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Economic Derivatives Markets—New Opportunities for Individual Investors: A Research Agenda

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Abstract

Economic derivatives markets offer exciting new risk diversification opportunities for individual investors. Mostly in the form of small denomination binary options, these markets trade contracts on consumer inflation, currencies, median real estate prices, gas at the pump, and retail-oriented indicators. The research into the role of these markets for individual investors is in its infancy. This paper provides a review of the current state of knowledge and sketch out three broad avenues of further worthwhile inquiry: economic derivatives as alternatives to traditional stock indexing, the viability of the markets in light of limited trading motives and small probabilities, and modeling difficulties inherent in pricing unhedgeable underlying events. © 2007 Academy of Financial Services. All rights reserved.

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1. Introduction

Individual investors are going to bear more risk of funding retirement. In the past, social security and defined benefit plans provided a large safety net for their needs. Future retirees' well being will be a result of their own financial decisions on asset allocation and security selection in their 401-K plans and taxable accounts. Hiring professional advisors will not change the fact that the amount of wealth they end up with will be more uncertain than in

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the past, as more of it will be subject to market performance, and less will be guaranteed. This has profound implications.

The main objective of retirement saving is to reach by the retirement age the level of wealth equal to the present value of the income stream drawn over the actuarial retirement period. The calculation of the goal amount takes into account the lifestyle of the retiree, inflation projections, and family circumstances. The problem is that although the target is fixed (think: strike price), the strategy to achieve it is not, as it involves investment in risky assets (think: underlying). In the "ownership society" where investors are on their own, the final shortfall or excess becomes a random variable with a very large variance, because the portion of the income subject to market fluctuations is large. One way to reduce the risk of the savings shortfall is to eschew stock investing for fixed income strategies combined with equity options. Sharpe argues for individuals not to own stocks but target income funds or principal-protected investments. Bodie (2001) advocates that defined benefits plans and individuals should only own inflation-indexed securities and long-term options on the general stock market.

As Sharpe (2006) explains, the problem is even more complicated. Retirement saving combines two types of risks: investment risk and insurance risk. Investment risk has to do with the market risk of asset values held in a portfolio. Insurance risk has to do with personal risks of being sick or facing life and property perils. It is the combination of the two that determines the final level of wealth achieved. Traditionally, investment risk has been dealt with through rational asset allocation and sound investment selection. Insurance risk has been dealt with by purchasing life and hazard policies. Now there may be a third way: economic derivatives.

The objective of this paper is to set a broad research agenda on economic derivatives and prediction markets in the context of their appeal to individual investors. Section 2 catalogs the history of the market. Sections 3 and 4 are the key sections of the paper. They survey the literature, develop important directions of inquiry, and sketch out opportunities for much needed theoretical and empirical work. In Section 3 discusses economic derivatives as risk space-completing alternatives to traditional indexing. In Section 4 tackles the viability of the economic derivatives markets: the motives for trading, the role of informed and uninformed traders, and the predictive power of these markets. Section 5 outlines the pricing issues for event-based contracts. The valuation techniques blend actuarial and hedge-based approaches. Section 6 offers conclusions.

2. The evolution of economic derivatives markets

In the 19th century, futures markets were established to transfer price risk between producers and users of commodities across time. In the 20th century, options markets, whose volume exploded after the 1973 modeling revolution, allowed contingent slicing of the risk across the price space. The 1990s saw double-digit growth in futures and options on new underlying assets: interest rates, bonds, swaps, credit spreads, and credit defaults, allowing sophisticated risk taking or hedging by large institutions. The 21st century appears to belong to active funds and retail investors. New electronic exchanges opened trading in small-denomination (≤$100) products that matter to individual investors' short- and long-term investment objectives: prices of gas at the pump, consumer inflation indicators, regional real estate indexes, mortgage rates, hurricane damage, to name a few. Early adopters have been quick to jump at these opportunities; other small investors have struggled to understand their significance. Financial advisors and academic researchers have been slow to examine and explain the role of these products in investors' portfolios.

