For all top traders except trader 19, this appears to hold true. Conversely, we expect the lowest ranked traders to have been generally unprofitable, buying high and selling low. The bottom four traders were founders and the average ending portfolio value across all founders was \$30,529 compared to an average of \$32,556 for non-founder traders. The only founder in the top five was trader 19, who was able to purchase many shares of his idea early in the market and then take advantage of a large price run-up during the last week. Trader 19 was the founder of the third ranked idea.

In general, the founders exhibited a very different trading strategy than traders who did not propose ideas on the market. This behavior could be considered a form of 'wishful thinking' as discussed by Forsythe.⁶ Forsythe found evidence in the Iowa Markets of behavior they termed 'wishful thinking' - the tendency of traders to perform irrational trades based on optimistic bias - thus making overly enthusiastic trades for preferred outcomes.

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Trader	Rank	Buys		Sells	
		Price Premium	Shares	Price Premium	Shares
23	1	91.0%	6934	109.2%	5929
22	2	93.2%	6100	108.8%	6249
19 (founder)	3	110.3%	1097	107.1%	1275
5	4	96.2%	3225	105.9%	3297
11	5	77.9%	698	127.4%	325
36	182	110.2%	438	86.2%	757
20 (founder)	183	113.0%	501	89.5%	623
45 (founder)	184	125.4%	735	84.2%	915
126 (founder)	185	110.9%	835	87.3%	1183
130 (founder)	186	111.0%	1937	94.7%	2328
Total		97.3%	22500	103.9%	22881

Table 4: Behavior of Top Five and Bottom Five Traders

Another likely explanation is that founders have another incentive in trading. The reward associated with funding for the top idea introduces an externality that makes the behavior quite rational, even though it reduces a trader's portfolio value. It is also possible, that the monetary reward alone may not have been a sole motivator for the founders' behavior as there may be a psychological or social benefit associated with being the submitter of a top idea (even in spite of the anonymity of the market). This effect could be investigated further in future markets.

The important question raised is whether markets can still perform accurately despite overly enthusiastic trading on the part of this biased subset of traders. Despite this behavior, Forsythe asserts that the Iowa Markets produce efficient outcomes due to the effect of a few 'marginal' traders. He asserts that marginal traders are heavily influential in setting market prices. They appear to have a sound assessment of the fundamental value of a security, trade considerably more than most traders, and submit limit orders at prices close to the market price. Our market also had several traders who performed as marginal traders. Traders 22 and 23 performed considerably more trades than other traders on the market. Their trading was consistently rational as can be evidenced by the fact that these traders scored the highest in net worth at the end of the market. Their trades tended to be in the form of limit orders around market prices.

As an internal market, our market had considerably fewer participants and therefore less liquidity than in the Iowa Markets. Given this, a single trader may have a larger influence than was found on the Iowa Markets. Due to our lower participation, we may also have had fewer marginal traders to mitigate the effect of the biased traders. Table 5 shows that several founders performed a large percentage of the trades on their securities.

For six of the top ten ideas, the founder accounted for greater than 30% of all trade volume.

Symbol	Final Price	Volume	Total Unique Traders	Founder Volume	Founder Volume %
D	98	2324	72	1098	47%
FF	98	1910	64		
H	89	2113	58	1121	53%
Q	81	1082	57		
JJ	80	2144	48	1536	72%
II	77	1614	50	1009	63%
F	73	1178	57	68	6%
HH	69	712	43	312	44%
R	54	1071	54		
C	53	1042	54	322	31%
S	52	1165	56		
KK	50	705	34	15	2%
O	50	1010	49	261	26%
EE	49	1350	52	465	34%
NN	45	1358	59		
MM	44	980	55	45	5%
Z	44	475	30		
E	42	931	50	228	24%
A	41	1215	53		
P	40	1453	58	625	43%
DD	36	1265	59		
LL	36	710	39	15	2%
W	36	1367	53	45	3%
BB	35	1691	57		
I	35	741	37	95	13%
J	34	780	46	50	6%
N	34	689	41	237	34%
T	34	735	34	105	14%
G	33	819	54		
X	32	974	52		
Y	32	1205	50		
CC	29	1035	54		
AA	28	876	48	217	25%
V	26	1120	48	10	1%
K	25	1655	58	15	1%
M	24	832	43	20	2%
B	23	987	37	351	36%
U	23	827	44	105	13%
L	22	857	47		
GG	21	655	40	31	5%

