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Full Length Research Paper

Trading procedure for the discovery of asset price risks

Steven S. Kan

Visiting Professor, Institute of Law and Economics, Southwestern University of Finance and Economics, Chengdu, China
E-mail: nthusskan@yahoo.com

Abstract

The traditional trading procedure as currently adopted in centralized financial exchanges sets, at a point in time, the most competitive price as the single transaction price of all units of an asset consummated in trading. The trading procedure for the discovery of asset price risks introduced in this essay, in opposite, sets a plurality of shared value appraisals between buyers and sellers to form a spectrum of concurrent transaction prices. In the received view of a probabilistic asset price, the contrast shows that the traditional trading procedure works like a filter suppressing investors' all other value appraisals, whereas the introduced trading procedure works like a prism to reflect a spectrum of shared idiosyncratic value appraisals. Transparency in price risk enabled by the prism-like trading procedure is shown to facilitate undistorted coordination and adjustment of investors' idiosyncratic value appraisals. The institutional source of recurring excess volatility in financial markets is thus traced to the unrecognized filter-like institutional frame the traditional trading procedure imposes on investment behaviors. This essay also elucidates the role of price discovery in coordinating idiosyncratic risk perceptions and its related issues.

Keywords: Excess volatility, price spectrum, risk discovery and trading procedure.

1. Introduction

Market phenomena occupy the primary focus of economic research. There are two approaches to study them, the institutional approach and the calculus approach. For institutional economists, research into the market is not just about functions and rules (Hodgson, 2006), its nature, process, role, and evolution are more important. For instance, investigating deep into market process, Knight (1921) elucidated the relationship between entrepreneurial role and profits in a world of ubiquitous uncertainty. In a different vein, Hayek (1945, 1973) expounded how market arises from human interactions and is a spontaneous order that coordinates mutual expectations of individual actions in production and consumption. The institution of market therefore transforms idiosyncratic subjective value appraisals amidst Knightian risk and uncertainty into objective prices. The calculus approach can be traced backed to the socialist calculation debate in 1930s, when proponents of social planning (Lange, 1936) focused on designing organization that could mimic the calculating function of the market. (See Boettke (2001) for a summary of the socialist calculation debate.) Market socialism, if not necessarily fails, can only follow leading market economies because entrepreneurship, market process, and the property and contract institutions supporting their success are beyond human design.

Recent research of the market nevertheless seems to have shown a predominant interest in the calculus approach (Mirowski and Somefun, 1998), though with some innovative twists. For example, with an aim to improve operational efficiency of financial asset trading, literature on the microstructure of financial market bloomed in the 1990s (Madhavan, 2000; Hasbrouck, 2007). Surveying over an array of literature, Mirowski (2002, 2007) finds such interest in trading procedures an undesirable shift to view markets as computational entities, algorithms, and even bits. (In Mirowski's finding such shift is throughout economics subfields of mechanism design, experimental economics with zero intelligence agents, and artificial intelligence and automated markets.) An irony of the shift is that the financial crisis of 2008 and the flash crash of US stock market on May 6, 2010 suggest only the worsening of excess volatility in financial markets. (Mushrooming of

financial derivatives (Shiller, 2008), unprecedentedly high financial leverage (Geanakoplos, 2009), and regulatory lapses (Stiglitz, 2010) are considered the factors contributing to the devastating financial crisis of 2008. Stub quotes and recently popularized algorithmic trading (see, e.g, Narang, 2009) are suspected to have triggered the flash crash of 2010, the biggest intraday decline, 998.5 points, in Dow Jones Industrial Average.) To some, they even mean that capitalism is in bankruptcy (Cassidy, 2009). It is not exaggerating to say that our understanding of market is still in a state of deficiency.

The nature and role of market is inseparable from that of price discovery, which would not be possible without a trading procedure. Market, as an upper level of spontaneous order, actually involves lower-level organized and spontaneously grown trading procedures, in tandem or in competition. Though sympathetic with recent interest in trading procedures as a result of economists' past preoccupation with the individual, Kirman (2007) agrees with Mirowski that "the phenomenal diversity of market forms" and "the ubiquity of change within that diversity" should guide the research of the market as an evolutionary institution. (The two quotes appear in Mirowski (2007:233).) Taking their emphasis on institutional aspects, this essay contends that existing market forms share primarily traditional price discovery and none espouses a trading procedure that can transform subjective value appraisals into objective price risk.

The lack of transparency in asset price risk under current trading procedures, once explicitly recognized, reminds not only ample room for market evolution but also our deficiency in understanding the nature of price discovery. Through a contrast of two trading procedures, this essay confirms that institutional approach to trading procedures can illuminate market insights that calculus approach is incapable of offering. (The title of this essay highlights a subtle distinction between comparative and contrasting institutional analysis (MacKenzie, 2007). My analysis goes beyond Coase's (1960) static comparison and gets into the dynamic adjustment as Mises and Hayek did in the socialist calculation debate.) The first trading procedure examined is the traditional trading procedure currently adopted in centralized financial exchanges, which sets, at a point in time, the most competitive price as the single transaction price of all units of an asset consummated in trading between buyers and sellers. The second is the trading procedure for the discovery of asset price risks, which sets a plurality of shared value appraisals between buyers and sellers of a traded asset to obtain a spectrum of concurrent transaction prices. (The defense of my counterfactual exercise is that it has often been proven more than a mind game. For example, before unraveling the mystery of entrepreneurial profits Knight (1921:267) engaged in a counterfactual world of zero uncertainty. Similarly, Coase (1960) conducted it with zero transaction cost to break a new ground for research into the delimitation and assignment of property rights.) The major finding from the contrast is that, by suppressing all other idiosyncratic value appraisals of investors, the traditional trading procedure entails a filter-like price discovery. On the other hand, by reflecting a spectrum of investors' idiosyncratic value appraisals, the counterfactual trading procedure discloses a prism-like price discovery.