Individual investors actively participate in cash markets for stocks and bonds. Households own 35% of stock directly and another 60% through mutual and pension funds. Of the 25-million brokerage accounts in the U.S., less than 5% have any option positions, and practically none have futures. Apart from the fact that most investors do not think that their well being is affected by variables like credit spreads, palladium prices, or 30-year Treasury rates, investors have to face large denominations, hefty margin requirements, and transaction costs. The new event derivative exchanges tackled all those issues head on. Some of their contracts are as small as $10. The underlyings are not just rates or spreads, but also retail price indicators, real estate indexes, economic events [Fed actions, Consumer Price Index (CPI), Gross Domestic Product (GDP), and unemployment releases] and political events (presidential, federal and state elections, and war, weather and pandemic events around the globe). Even the set of commodity underlyings is retail-oriented (gasoline-at-the-pump, oil, gold). (Previously, only the Iowa prediction market, exempt from U.S. antigambling regulation on research grounds, had covered a tiny subsample of this product space.) The U.S. regulators continue to throw roadblocks by allowing esoteric volatility or spread-related contracts that appeal to institutions, but disallowing weather or catastrophe-related contracts that might appeal to households. Yet the retail revolution appears unstoppable. In the late 1990s and early 2000s, unregulated currency trading shops opened doors (e.g., FXCM, InterbankFX) attracting tens of thousands of active speculators and cracking open the wholesale foreign exchange market dominated by large money center banks. The currency houses leverage their clients' smallholdings 1000:1 through innovative futures-like spot FX contracts. Individuals transact with the house and the house then hedges their collective demand in the interbank market. This is not unlike an electronic communication network crossing stock orders within its network and sending an imbalance to the New York Stock Exchange (NYSE). In 2004, two offshore markets opened trading in economic and political event derivatives. IG Index, based in the U.K., is a book-making operation closed to U.S. residents. InTrade, based in Ireland, offers accounts that can be funded with U.S. originating debit and credit accounts. Like the FX trading venues, both are essentially well-capitalized dealer institutions with the house playing the role of a monopolist market maker. Contracts are standardized, but customers bear full credit risk of the institution. In the early 2000s, Goldman Sachs and Deutsche Bank teamed up with the Chicago Mercantile Exchange (CME) to launch CME/Economic Derivatives. Investors bid or offer futures and options on government economic releases through a series of electronic Dutch auctions rather than in an open outcry setting. The trading is not continuous, but multiple auctions at pre-specified intervals allow investors to get in and out of positions.

In 2004, the Commodity Futures Trading Commission granted an exchange license to a new electronic market called HedgeStreet. For the first time, small investors have direct access to a U.S. based exchange with a mandate to list economic or event derivatives.

HedgeStreet offers capped futures and binary options contracts on Fed announcements, CPI, oil, gold, silver, gasoline, real estate (by region), currencies, and several other underlyings. It operates as a self-collateralized and disintermediated exchange: investors open accounts directly with the exchange avoiding brokerage commissions, trade with each other, not the house, and post full collateral on each transaction. Contract sizes are small ≤$100, and gains and losses are contractually limited. The exchange does not publish volume numbers, but trading activity is already large enough to sustain continuous two-way market making in all contracts, and the product menu has steadily increased. In August 2006, the exchange listed hurricane contracts on the total property damage for the season and on individually named tropical storms. Also in 2006, the CME announced the introduction of real estate contracts to compete directly for institutional and retail business.