Table 5: Founder Involvement in Market Securities

One of the top ideas, FF, was one initially seeded into the market and didn't have a specific founder, but subsequent investigation revealed that two major traders of this security were involved with this product concept in its early stages and would benefit significantly from the award of the \$50,000. Statistically, there is a strong positive correlation between founder trade volume and final price ($p < 0.001$ by linear regression). The data also suggests that heavily traded securities with significant founder volume

tend to perform better, but significant founder volume alone is not sufficient to drive higher prices. It is not clear to what extent this can be attributed to networking outside the market mechanism or herding behavior within the market. It may even be coincidental that four of the top five ideas were both heavily traded and had a high degree of founder activity. Regardless, increasing participation would help limit the impact of founder influence; the more traders, the harder it is for any individual to shift security values (long term) in the market. It may also be that market exuberance for a founder's idea drives that founder to greater trading on that security.

Another interesting phenomenon in this market was the strong competition that arose between the top two ideas. The founders and interested parties of each idea were quite vocal during the market in pointing out potential trading improprieties of the other security (none of significance were actually found). Prices of the two securities were highly correlated as seen below (Pearson correlation of 0.970).

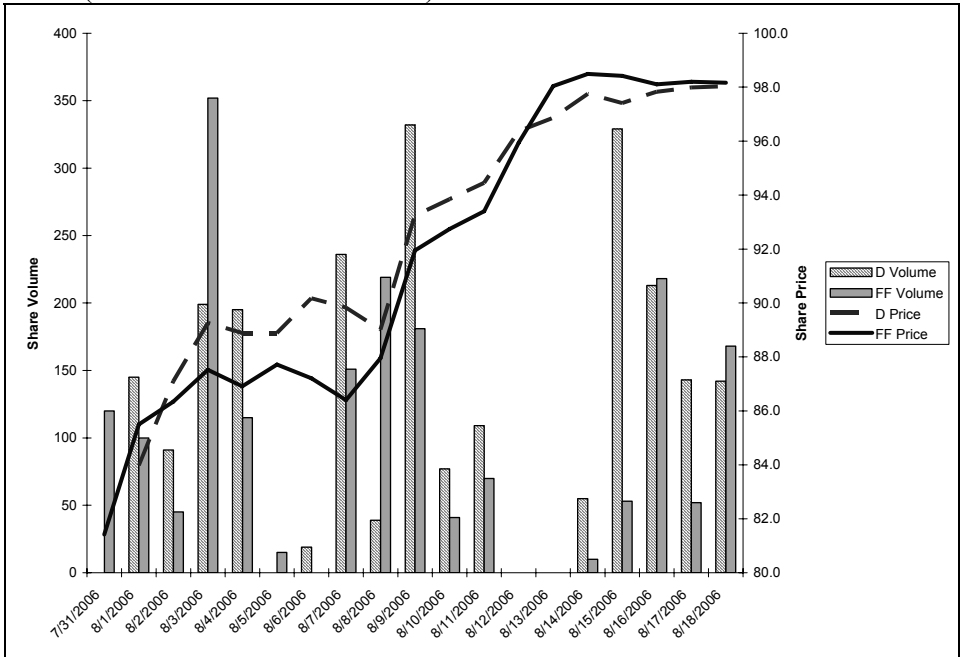


Figure 5: Price and Trading Volume for Securities D and FF

2. PARTICIPANT SURVEY RESULTS

Having witnessed behaviors in the market that could have influenced the results, we wanted to see how the market participants felt about the market

and its ability to accurately rank the given ideas. Clearly, an objective measure of market effectiveness is difficult, if not impossible to develop. To measure the real success of ideas requires business development and many years for sales and profits to be realized. To obtain a nearer term answer, an anonymous post market survey determined participants' opinion of ranking effectiveness. Due to the anonymous nature of this survey, specific responses of founders, or information regarding responses in relation to trader success is not available. This is noted as an area for investigation with future markets.