As price risk is surely a concern of every economic agent, the distinction between a filter-like and a prism-like price discovery helps open up related institutional questions as: what insight from the finding of a filter-like traditional trading procedure can benefit our understanding of current investment behaviors, what a prism-like price discovery would mean for the coordination of dispersed, intertemporal saving and investment decisions, how a prism-like trading procedure can be made a reality, and why market evolution has not resulted in a prism-like trading procedure. For above questions this essay obtains five findings. First, regarding behavioral finance literature's emphasis (see, e.g., Barberis and Thaler, 2003; Shiller, 2003) of Kahneman and Tversky's (1979) psychological framing effect on decisions under uncertainty, the filter-like traditional trading procedure is identified as the actual, institutional frame that sets off herd behavior in financial markets (see, e.g., Bikhchandani and Sharma, 2000; Rook, 2006). Second, in contrast, price risk transparency offered by the prism-like counterfactual trading procedure would facilitate undistorted adjustment and coordination of investors' idiosyncratic value appraisals and risk perceptions. The two results together shows that recurring excess volatility in financial markets is inherent with traditional trading procedure that is still being applied to asset trading. Third, to the challenge of an institutional innovation for financial markets (Shiller, 2005), a viable prism-like trading procedure is obtained by extending Hayekian knowledge discovery (Hayek, 2002) to a setting of non-price competition and reconciling it with the short-side determination à la Keynes (1936), when quantities in selling and buying orders are unequal. Fourth, debates on puzzling market phenomena reflect a failure in recognizing the role of price discovery in coordinating idiosyncratic risk perceptions. And, fifth, the absence of a prism-like trading procedure stems not from technology constraints (Demsetz, 1967) but from habits (Hodgson, 1997) in the indiscriminate borrowing of practice and theorizing from consumption goods trading.

Before giving an outline, I need to explain my point of departure and the motivation for some new terms introduced in this essay so that my central message can be received with clarity. First, prominent economists have long envisioned asset price, at a point in time, to involve an underlying probability distribution and used its second mathematical moment as price risk in modern financial economics (see, e.g., Markowitz, 1952; Sharpe,

1964; Black and Scholes, 1973). The received vision of a probabilistic asset price is my point of departure.

Second, the image of a probability distribution of asset price is in stark contrast to that of a single price and images of a non-uniform probability distribution of asset price intuitively alerts the threat of asset price risks. While the received vision enables an image of the probabilistic asset price in the brain, traditional trading procedure presents no such observable image. It reminds that sunlight had long been nothing but sunlight before a prism was crafted to replicate the picturesque image of a rainbow and show that it actually entails a spectrum of seven constituent colors. Responding to Mirowski's (1989a) call for "more light than heat" in economics and following the use of a light spectrum in conveying the multiplicity of constituent colors of a picturesque rainbow, I use "asset price spectrum" in this institutional analysis to refer and enliven the probability distribution of asset price. In this sense, the received vision of a probabilistic asset price is referred as the "spectrum vision" of asset price. Despite that it has long been embraced by financial community, its counterpart "spectrum image" is still missing from financial asset trading. The trading procedure offering price risk transparency in this essay then represents a "spectrum discovery" of asset price beyond the traditional price discovery. (Following Mirowski (1989a), I defend my use of the spectrum analogy by referring to Jorge Luis Borges' consideration: "It may be that universal history is the history of a handful of metaphors.")

The unrecognized filter-like nature of traditional price discovery and the vista of a prism-like spectrum discovery help not only alert the deficient diversity in market evolution but also generate insights into puzzling market phenomena that have only been misinterpreted by the calculus approach. In the remainder of this essay, Section 2 reviews the competition and single-price aspects of the traditional trading procedure and elucidates its filter-like nature. Using spectrum images of asset price as the benchmark of comparison, Section 3 expounds how such images would render price risk transparency and facilitate undistorted adjustment and coordination of investors' idiosyncratic value appraisals. Section 4 highlights a prism-like trading procedure that current technology readily supports.

In light of the prism-like trading procedure's price risk transparency, price discovery's role in coordinating risk perceptions is the focus of Section 5, which also briefly reexamines three issues related to its neglect. They involve the neglected differences between consumption goods and assets, the calculus debate on capital market efficiency, and the recent emphasis of animal spirits in macroeconomic phenomena (Akerlof, 2002; Akerlof and Shiller, 2009). Finally, Section 6 concludes that habits, not technology constraints, have delayed the emergence of a prism-like trading procedure, while echoing some recent calls (Mirowski, 1989b; Karsten, 1990; Coase, 2002; Hodgeson, 2009) for a new landscape of economics.

2. Traditional Price Discovery And Its Unexamined Limitation

Leaving aside differences between the New York Stock Exchange (NYSE-Euronext) and the NASDAQ, we can see two common aspects of current financial asset trading procedures. (Without loss of generality, my analysis focuses only on stocks. The two aspects are ubiquitous for the trading of options, currencies, futures contracts, and financial derivatives.) First, buying (selling) orders compete with one another through bidding (asking) prices—the competition aspect. Second, one and only one numerical value is set, at a point in time, as the single transaction price for all asset units consummated in trading between buyers and sellers—the single-price aspect. For market orders within the prevailing bid/ask spread, the market price buyers pay is the ask price and the market price sellers get is the bid price. Limit orders are not matched until the limit price meets the market price. The single-price aspect is retained by the increasingly popular Alternative Trading Systems (ATSs) that have recently gained NYSE-Euronext's and NASDAQ's accommodation (see, e.g., Markham and Harty, 2008).

The two aspects of financial asset trading can be traced back to Smith's (1976: 65) beaver-for-deer barter in primitive hunting societies. There could not have but emerged the single-price aspect since the single price uniquely would determine the hunters' utilities for respective consumption of the meat, fur, or hide. The single price necessarily would fall within the two hunters' reservation prices and was determined through negotiation. The competition aspect would emerge when a third hunter stepped in to barter for beaver, or deer. The two aspects of traditional price discovery were passed down to the exchange of surplus agricultural produce and implements as well as the trading of consumer and industrial goods in modern monetary economy, though with some twists. For example, prices of groceries at supermarkets are administered rather than negotiated. They have also become the two cornerstones of neoclassical price theory's proposition of market efficiency (Arrow and Debreu, 1954; Debreu, 1959, Merton, 1973). Retaining its single-price aspect, financial asset trading further expanded its competition aspect from Colonel Anderson's simple farm auction to double oral auction because there were many simultaneous buyers and sellers. The adoption of information technology to speedily process a huge amount of trading orders in modern centralized financial exchanges and through Electronic Communications Networks (ECNs) does not change the two fundamental aspects of traditional trading procedure as applied to asset trading

(see, e.g., Barclay et al., 2003).