3. Do economic derivatives complete investors' risk space and can they serve as risk factors in indexing strategies?

Ever since Markowitz (1952), Sharpe (1964), and Lintner (1965), the modern portfolio theory has held that a utility-maximizing long-term investor should only hold a combination of a riskless asset and a fully diversified stock market portfolio. Diversification would eliminate idiosyncratic risk, any short-term fluctuations would have no impact on the long-term outcome, and the combination of money market account and an index fund could be tailored to the investor's risk aversion. The practical advice following this theory called for focus on asset allocation, indexing, and restraint from active management and market timing. Numerous research studies showed that active management leads to inferior performance, higher costs and taxes, and that asset allocation matters a lot more than security selection.

3.1. Can economic derivatives be used to optimize a stock portfolio?

In a single-factor index model á la Capital Asset Pricing Model (CAPM), the realized return on a stock or a portfolio is the sum of the risk-free rate and a factor loading, or beta, times the risk premium, plus the unexpected component, or:

$$r = r_f + \beta(E[f] - r_f) + \tilde{e} \tag{1}$$

In CAPM, one argues that mean-variance optimizers all hold the same tangent portfolio and therefore the single factor in the model is the market portfolio that serves as a summary statistic for all systematic risk. The model has been challenged empirically. Lo and MacKinlay (1988) found predictability in stock returns. Keim (1983) evidenced positive abnormal returns in January and many seasonal studies followed. Research by Shanken (1990), Fama and French (1992), and others then firmly established that within CAPM one has to at least allow for time-varying risk premia or admit more than one priced risk factor. In Fama and French (1996), the additional factors do not come out of the representative agent utility maximization theory, but out of empirics showing that firm size and book-to-market ratios have historically had positive risk premia. Perhaps we knew that something might be amiss when Ross (1976) showed that within the Arbitrage Pricing Theory, without any utility arguments, at least three mimicking portfolios seem to improve the explained variation of stocks. Fama and French (1996) identify what they are and clearly demonstrate that the market portfolio does not capture all systematic risk! Yet there exists a trillion dollar industry devoted to indexing, even though their mean-variance efficiency is questionable.

The issue of indexing has been dormant for the last 10 years only to come back to life in 2005 and 2006. Bogle and Malkiel's (2006) Wall Street Journal op-ed was a reaction to the challenges to fundamental cap-weighted indexing launched by some prominent researchers. Among them, Siegel (2006a, b) proposes dividend size-based indexing. See also Seneker (2004). A variety of cap-indifferent indexes are studied in Treynor (2005) and Arnott, Hsu and Moore (2005); many are shown to offer benefits to long-term investors. What all these studies seem to point to is that although indexing is not dead, a single cap-weighted index may not be enough to capture all systematic risk of a stock portfolio and produce a risk-return bundle on the efficient frontier. What one needs perhaps is a multidimensional view with at least two more risk factors. The challenge is to find what they may be and to expand the searched universe to company-specific (accounting?) and macro data. Chen, Roll and Ross (1986) tried it before and MSCI-Barra continues to supply the asset management industry with risk factor decomposition data. What is changing now is that the risk factors are becoming tradeable. With the emergence of economic derivatives, investors can take dollar positions on inflation, non-farm payrolls, or mortgage rates.

3.2. Can economic derivatives be used to optimize a broad portfolio of stocks, real estate, and consumer durables?

The case for including economic variables becomes stronger when we consider a typical household's broad portfolio of wealth of which 50% is real estate and the remainder is split between financial asset and consumer durables (cars, household equipment). Can a stock market index be a summary statistic for the systematic risk of such a portfolio? Breeden (1979) showed that consumption patterns needs to be accounted for in explaining stock returns. Therefore, consumption, and its dependent variables, must be accounted for in explaining broader wealth variation. In 2005, residential real estate was worth $19 trillion, non-residential $12 trillion, consumer durables $3 trillion, equipment and software $5 trillion, whereas financial assets claimed $17 trillion for stocks and $12 trillion for bonds.[1]

Empirical studies of risk factors have focused primarily on stock wealth. Yet an investor holding stocks, bonds, foreign securities, durables, real estate, and the present value of his human capital is exposed directly or indirectly to inflation, local real estate shocks, GDP changes, or currency risk. Shiller (2003) calls for the opening of derivative markets in all of these risk variables arguing that individual investors cannot close their eyes and pretend that their only exposure is to the Standard & Poor's (S&P) 500 index. His main focus is of course the unbundling and tradeability of real estate.