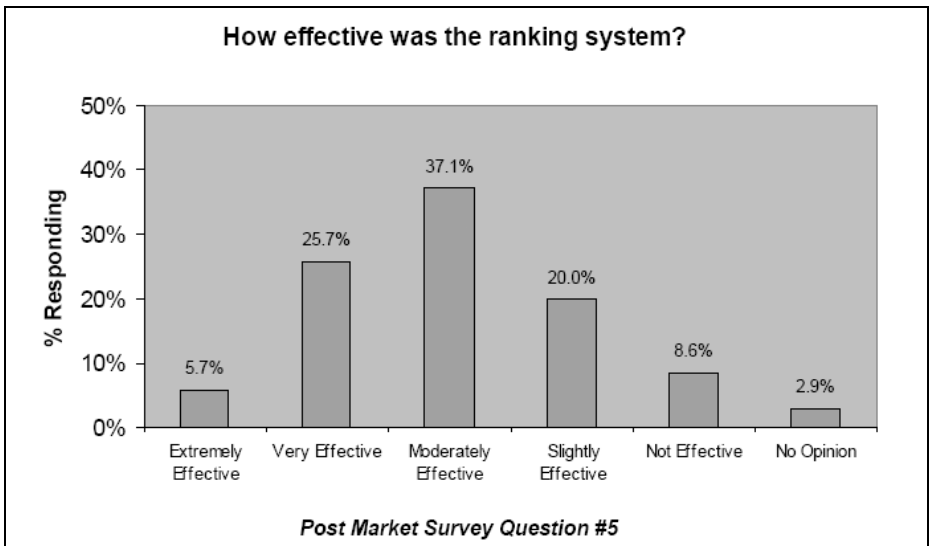


Figure 6: Survey Results on Ranking Effectiveness

Since the market is being used to aggregate the opinions of the entire group, it is not at all surprising that the participant survey yielded mixed results when asked about the market's effectiveness.

The survey results regarding the quality of the ideas were very positive, as shown in Figure 7. The overall quality of the ideas surpassed other idea generation and brainstorming activities GE Energy has tried in recent history.

Overall, in spite of the potential undue influence of founders, the market was successful in achieving GE Energy business objectives.