It is, however, fun to watch a rainbow in the sky. It is also magic and inspiring in seeing that a prism reflects sunlight into a spectrum of seven constituent colors just like that of a rainbow. A prism indeed makes a difference in confirming that there is something beyond what naked eyes can see. As a result of traditional price discovery applied to asset trading, the single transaction price for each unit of a traded financial asset is only what naked eyes see at a point in time. Nevertheless, prominent economists referred earlier were able to envision asset price as a random variable with its underlying probability distribution. Their spectrum vision of asset price inspires that a financial asset is like the sunlight consisting of many unobserved colors. Despite it has become the underpinning of modern finance, there is yet a financial prism to reflect an asset's price spectrum as physicists did in confirming the light spectrum.

If we take more seriously the received spectrum vision, then the sunlight analogy helps illuminate that the traditional price discovery works like a filter. Instead of turning seven colors of light observable, a filter, as used in photography for example, may absorb other colors of light and allow only a particular color of light through. It reminds that nothing but the single transaction price passes through the traditional trading procedure. Thus, together, the competition and the single-price aspects of the traditional trading procedure suppress investors' all other value appraisals of the asset being traded. In this sense, the traditional price discovery exhibits a filter-like nature unrecognized before.

The finding suggests that the filter-like traditional trading procedure has been imposing some institutional frame on investment behaviors. It reminds that, in addition to the psychological source emphasized in behavioral finance, allegedly irrational investment behaviors may have an institutional source related to the institutional frame. For the two points let us turn to additional specifics of the traditional trading procedure.

The bid/ask spread posted by financial exchanges, or ECNs, informs the highest bidding price and the lowest asking price of all remaining orders to be matched, with the latter exceeding the former to compensate market makers who buy low and sell high. In other words, in order to immediately fill orders buyers must be willing to pay the higher prevailing ask price and sellers must be willing to accept the lower prevailing bid price. Hence, when a shiny market outlook spreads through word of mouth, optimistic buyers would adjust upwards their bidding prices to fill their orders as soon as possible. Similarly, optimistic sellers would adjust upwards asking prices especially when short sales are few, which have been so because of institutional, social, and psychological barriers (Shiller, 2003).

Herd behavior and feedback dynamics emphasized in behavioral finance, however, cannot be started without some herd leadership. Being filter-like, the traditional trading procedure's competition aspect screens orders and picks herd leaders. Additionally, its single-price aspect announces the most optimistic bidding and asking prices and the new, prevailing bid/ask spread. With less optimistic bidding and asking orders unfilled, what the filter allows through is nothing but the shiniest color (the most competitive price) of the light (financial asset). Conversely, the gloomiest color comes out of the filter when bad news spread around through word of mouth and the most pessimistic investors become herd leaders. Thus, behavioral finance's explanation of excess volatility is incomplete without explicitly recognizing the traditional trading procedure's two filter-like institutional features in framing investment decisions and triggering herd behaviors.

In sum, despite that the spectrum vision of asset price is embraced by all members of the financial community, prevailing financial asset trading simply does not render its counterpart spectrum image observable to naked eyes. The filter-like features of traditional trading procedure have been institutionally framing investment decisions and causing herd behaviors, but gone unnoticed. As a result, the traditional price discovery necessarily compels investors with a single transaction price regardless of their other idiosyncratic value appraisals and therefore distorts investment behaviors.

3. Transparency in Price Risk and the Institutional Source Of Excess Volatility

This Section uses spectrum images of asset price as the benchmark of comparison to show how investor might respond under a prism-like spectrum discovery procedure. Its first purpose is to highlight different investment behaviors under contrasting asset trading procedures, particularly one with and one without price risk transparency. The second purpose is to provide an otherwise unavailable insight into the institutional source of the infamous excess volatility in financial markets.

Suppose, for simplicity, that a spectrum discovery trading procedure produces, at a point in time, two constituent prices. Suppose further that all factors influencing asset fundamentals are unchanged Contribution to excess volatility of financial markets by monetary authority, macroeconomic policy, or industrial production is beyond the focus of this essay. The focus is therefore only on the adjustment and coordination of investment decisions with the simplest spectrum image of two constituent prices. In this case, after observing the lower constituent price of the given simple asset price spectrum, an investor who bought at the higher constituent price may regret that she has been too optimistic and unexpectedly become a herd leader. The reason is that she could have bid less and gotten her order filled, since the lower constituent price indicates that there were less optimistic sellers as well. On the

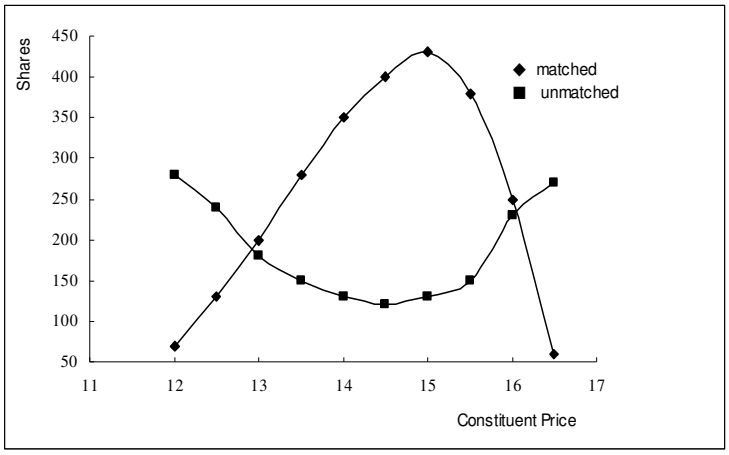

Figure 1. A Fictitious Effectuation of Constituent prices

other hand, while a herd leader in selling may feel very happy that she has gotten the higher selling price, she would also wonder whether she will be as lucky next time. The reason is similarly that she is able to observe the less optimistic bid. The two simultaneously observable constituent prices thus render some transparency in price risk.