There are other problems with broad wealth indexing. Multiple studies have shown, for example, that neither real estate nor equities are good inflation hedges. If inflation risk cannot be hedged with real estate or financial assets, then what can it be hedged or diversified away with? There is also a wealth of literature documenting small investors' inefficient asset allocation. In Vanguard's (2005) report on U.S household savings, 13% of 401-K savers have their entire portfolio in fixed income, 21% all in equity, and 20% in company stock. Although the U.S. economy represents 25% of the world's and the U.S. market capitalization is less than 40% of the world's, U.S. investors have more than 90% of their equity assets in domestic stocks, and Lewis (1999) finds that no single theory explains this "home bias." According to the Investment Company Institute Fact Book (2006), U.S. mutual fund assets are split 45% domestic, 10% international, 23% money market, 15% bond, and 6% hybrid. Although investment in other asset categories is constrained and costly, investors have flocked to them. Real Estate Investment Trust (REIT) assets have increased rapidly, and in addition to two large gold exchange-traded funds (ETFs), the first silver ETF opened in 2006, all holding not mining stocks, but claims on the real commodities held in trust. The mere emergence of economic derivatives markets suggests that investors and traders are willing to pay for or speculate on the price of bearing exposure to the economic underlyings.

3.3. Can economic derivatives help with a diversification dilemma in the world of increasing correlations?

The international finance literature is full of evidence that the average correlation between the world's stock markets is increasing over time. The domestic mutual fund industry literature is full of evidence of active management's mediocre performance coupled with closet indexing. Not only do managers underperform benchmarks, they do it while secretly trying to match them. All of that leaves investors with few real diversification opportunities.

In international finance, Koch and Koch (1991) and others show that correlations between national stock indexes are unstable over time. King and Wadhwani (1990), Lin, Engle and Ito (1994), and others find that correlations increase during precipitous market declines, but not during market advances. Longin and Solnik (2001) confirm the same result for extreme bear markets and extreme bull markets and find that correlation is correlated (sic) with trend and not volatility. Ang and Bekaert (2002) offer a regime-switching dynamic allocation model for dealing with increased correlation in volatile bear markets. Morana and Beltratti (2006) decompose the factors that co-drive correlations, volatility, and trend. The upshot of this research strand is that international diversification works in stable up-trending markets but may fail exactly when the investor needs it, in crisis sell-offs.

The research on the correlation of U.S. stock sectors has shown similar patterns. More importantly, it has been shown that fund managers eschew stock picking in favor of closet indexing. Although some actively managed funds offer 60% correlation or lower, most are very highly correlated with their benchmarks. Instead of seven thousand mutual funds, perhaps we only have a few hundred distinct ones, the rest differing only in fees they charge. Yet if economic variables can be traded, perhaps they and not additional funds or stocks should be added to investors' portfolios as a diversification tool. Investors have already shown their appetite for true alternatives with the emergence of commodity ETFs. Gold and silver ETFs that own real commodities were snapped up by investors despite reservations that the trust holding the commodities would deplete the supply of the metals creating an artificial premium on the funds. The energy stock mania of 2005 can also be explained not by stellar cash flow of the energy stocks, but by the lack of direct exposure vehicles for oil, natural gas, and gasoline. In this context, a gas-at-the-pump or a real estate economic derivative can provide for an individual investor a means to gain direct exposure to an asset or commodity as opposed to exposure to an energy stock or a REIT. In addition, unlike ETFs that have to hold the underlying asset, economic derivatives can be written on non-tradeable variables, expanding the range of diversification choices.