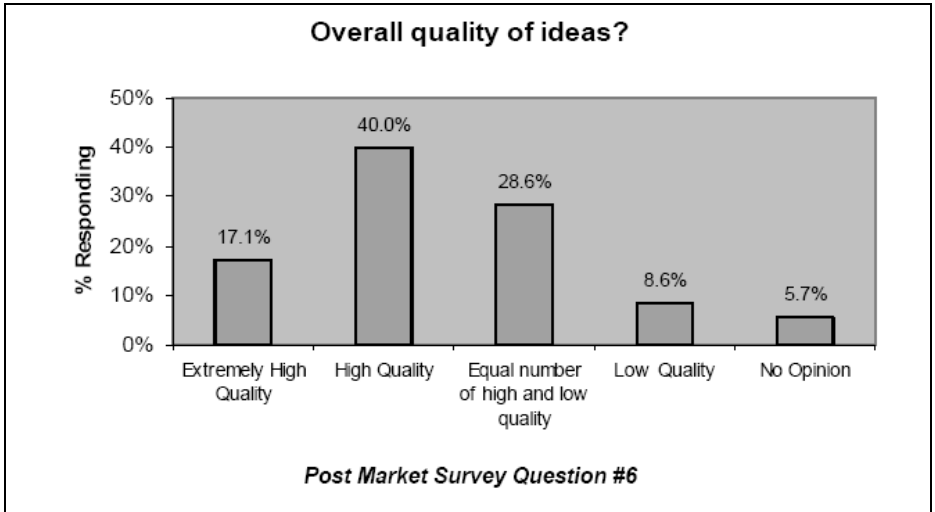


Figure 7: Survey Results on Idea Quality

3. MITIGATION STRATEGIES FOR FOUNDER'S BEHAVIOR

Having run several successful Imagination Markets within GE, we had not encountered such zealous idea founders before. The founder behaviors described earlier have been detected in some of our other markets, but not to the extent that they could have influenced the outcome. Now that we have witnessed this interesting behavior in full force, what market design changes or other strategies could we utilize to limit the influence of this kind of behavior?

1) Do not allow the founder to trade on his own idea: This option would unquestionably eliminate overzealous founder trading as it will change the trading motivation for founders. We thought, however, that participants would be more motivated to suggest ideas and compare them to other ideas if they could trade their own ideas. It would also not prevent friends or coworkers of the founder from overzealous trading on behalf of the founder. We can also reduce founder influence simply by not allowing the founder to *sell* any shares of their own security. This would allow them to profit from a good idea but not to aggressively trade by repeatedly buying and selling the same shares. However, the founder would not be able to sell any of his position (to buy another idea, say) if his idea's worth fell a lot. An alternative would be to limit the price for which the founder can trade. This may entail

allowing founders to trade on their own ideas only up to a pre-defined price, such as \$80/share.

2) Capping the total amount of shares a given security can be owned by an individual trader: By capping the number of shares a trader can own of a given security, it prevents a single individual from owning a large percentage of the shares. It does not, however, prevent a founder from repeatedly buying and selling the same shares in order to keep the price up.

3) Capping the total amount of money that can be invested in a single security by a single trader: This would be similar to the effect of option 2 above.

4) Limit the number of shares a trader can submit for a limit order: Several founders were performing most of their trades by setting up very large limit orders at attractive prices. For example, if the security were trading around \$95/share, the founder would place a Buy limit order of \$96/share for 100 or more shares. This would ensure that they keep the Buy price up until their limit order was exhausted. By restricting the number of shares that can be placed as a limit order, and thus requiring them to spend more time reissuing their limit orders, we may be able to reduce the founders' trading.

5) Disallowing 'straddling' limit orders; or requiring the straddle have a minimum spread: Founders were also able to keep prices inflated by setting high-volume buy and sell limit orders which straddled the current trading price and differed by only a few dollars. Thus if the security was trading around \$95/share, a founder would place an order to buy 100 shares at \$94 and sell 100 shares at \$96. This forced the price between these two thresholds until one of the limit orders was exhausted. Once exhausted, the founder could then issue another limit order to reestablish the straddle. Although similar to the behavior of a savvy trader playing fluctuations in the market, the founder's behavior differed in that their orders offered considerably more shares and had a tight spread between the bid and ask limit order prices. By requiring that the difference between the buy and sell orders be at least \$10, we can make it much more difficult for founders to have such a heavy influence on trading. While it will not prevent their overzealous trading, it would likely reduce it. This would be less of an issue with thicker markets.

6) Eliminate motivation to zealously trade: Our market typically offers a reward for the best idea – either in the form of funding, or in the form of an opportunity to pitch the idea to the businesses leadership team. This provides motivation to the founder to influence the price of their idea, including trading to keep the prices up. As the purpose of the market is to identify and fund the best ideas, it is difficult to find a way to obtain good ideas without rewarding founders.

7) Reduce the amount of liquidity in the market: We can prevent founders from taking huge losses in order to increase the value of their security by eliminating any excess cash and allowance given to the participants. We suspect, however, that this would have limited impact since several founders on our market were so passionate that they liquidated their holdings in all other securities in order to raise cash to buy shares of their security.

8) Allow short selling: We chose not to implement short selling in our market since users found short selling difficult to understand in early market prototypes. As a result, traders have a limited ability to demonstrate that they feel a security is over-valued. If a trader believes the fundamental price is lower than the current market price, they can only sell their shares. Once done, that trader cannot further express his opinions through subsequent trades. If we allow short selling, traders could continue to express their opinion that a security is over-valued; this may help offset the exuberant trading by the founder.