Given that matched quantities are also observable, buyers and sellers would have no difficulty in calculating the discrete probability distribution of the two constituent prices. (The probability distribution is conditional on orders being matched.) Insofar as prospect and regret (Loomes and Sugden, 1982) would shape decision making under uncertainty, the available information of the two constituent prices and their corresponding probabilities imply that investors' bidding or asking behaviors, at the next point in time, would be more modest in comparison with those under the traditional trading procedure. If we move back the time to that before trading, then expecting a trading procedure to consummate in two constituent prices an investor would take into account the foregoing analysis and be modest in investment behavior as well, because she is no longer framed by the single-price and competition aspects of the traditional trading procedure. Thus, when promising business outlook spreads, the two counterfactual constituent prices would be lower than the single transaction price of traditional trading procedure. Conversely, they would be higher than the single transaction price of traditional trading procedure when gloomy business outlook spreads. It therefore confirms that the filter-like traditional price discovery impose a frame that distorts investment behaviors and leads to price overshooting.

Extending the number of constituent prices from two to ten, for example, helps shed further lights on price risk transparency that is not available under the traditional trading procedure. Figure 1 shows the case of a fictitious spectrum discovery of 10 constituent prices. Beyond the two extreme constituent prices of $12 and $16.5 no match was made in the case. For each constituent price it can be seen that some orders are matched and others are not; the matched quantities and the unmatched quantities are also indicated in Figure 1 to suggest some price risk involved. It should be noted that Figure 1 involves the assumption of a regular condition. That is, while matched quantities show a single peak, the unmatched quantities is U-shaped.

The following analysis focuses mainly on spectrum images satisfying the regular condition.

Dividing matched quantities at each constituent price by the total number of matched quantities, we obtain the probability distribution of orders being matched at various constituent prices as the hump-shaped spectrum image shown in Figure 2. The hump-shaped spectrum image is slightly tilted to the right and informs that probabilities of being matched at inner constituent prices are, as intuitively expected, much higher than those at the two ends. While the two ends represent extreme investment behaviors that have been accommodated, the observable risk of placing too optimistic or pessimistic orders without being matched would help restrain, at the next point in time, such extreme investment decisions. The spectrum image thus not only gives a plurality of concurrent transaction prices but also offers price risk transparency.

The number of unmatched quantities at a constituent price is a piece of useful information. For an order at a constituent price, its conditional probability of match can be obtained as the ratio between the matched quantities and the sum of the matched and unmatched quantities at that constituent price. Figure 3 shows an example of the conditional probabilities of match at various constituent prices. From direct observation, it is also single-peaked and an order of outer constituent prices has lower conditional probability of match than that of inner constituent prices. Aggressive behaviors thus would en-

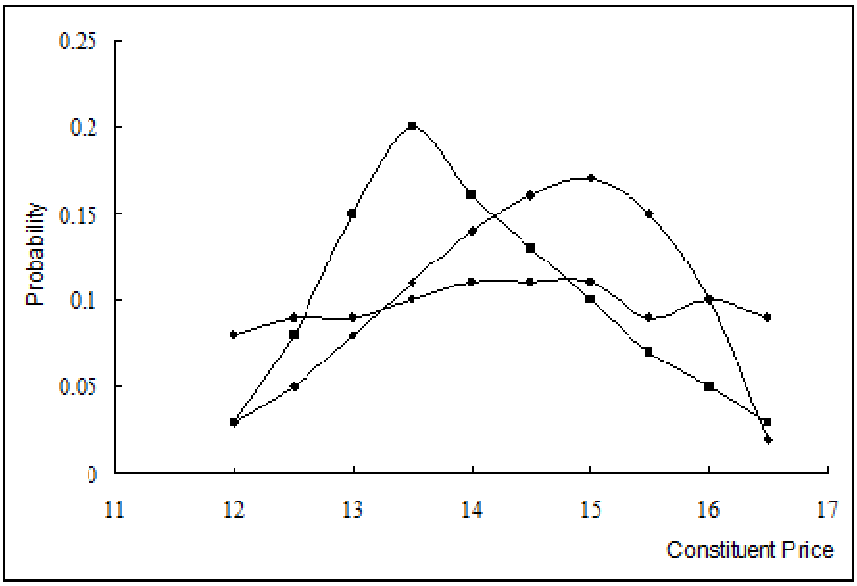

Figure 2. Typical Spectrum Images of Asset Price

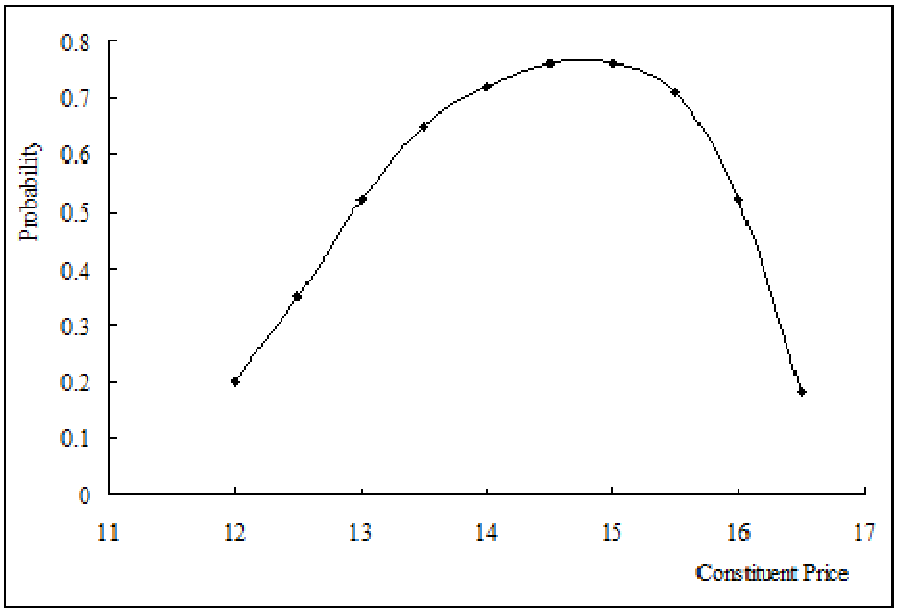

Figure 3. Conditional Probability of Match

tail two types of risk. First, too optimistic prices may fall out of the range and become unmatched. Second, even if a not too optimistic price is within the spectrum range, it may have a lower chance to be matched. Information of conditional probabilities of match, therefore, helps not only restrain unwarranted spread of optimism or pessimism through word of mouth but also inform investors to adjust and place their orders, at the next point in time, on adjacent constituent prices.