3.4. Can economic derivatives be substitutes for insurance?

The primary difference between insurance and traditional derivatives markets is the fact derivatives are written on underlyings that are broadly traded assets (stocks, commodities), or on variables related to traded assets (rates in bonds), and market participants do not directly influence the prices of the underlying assets. Insurance contracts are written on events and variables that do not have traded assets associated with them; the events are often related to random physical phenomena, and the contracts are personalized in that the policyholder's actions may influence on the value of the policy. Although a derivative writer is able to protect his exposure through dynamic trading in the related asset, an insurance writer can only count on a pooling effect of his actuarial assumptions or can diversify his risk across insured individuals or properties. Economic derivatives fall in between these two extreme cases. An economic derivative on the announced Fed target rate is a contract whose payout depends on an outcome of a random event rather than on a price of a traded asset. The pricing of economic derivatives does not rely on risk-neutral valuation around a forward price, but on subjective probabilistic assumptions. Although traders may be able to hedge some of the risks in gas-at-the-pump or real estate contracts by trading oil futures or REITs, they cannot hedge non-farm payrolls or hurricane contracts that are more akin to insurance. They cannot eliminate the exposure; they can only develop a probability model and try to collect enough premiums across different strike space to cover the exposure for all possible outcomes. Economic derivatives cannot be personalized the way insurance can, but they can come close. HedgeStreet trades hurricane contracts on specific hurricanes that threaten particular geographic areas. Although this does not cover an individual house, it narrows the scope of the damage to a small stretch of the coast. Both HedgeStreet and the CME trade regional real estate contracts. Whereas this does not cover an individual house, it narrows the scope of the contract to a particular metro area. In the future, college tuition contracts, regional unemployment contracts, and industry revenue contracts may perform the same functions of narrowing the population affected by particular physical or lifestyle risks.

Whereas there have been numerous attempts by the insurance industry and broker-dealers to cross over and merge the two fields, few have been successful, because of the inherent unhedgeability of insurance contracts. Harrington (1997) suggests that catastrophe derivatives can offer a way to reduce underwriting, distribution, and capital costs for catastrophe insurance and reinsurance. Hodgson (1999) suggests ways derivatives can be used in pooling insurance risk and as a basis for estimating potential losses and the value of real assets. Muermann (2001) provides a model of the Chicago Board of Trade's catastrophe insurance derivatives. Krutov (2006a, b) lists the use of insurance risk swaps and Industry Loss Warranties in the risk management of property insurance, and points to the difficulties of developing index products for life insurance whereas noting that at least three mortality bonds have been issued in capital markets. In general, there appear to be two ways in which event derivatives can be used by insurance. The first is for insurers and re-insurers to take basis risk by hedging their catastrophe portfolio with an index product. Traditionally, insurers have been unwilling to take this basis risk, preferring instead risk pooling and reinsurance. Yet the risk portfolio of an insurer is typically highly correlated with an industry index when a catastrophe strikes. The second way is for the insurance derivatives products not to offer cash payouts, but to trigger capital market events when catastrophes occur. This does not provide a perfect hedge, but solves capital-raising problems for insurers hit with substantial payout claims. In both of these cases, a derivative would have to have an event (catastrophe, property damage) as an underlying with reasonable strike levels based on actuarial estimates. It appears that the hurricane contracts introduced by HedgeStreet in August of 2006 have been designed to meet these criteria. Interestingly, HedgeStreet kept the sizes of the contracts small to allow individuals to participate in the market. Households unable to obtain coverage in the insurance market can purchase hurricane binary contracts. They may also be able to arbitrage the cost differential.