9) Require founders to disclose their trades or all traders to disclose their trades once they buy more than some percentage of outstanding shares of an idea (similar regulations exist for financial markets). We already allow any trader to look at the transactions log and see the entire history but we haven't implemented any mechanism to alert other traders when a founder makes trades in his own idea or when any trader accumulates a certain percentage (note, however, that buying a lot of an idea's outstanding shares should not be very feasible unless the market has unusually few participants).

Finally, we should also acknowledge that restricting founders' behavior might not improve market performance. Presumably the founder of an idea knows more about the idea than other participants, so we may want them to play a big role.

4. CONCLUSIONS

Overall, the GE Energy business was extremely pleased with the results of the Imagination Market. Funding was immediately provided to kick-start the two ideas tied for the top, and the business has decided to file patents for several others. GE Energy plans to continue use of markets in the future. The volume and quality of ideas compared favorably to brainstorming sessions, on-line suggestion boxes, and on-line discussion forums. One of the keys to success for using a market as a brainstorming tool is having an active and engaged trading population. Further work will be done to find more and better ways to encourage higher participation.

Incentives proved to be useful and the seed money prize for best idea helped convince participants that the market was a serious tool for idea generation. The prizes for top performing portfolios may have caused some tournament behaviors, but they did help stimulate trading activity to improve liquidity. Incentives for the top ideas contributed to “founder” behavior. This behavior in of itself is not bad for the market, but care should be taken to ensure its influence is limited by larger participation in the market.

NOTES

1. LaComb, C., Barnett, J., & Pan, Q. (2005).
2. Chen, K., & Plott, C. (2002), Bingham, A. (2003), Kiviat, B. (2004), Hapgood, F. (2004).
3. Chan, N., Dahan, E., Kim, A., Lo, A. & Poggio, T. (2002), Feder, B. (2002).
4. iPod® is a trademark of Apple Computer, Inc.
5. James, D. & Issac, R.M. (2000).
6. Forsythe, R, Reitz, T. & Ross, T. (1999).

REFERENCES

- A Bingham, "Complexity Theory and Pharmaceutical R&D" [2003] *Boston: Credit Suisse First*.
- N Chan, E Dahan, A Kim, A Lo and T Poggio, "Securities trading of concepts" [2002] *Massachusetts Institute of Technology technical report*, Cambridge, MA.
- K Chen and C Plott, "Information aggregation mechanisms concept, design and implementation for a sales forecasting problem" [2002] *Social Science Working Paper 1131*, Pasadena, California. California Institute of Technology.
- B Feder, "To learn what people want, trade idea stocks" *The New York Times*, 10th February, 2002 at pB4.
- R Forsythe, T Reitz and T Ross, "Wishes, expectations and actions a survey on price formation in election stock markets" [1999] *Journal of Economic Behavior & Organization*. 39(1) at pp 83-110.
- T Gruca, J Berg and M Cipriano, "The effect of electronic markets on forecasts of new product success" [2003] *Information Systems Frontiers* 5(1).
- F Hapgood "Future Shock" [September 2004] *CMO Magazine*.
- D James and RM Issac, "Asset markets: How they are affected by tournament incentives for individuals" [2000] *American Economic Review* 90 995-1004.
- B Kiviat, "The End Of Management? and Looking Ahead" [12th July, 2004] *Time* at p A4..
- C LaComb, J Barnett and Q Pan, "The imagination market" [July 2007] *Information Systems Frontiers* Volume 9, Issue 2-3. 245– 256.

APPENDIX 1: INSTRUCTIONS TO TRADERS AND SCREEN SHOTS OF APPLICATION

Upon logging into the Imagination Market application, the following instructions were given to market participants:

The Imagination Market allows you to trade securities that represent the different product breakthrough ideas proposed by your colleagues. Like the ideas your colleague proposed to generate revenue? Buy the idea's stock with your Imagination Market bucks. Have your own idea that could contribute to the bottom line? Propose it and if your colleagues buy in, your idea will be funded. The market aggregates the players' opinions and provides a single measure representing the relative value of each security: share price....