Two alternative shapes of spectrum image that are slightly skewed to the left and relatively flat are also shown in Figure 2. They further help enable direct intuition on how investors' appraisals of asset price are inclined to change at the next point in time. Suppose, in the spectrum image slightly skewed to the left, the conditional probabilities of match are what shown in Figure 3.

Suppose further that unmatched orders to the right (left) of the peak are all selling (buying) orders. The more modest investment behavior just obtained implies that these unmatched investors would adjust selling (buying) prices downward (upward) to increase their conditional probability of match. Other things being equal, into the next point in time, the range of effectuated constituent

prices will not get wider and matched transactions will increase toward both ends. The resulting spectrum image will thus be flatter. Price risk transparency through the spectrum image of 10 constituent prices and their conditional probabilities confirms more picturesquely that price movements would be less volatile in comparison with those under the traditional price discovery.

Lastly, the relatively flat spectrum image in Figure 2 suggests a more or less uniform uncertainty within the range. If there is a significant difference among the conditional probabilities of match at these constituent prices, similar adjustment as described above would be triggered. However, if the difference is not significant enough, then no further suggestion to investors on the direction of adjustment exists until new relevant information arrives or is acquired. (Double peaks in a spectrum image may represent a transient that would motivate investors to acquire more relevant information. It suggests that SEC's circuit breaker regulation is necessary only under the traditional price discovery where risk transparency is absent.). Without the need to examine all possible variations in the shape of a spectrum image, the conditional probabilities of match, and the composition of unmatched orders, above analysis already indicates that the shape of a spectrum image into the next point in time is determined by the expected gain of a price change, the expected gain of increased conditional probability of match, and the transaction fees involved. Similarly, if we move back the time to that before trading, then expecting a trading procedure to consummate in 10 constituent prices an investor would take into account the foregoing analysis and be more modest in her investment behavior. Thus, with price competition being stripped off, the spectrum image of asset price provides undistorted coordination and adjustment of investors' idiosyncratic expectations about the business outlook.

The analysis via a spectrum image of asset price echoes that an otherwise rational individual's investment behavior may be falsely considered irrational (LeRoy, 2004), though in a different context. Particularly, the analysis shows how the filter-like traditional trading procedure have been framing and distorting investment behaviors and how a spectrum image would help restore undistorted coordination and adjustment of rational investment behaviors. Emphatically, it also shows that transparency in price risk through spectrum images would extend the role of price discovery into the coordination of idiosyncratic risk perceptions that the traditional trading procedure is incapable of offering. In other words, the institutional source of recurring excess volatility in financial markets hides in the distorting, filter-like traditional trading procedure that fails to coordinate the dispersed, idiosyncratic risk perceptions among investors.

4. A Prism-like Trading Procedure That Current Information Technology Readily Supports

That a spectrum discovery of asset price helps reduce excess volatility in financial markets is not very meaningful if it is impossible to have a prism-like trading procedure in the real world. Reconciling Hayek's and Keynes' insights, Subsection 4.1 outlines four salient features of a prism-like trading procedure that current information technology readily supports to deliver the desirable risk coordination and price risk transparency. Since its detailed execution is beyond my purpose, Subsection 4.2 provides some necessary clarification in anticipation of a few technical doubts and theoretical concerns (For detailed steps toward the generation of an observable asset price spectrum, see Kan, 2006).

4.1 Four salient features

In order to generate an observable spectrum image at a point in time, its constituent prices must be concurrently effectuated in matching buying and selling orders. In the perspective of an exchange operator, this general principle leads to three salient features. First, only orders submitting explicit buying and selling prices are accepted. It is necessitated by the fact that the meaning of a traditional market order becomes indefinite when a plurality of constituent prices is allowed at the same time. Second, constituent prices of the resulting spectrum are determined by investors' shared value appraisals, namely the common prices submitted in buying and selling orders. (Since a limit order cannot be filled until the limit price hits the market price under the traditional trading procedure. Orders of the prism-like trading procedure are thus different from limit orders.) Third, buying and selling orders at a constituent price are matched with a form of non-price allocation. Since the total buying and selling quantities at a constituent price are rarely equal, voluntary exchange can only be fulfilled with the short side—a familiar feature of Keynesian economics. With unequal sides, orders of the short side can all be matched while only some orders of the long side can be matched with their counterpart short-side orders. A form of non-price allocation is consequently needed to match particular buyers and sellers. For example, a random draw or the first-come, first-served rule can accomplish the purpose (see, e.g., Taylor et al., 2003). It goes without saying that the exchange operator discloses relevant information, including graphical displays, of the effectuated constituent prices, the matched and the unmatched quantities, the probability distribution of constituent prices, and conditional probabilities of match at different constituent prices.

In the perspective of an investor, the effectuation of multiple constituent prices can be facilitated by empowering investors to submit a plurality of price-

Table 1. Contrasting Features of the Two Trading Procedures

Trading Procedure	Institutional Nature	Orders	Matching	Result
traditional	filter-like	inhibiting mixed strategies	price competition	single price only
counterfactual	prism-like	accommodating mixed strategies	non-price competition in shared value appraisals	a price spectrum, transparency in price risk

quantity pairs, for the same traded financial asset, in her buying or selling order. If we take seriously Hayek's teaching for the use of dispersed and idiosyncratic knowledge in society, then such empowerment of multiple value appraisals at the same point in time represents the fourth salient feature that is advantageous for undistorted adjustment and coordination of investors' value appraisals and risk perception. The casino game of roulette, which involves a table, a wheel, and a ball, serves an analogy to make the point clearer.

A roulette game allows players to simultaneously wager on a single number, two numbers, four numbers, and so on by placing chips on the number, the line between two numbers, the corner of four numbers, etc. The game thus accommodates players' diverse probability appraisals on where the spinning ball may land. More specifically, the combination of numbers indicates that the casino game is special in accommodating mixed strategies from players. It helps illuminate that, while the specific location the spinning ball may land is a pure chance event in a roulette game, it is interactively determined by investors through price competition in traditional price discovery. Nevertheless, the competition and single-price aspects of traditional price discovery effectively limit investors to indicate only a single price-quantity pair at a point in time. The use of mixed strategies by investors to express their idiosyncratic value appraisals is thus inhibited.