3.5. Example: Insuring hurricane damage and job loss using derivatives?

Katrina and Rita victims not only found it hard to collect on their homeowners insurance policies because of the double fault cross clauses and state regulation of flood policies, but also saw their policy premiums increase by 50% and more. Suppose a family on the Texas coast owns a $300,000 home, and has one head of household earning $70,000. They are covered by homeowners insurance that costs $1,300. That policy only covers damage because of wind and a flood policy may cost another $1,000. Suppose that instead of purchasing flood, the family goes long on hurricane binaries. In an insurance policy, they face a tradeoff of the maximum amount insured and deductible against the premium level. In a binary contract, they face the tradeoff of the total level of insured damage in the region (strike price) against the cost of the binary. The interesting feature of the economic derivative market is that the premium depends on the market's collective expectation of the total damage, so that if the total damage is expected to be small, because, for example, the hurricane is heading toward a rural area, the premium may be quite small. For example, a <$25 million strike on a $100 payoff may cost as little as $5. The homeowner may be able to exploit the difference between the expectation of the total damage and his private damage. The basis risk may actually work for him in this case. In addition, in case he loses a job because his business is struck, the binary may incidentally cover that loss too.

4. The viability of economic derivatives: predictive power, uninformed traders, and small probabilities

Although economic derivatives have not attracted a lot of empirical research, theoretical work has focused on microstructure issues related to the notion of prediction markets and behavioral motives for trading. The microstructure analysis questions whether prediction markets can successfully sustain continuous trading. Behavioral insights suggest that prediction markets may be more prone to economically "irrational" decision making.

4.1. Are economic derivatives markets viable? Can trading in derivatives on event underlyings be sustained?

The seeds of the discussion are in Kyle (1985) who considers three types of agents participating in any financial market. Perfectly informed traders trade on their superior information by knowing the true value of event probabilities. Liquidity (uninformed) traders have noisy expectations of the true probabilities subject to random error component. The two are matched by perfectly competitive market makers. Wolfers and Zitzewitz (2005) show that in this framework, if noise traders' beliefs coincide with those of market makers' beliefs, the noise traders do not trade unless their utility function includes non-economic benefits (gambling, entertainment) or a hedging motive. Only then does the utility gain from these extraneous motives outweigh expected loss because of noisy information. The existence of perfectly informed traders assures the mid price to stays close to the true probability events, but it forces the market makers to add an adverse selection component to the bid-ask spread. This further decreases the likelihood that the uninformed traders will trade as their certainty-equivalent point slips further up and can lead to the unraveling of the market as posited by Milgrom and Stokey (1982). The critical question for any prediction market is how to attract liquidity traders. Wolfers and Zitzewitz (2005) seem to underestimate grossly the hedging motive. Although it is true that currently the markets may be too thin to offer meaningful hedging to large players, the risk diversification motive, as I posited in Section 2, exists for households with assets concentrated in real estate, human capital, and stocks. This ensures the economic demand and supply for the prediction market. The speculators then enter to earn positive expected profit from the bid-ask spread and temporary risk holding. They bridge the timing and risk gap for the demand and supply agent, similarly to Chicago "locals" in the coffee futures pit intermediating between coffee growers and Starbucks. Moreover, if, as Dubil (2004) postulates, investors and hedgers are relative value speculators, they will prefer taking positions directly in risk factors rather taking the basis risk of one-dimensional market proxies.

4.2. Can event markets exist if people suffer from behavioral biases?

The second line of theoretical inquiry related to prediction markets is that of behavioral finance. Economic derivatives are often written on non-continuous variables or low frequency events. Thaler and Ziemba (1988) document the favorite long-shot bias in horseracing as evidence that people do not predict low-probability events accurately. People's subjective estimates of unlikely event are much higher than their true frequency of occurrence. This psychological failing can lead to consistent losses for long shot gamblers, discouraging subsequent trading, and driving these uninformed traders away from the market. People also tend to give too much weight to recent events in estimating event probabilities. Hurricane victims in one year would probably tend to overestimate the hurricane threat over the next year. If they traded based on their bias they would suffer losses and be driven away from the market.