Each player begins with \$3,000. Active players also receive an additional \$1,000 each week. When securities (ideas) are added to the market, each player will receive 15 shares at no cost. During the course of trading, you can buy or sell shares on any given security. If you like a security's idea, or believe the price is going to go up, buy shares from other players. If you do not like an idea, or believe the price is going to go down, sell your shares to other players. When the market is closed, each of your securities' worth will be determined by the volume-weighted average price (VWAP) over the last five days each security was bought or sold.

In addition to this short set of instructions, a 3-page instructional manual regarding specific examples of trading strategies, as well as Market Rules, were provided to market participants. If you would like a copy of these documents, please contact the authors.

The following screen shots illustrate the manner in which the market and securities were presented to the users. Figure 8 illustrates the securities listing (idea titles have been replaced with ticker names for the purposes of this illustration). Figure 9 illustrates the trading page for a given security (description removed and idea titles replaced with ticker name for the purposes of this illustration).

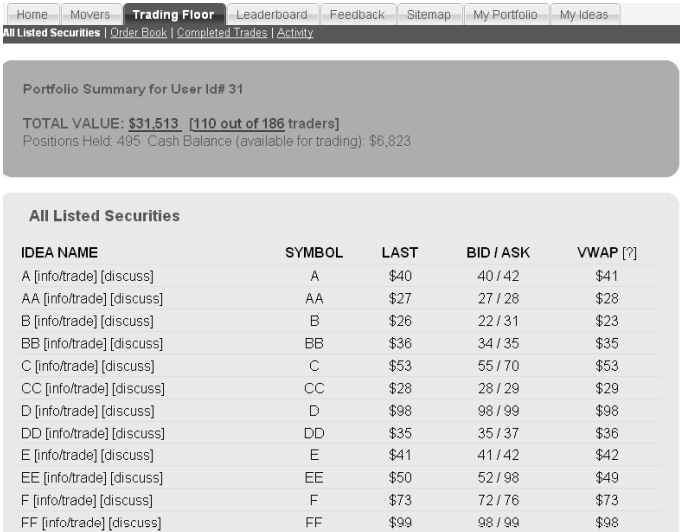


Figure 8 - GE Imagination Market Trading Floor

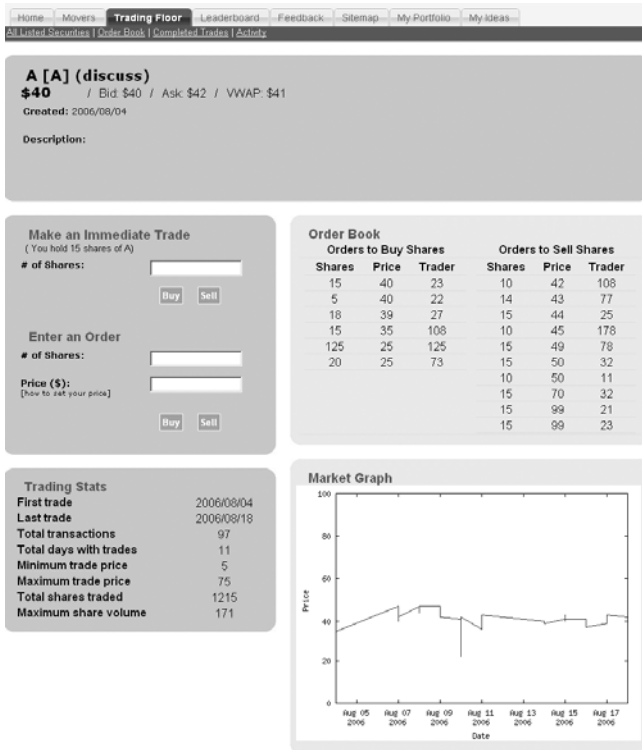


Figure 9 - GE Imagination Market Trading Page