By empowering simultaneous indication of a plurality of price-quantity pairs, the prism-like trading procedure accommodates, like the roulette game, investors' mixed strategies under Knightian risk or uncertainty. More figuratively, with such empowerment, the prism-like trading procedure enables investors to interactively determine the number of spinning balls as well as the locations they will land. Recall that, at a constituent price, the ratio of unmatched quantities to the total quantities of the long side suggests an implicit cost of being rationed out by non-price allocation. Ensuing adjustment and coordination of value appraisals next point in time thus involves a non-price competition to reduce such rationing cost. In this sense, the feature expands Hayekian knowledge discovery into non-price competition in mixed investment strategies. Major differences between the traditional trading procedure and the prism-like counterfactual trading procedure are summarized in Table 1.

Operationally, the prism-like trading procedure starts with a plurality of explicitly indicated buying or selling price-quantity pairs from investors. It then sets common prices indicated in selling and buying orders as the constituent prices of an asset price spectrum. A form of non-price allocation follows to match, at each constituent price, orders of the short side with their counterpart orders of the long side. Through graphical displays, it enlivens the received spectrum vision by impressing a clear spectrum image on investors' computer monitors. With price risk transparency, investors get a chance to confirm or falsify their risk perception from financial analysts or word of mouth. Instead of aggressively competing for the highest price to sell, or the lowest price to buy, an investor would adopt mixed strategies and spread her risk exposure. While she would be empowered to do so, at a point in time, under the prism-like trading procedure, her pseudo-mixed strategies under traditional trading procedure are ineffective until some indefinite time, across the trading day, when her buying or selling orders get to meet prevailing bid/ask spreads. Emphatically, mixed strategies, spectrum discovery, and price risk transparency are possible under the prism-like trading procedure because Keynes' and Hayek's contributions are not pitted against each other but reconciled.

4.2 Some clarification

There may, however, arise two minor technical doubts to be clarified. First, with infinitely many real numbers, buying and selling prices indicated by investors can hardly coincide with each other to effectuate any constituent price. My clarification is that tick sizes can be set to guide investors just as that in the traditional trading procedure. Additionally, bounds of price submissions or the number of constituent prices may also be set to expedite sharper focus of investors and reduce strategic outliers. With the assistance of computer algorithms, they can even be dynamically adjusted to suit market conditions. Second, matching buying and selling orders at a particular constituent price does not appear to be easy because selling and buying quantities indicated would reflect investor's budget or asset holding constraint such that they may not mesh with each other. My clarification is that a round lot size can be set as well.

For example, the round lot size for the spectrum discovery of 10 constituent prices may be set at 1/10 of the present.

There may also arise two major theoretical concerns related to the convergence of a stable asset price spectrum. First, the spectrum discovery seems infeasible because it would be awfully hard for an investor with bounded rationality to determine, within her asset holding or budget constraint, a plurality of price-quantity pairs to buy or sell. Indeed, the plurality of price-quantity pairs and corresponding probabilities of constituent prices represent a bundle of lotteries. Experiments and theories of decision making under uncertainty show that an investor is able to tell whether a lottery bundle is utility-enhancing. The concern here is, however, about the reverse—the composition of a utility-enhancing lottery bundle. More particularly, it is about how to structure a mixed strategy with a plurality of price-quantity pairs. While game theorists have long established that mixed strategies help reach Nash equilibrium, there is yet a theory or experiment suggesting how to structure a mixed strategy from utility to lottery space. (In Scene 4, Act 4 of an interesting book of scientific dialogues of game theory, Kaneko (2004) discussed the complex problem and suggested a way to structure a mixed strategy.) Nevertheless, the roulette game reminds that casino players show no great difficulty in coming up with how to wager on a plurality of numbers and determine corresponding amount of chips on the table. Similarly, it is not uncommon for investors to engage in pseudo-mixed strategies, gradual buildup or sale of shares within a trading day or in several trading days, under the filter-like traditional trading procedure. Thus, Alchian's (1950) insight into economic behaviors under uncertainty suggests that with imitation and evolution investors will learn to satisfactorily structure mixed strategies of a plurality of price-quantity pairs. Second, comprising at a point in time multiple transaction prices that may result from intraday trading under the traditional price discovery, spectrum images appearing throughout the same trading day might not be less chaotic. Indeed, prices showing intraday variation of 1% in a normal trading day, or 5% in a more volatile trading day, under the traditional price discovery may all appear instantly in the range of a spectrum image at a point in time. Nonetheless, as explained earlier, into the next point in time the range of constituent prices may narrow to 0.6%, or 3%, for example. The reason is again that, other things being equal, the probability distribution of the constituent prices and the conditional probabilities of match at various constituent prices would help undistorted coordination and adjustment of investors' idiosyncratic value appraisals and risk perceptions. The concern thus misses the rich informational content the spectrum image can reveal, to which recent empirical research results have suggested strong supports. (Cao et. al., 2009; Harris and Panchapagesan, 2005; they found, respectively, that the imbalance between buys and sells in Australia's open limit order books was informative about future price changes and that NYSE specialists favored themselves through such information.)

Lastly, advances in information and network technologies have indeed changed financial asset trading in many ways since the last decade of the 20th century (see, e.g., Klein and Fadiman, 2004). Nonetheless, the difference between the filter-like traditional price discovery and the prism-like spectrum discovery is more in vision but less in technological requirements. The pre-matching processes of order handling, routing, and aggregation and the post-matching processes of settlements and payments basically remain intact. On the other hand, the spectrum discovery's short-side determination and non-price allocation would require no more sophisticated database technology and computer algorithms than those associated with matching buying and selling orders under the filter-like traditional price discovery. Thus, current information and network technologies readily supports the spectrum discovery of a plurality of constituent prices to coordinate risk perceptions, render price risk transparency, and reduce the frequency and amplitude of excess volatility in financial markets, which government regulations, innovation of financial instruments, and various investment strategies have promised but failed to deliver. As technological advancements have produced cocktail therapies in medicine, multiple warheads in weaponry, and multi-core microprocessors in computing, the absence of a prism-like trading procedure appears to be indeed intriguing.

5. The Role of Price Discovery in Coordinating Idiosyncratic Risk Perceptions

The institutional approach of this essay reveals that there may be two different kinds of price discovery, one filter-like and the other prism-like. It also shows that price discovery may serve two different coordinating roles, one on idiosyncratic value appraisals and the other on idiosyncratic risk perceptions. In light of the overlooked prism-like price discovery and its coordinating role, this section intends to further highlight some drawbacks associated with current discussion on the coordination of decentralized, intertemporal saving and investment decisions in market economies. Since a comprehensive discussion is beyond the scope of this essay, I can only touch briefly on three related issues to suggest advantageous implications of an extended risk coordination role of price discovery. Subsection 5.1 examines the differences between consumption goods and financial assets to suggest how economists have neglected the potential risk coordination role of price discovery. It is then suggested in Subsection 5.2 why the proposition of capital market efficiency is not very

meaningful and its debate could only turn into a calculus contest of quantitative methodologies and data-mining skills. Subsection 5.3 explains how spectrum discoveries across various financial markets would further help, through price risk transparency, harmonize dispersed saving and investment decisions and why behavioral macroeconomics' emphasis of animal spirits is distracting due attention away from the crucial, institutional role of price and risk discovery.

5.1 Neglected differences between consumption goods and financial assets

The application of traditional price discovery for goods and services to financial assets represents a big leap and needs to be examined. First, assets are not consumption goods that generate direct utilities. Second, the divisibility of a financial asset, compared to that of consumption goods, is arbitrary and explains in part why a large number of identical units are usually issued. More importantly, financial assets are instruments to store value for future consumption. After acquiring a financial asset, an investor must make another financial transaction before postponed consumption can be executed. Similarly, an arbitrageur realizes profit only from round-trip transactions of buying low and selling high. What determines the utility gain from a unit of financial asset is, ceteris paribus, the expected price difference between round-trip transactions. (Wholesalers of goods engage in resale and negotiate for an average price of multiple, identical units. Their profits are determined by the price difference of their round-trip transactions as well. In this sense, only retail transactions in consumption goods using the competition and single-price aspects of traditional price discovery are as intuitive as the beaver-for-deer barter.).

Though units of a financial asset are exactly the same, investors would hold diverse appraisals of their values at a point in time. The reason is that they somehow form different expectations of a company's operating cost, sales, strategic plans into the future, or others' expectations of market sentiments. Sellers and buyers in financial asset trading strike a deal not because they have different tastes or skills but because they hold different expectations and value appraisals. Apparently, even if traditional price discovery applied to financial asset trading produces the "best execution" for each leg of the round-trip transactions, it does not guarantee the resulting price difference to be satisfactory—the reason of investors' concern with excess volatility in financial markets. It suggests that the single, competitive price of a financial asset, at a point in time, should not be as important as that associated with consumption goods. Indeed, various pricings offered by ATSs and ECNs lend a support to the suspicion. For example, in lieu of the competitive price, Instinet accommodates three different crossings at the mid-point of the bid/ask spread, the volume weighted average price (VWAP), and the closing price, depending on the time of the day. (See, http://www.instinet.com/includes/pdf/ls/US_VWAP.pdf (Last visited on September 24, 2012).) The VWAP pricing strategy, as an example of what being adopted in the growingly popular algorithm trading, indicate that at least institutional investors are averse to intraday fluctuations of the most competitive prices. Risk is necessarily associated with the span of time between round-trip transactions. If risk is sufficiently small in consumption trading, the lack of risk coordination in traditional price discovery is adequate. On the contrary, if risk is significant as roundabout productions and financial assets of various liquidities prevail in modern economy, then an extended role of price discovery in coordinating idiosyncratic risk perceptions is important.

In spite of the apparent differences, no question seems to have been raised on why all identical units of a financial asset must share the same single transaction price at a point in time to forsake the opportunity of expanding the role of price discovery into the coordination of idiosyncratic risk perceptions.

5.2 The calculus debate on capital market efficiency

There are different versions of the efficient capital market proposition (see, e.g. Fama, 1991) with differences primarily in the informational set available to investors (see, e.g., Timmermann and Granger, 2004). The proponents of capital market efficiency hold essentially that the single, competitive transaction price of the traditional trading procedure applied to financial asset trading reflects information available to investors and is efficient. As I have argued that investors' naked eyes cannot see the underlying probability distribution of asset price and therefore their price risk, the debate on capital market efficiency has hence become a calculus contest in digging into data and recovering the underlying probability distribution (see, e.g., Fornari and Mele, 2001). In result, more sophisticated quantitative methodologies get developed and the capital market efficiency proposition stands firm without being refuted in empirical investigations. A tension nonetheless hovers because economic agents cannot welcome economic efficiency without paying the price of excruciating volatility in financial markets.

The efficiency concept the proponents use however is based on the competitive and single price aspects of traditional trading in consumption goods. The spectrum discovery instead opens up the potential of a contrasting efficiency concept that builds on its multiplicity in constituent prices. Efficiency is therefore not absolute but depends on the institution involved. Insights into the role of price discovery in coordinating and harmonizing dispersed, intertemporal saving decisions can only be

understood when filter-like and prism-like trading procedures are contrasted with each other. The capital market efficiency proposition is thus not very meaningful without explicitly having an alternative trading procedure to compare with. In this light, the spectrum discovery's advantage in offering price risk transparency suggests that, for capital markets, it may be "more efficient" then the traditional price discovery because it can additionally coordinate idiosyncratic risk perceptions and significantly reduce the excess volatility resulting from the traditional trading procedure applied to asset trading. Reversely, the filter-like traditional trading procedure may be more efficient than the prism-like trading procedure in consumption goods market.

If the spectrum vision of prominent economists referred above has been taken seriously, then proponents of capital market efficiency should realize that excess volatility is in part due to the lack of a spectrum image of asset prices. If they would pay more attention to institution rather than calculus, then they should find their notion of efficiency is institutionally dependent and quite narrow. However, it was not the road taken and they paid little attention to the important coordination of idiosyncratic risk perceptions.

5.3 The distracting emphasis of animal spirits in behavioral macroeconomics

In their criticisms against the efficient capital market proposition, proponents of behavioral finance also failed to recognize the institutional frame the traditional trading procedure has been imposing on investment behaviors. Instead of taking an institutional diagnosis of the excess volatility problem, they borrow in part from Keynes' animal spirits to argue against the fallacy of capital market efficiency. Recently at the wake of the 2008 financial crisis, there also arises the behavioral macroeconomics (Akerlof, 2002) that alerts animal spirits and human psychology in global capitalism (Akerlof and Shiller, 2009). Though behavioral macroeconomics is not centered on the calculus of market efficiency, it is neither institutional nor penetrating in terms of elucidating price discovery's role in coordinating and harmonizing decentralized, intertemporal saving and investment decisions.

Economics distinguishes financial investment from real capital investment. As a bridge to the real capital investment of various industries, financial investment is actually carried out with savings stored in various financial instruments such as stocks, bonds, currencies, insurance contracts, futures, and derivatives serving different needs and functions. Macroeconomic performance is intricately related to prices of these financial assets and their associated price risks because they affect not only aggregate savings but also aggregate real capital investments. Price risk transparency and the extended Hayekian knowledge discovery elucidated in this essay thus worth a recapitulation so that price discovery's role in coordinating and harmonizing macroeconomic savings and investments can be further appreciated.

Since various financial instruments serve different purposes, spectrum images and corresponding data out of a prism-like trading procedure would offer price risk transparency across these assets and provide information necessarily to establish specific linkages among them, to which the traditional trading procedure and an alert of animal spirits are incapable of offering. Similarly, firms issuing equities, as an example of the various financial instruments, have upstream or downstream vertical relationship with other firms as well as some horizontal relationship because of substitutable or complementary nature of their products. The rich set of information conveyed through spectrum images and corresponding data would further help the undistorted coordination and adjustment of equity prices and their price risks across firms and industries. Insofar as their special links between firms and industries may be better established, the advantageous spectrum discovery would also enhance undistorted coordination and adjustment of real capital investments.

Were Keynes and Hayek not pitted against each other, the extension of a spectrum discovery that reconciles Hayekian shared value appraisals and Keynesian short-side determination with non-price competition would offer an opportunity to improve macroeconomic coordination and performance. In this sense, the recent borrowing and emphasis of Keynes' animal spirits is distracting due attention away from the crucial risk coordinating role of spectrum discovery in market economies.

6. Summary and Conclusion

Through the contrast of two trading procedures, this essay identifies the filter-like and the prism-like natures of price discovery, extends price discovery's role to the coordination of idiosyncratic risk perceptions, traces the institutional source of excess volatility in financial markets to the filter-like traditional trading procedure, reconciles Hayekian and Keynesian insights to show that a prism-like spectrum discovery of asset prices is readily supported by current technology, and explains how macroeconomic coordination and performance can be improved with price risk transparency. Emphatically, these results are obtained along institutional approach and what calculus approach is unable to offer.

Ronald H. Coase, (2002) recently made two noteworthy remarks. First, he admonished that the landscape of economics, unlike that of physics, chemistry, or biology, has not changed much since the publication of Paul Samuelson's classic principles text-

book. Second, he attributed the lack of significant change to economists' failure to look at economic system as the object of study. As they are related to this essay, I offer two brief responses before concluding this essay. First, visions stand out prominently in expanding the landscape of economics. Adam Smith's vision of invisible hands is a clear example that has made competition and efficiency the focus of neoclassical economics. Coase's vision of ubiquitous transaction costs has similarly changed the landscape of institutional economics. Second, society grows with visions, their confirmation, and further applications. Scientists observe natural phenomenon, form new visions, design new tools and experiments, and replicate their success in the real world. As the rainbow example used in Section 2, scientists used a prism to confirm sunlight as a spectrum of seven constituent colors. Similarly, after observing the interaction of light and matter, they envisioned wave phenomena of tiny particles, an electron for example, and explained it with quantum physics whose nature can be characterized as discrete and probabilistic. In this particular sequence landscapes of various scientific fields have been advancing and changing the world we live in.

It reminds that probabilistic concepts were introduced to neoclassical economics in a different path that was described as a "probabilistic counter-revolution" (Mirowski, 1989b). In its continuous and deterministic nature the neoclassical flow approach to the price behavior of consumption goods is indeed like Newtonian mechanics (Mirowski, 1989a; Karsten, 1990). The juxtaposition of probabilistic concepts to neoclassic economics however did not enhance our understanding of market economy as an institution but only turned economics and finance to be more calculus-oriented. As a result, mathematicians and physicists are welcomed on the Wall Street in large numbers and fashionable phrases like "nuclear phynance" and "statistical phynance" emerge to pronounce the debacle of financial economics. I am not suggesting that prominent economists who pioneered the spectrum vision of asset price should be blamed for such intriguing development. To the contrary and with due fairness, I consider them to have been close in bringing true probabilistic concepts to economics. In view of the particular sequence various scientific fields have made progress, the long called for "quantum economics" would have emerged if we took seriously their vision and followed it with a prism-like trading procedure to enliven the spectrum image of asset price. My exploration of a spectrum discovery of asset prices and risks is therefore more than heuristic and not self-indulging. Insofar as rich sets of spectrum data should become available, economists would have a chance to engage, like their counterpart natural scientists, in falsifiable tests of investment behaviors under uncertainty and develop new visions into sophisticated interactions between real flows of durable goods and nominal asset stocks so that macroeconomic coordination is improved and the amplitude and frequency of economic fluctuation are reduced. In this sense, new visions, new institutions, new data, and new theories will continue to change future landscape of economics.

Finally, to the question why there is yet a prism-like asset trading procedure, I need not follow the common practice to identify various technology constraints that might have inhibited the emergence of a spectrum discovery of asset prices. The reason is simply that information, database, and network technologies have all been with us for more than twenty years and we still do not have such a trading procedure. As my brief examination of related issues in Section 5 suggests, economists have paid little attention to price discovery's nature and role in coordinating and harmonizing decentralized, intertemporal saving and investment decisions. They instead only research under the spot light of the traditional trading procedure without recognizing apparent differences between consumption goods and assets, the limitation of the efficiency concept that is based on the traditional trading procedure's single-price and competition aspects, and potential coordination of idiosyncratic risk perceptions through markets. In conclusion, whether researching only under the spot light is the result of academic constraints on fast and more publications, habits developed from past institutional achievements, not technology, seem to have much to do with the absence of a prism-like trading procedure that would offer price risk transparency.

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