Prediction markets, however, do not deal only with low probability events. "Will the Fed raise rates" is often a close to 50/50 events. Even if it not, the strike space is divided into long- and short-odd events, offering a menu of outcomes. The behavioral failing of overestimating small probabilities will lead to losses on long-odd options, but not on short-odd options. Speculators on a Fed Funds rate announcement can choose to bet on a high or low probability event. Moreover, individuals tend to participate in the markets they are familiar with (computer programmers tend to trade tech stocks) bringing information (and noise) to the market. If the hedging motive to participate is strong enough, it can lead to higher expected profits for informed traders and market makers, bringing more information to the market and ensuring that the traded probabilities are closer to true probabilities of underlying events. This can then encourage profit-driven innovation toward longer-term contracts and new risk factors, in turn encouraging new entrants into the market. This network innovation effect can ensure noise reduction in the pricing of the traded events and strikes.

4.3. What is the predictive power of economic derivatives?

The closer to the true probabilities the prices can get, the more hedging opportunities there are for participants. Research thus far examined the predictive power of the political and economic event markets and concluded that often these markets predict these events better that analyst or voter polls.

Leigh and Wolfers (2006) show that prediction markets beat economic models and opinion polls in forecasting the highly contested Australian election of 2004. The markets offered lower volatility of forecast, whereas polls flip-flopped and turned out to be inaccurate. Servan-Schreiber, Wolfers, Pennock and Galebach (2004) contrast real-money prediction markets to play-money prediction markets. Both turn out to be very accurate with real money motivating better information discovery and play money yielding better information aggregation. Rhode and Strumpf (2006) add that prediction markets are difficult to manipulate and even sizeable cornering attempts are eliminated quickly. Wolfers and Zitzewitz (2004) check the predictive power of the markets on a variety of events and find it extremely high.

5. Product structure and the pricing of economic derivatives

The two most common contracts traded on the organized prediction markets (CME/ Economic Derivatives, HedgeStreet, and InTrade) are binary options and capped futures, with binaries accounting for 90% of the trading volume. Expiry dates are set before the resolution of the underlying event, for example, release of an inflation index. Trading takes place either through a series of Dutch auctions or continuously. The underlying events tend to be defined as economic variables assuming or exceeding particular values, for example, CPI equal to +0.2%, exceeding +0.4%, or the Federal Open Market Committee's announced rate equal to 4.75%. The key feature of the binary option structure is that if the event takes place, the holder of the binary option gets paid a fixed amount $10 or $100, and not, as in standard calls or puts, a variable amount that depends by how much the underlying variable exceeded or was below the strike level. The capped futures contract is similar to standard futures with daily mark-to-market, but the allowed price variation is capped and floored. This limits the potential gain and loss. Why have the exchanges chosen these structures instead of standard options and futures despite high learning curve costs? Possible answers include simplicity and the ability to limit losses or gains. These in turn imply an easier margining or collateralization, that is, contracts are designed to appeal to individuals. Other possible answers have to do with leverage. A binary's delta can be greater than one at the money. The price of a binary can move more than that of a standard option even if the expectations about the outcome of the event change little. Binaries perhaps are more easily defined for events that do not have a "magnitude" variable associated with them (e.g., political elections). Whether the chosen structures are optimal is an open question.

The pricing of economic derivatives is more akin to actuarial insurance pricing than to Black and Scholes' (1973) option modeling. The payout formula often does not depend on a variable (price), but rather on whether the event happened or not happened. This implies that the event probability is not a tradeable asset, or linked to one, and that modeling is not on a continuous variable with a standard distribution. The key difficulty is the non-hedgeability of the payout trigger (e.g., next week's CPI release).

These issues are not new to option modeling. In exotic fixed income and credit derivatives, it is common to encounter options on variables that are not directly hedgeable. For example, a yield squared is not a traded asset, but first-order risk may be hedged with a bond whose price is a function of the underlying yield whereas second-order risk will be unhedged. A model price will be correct only under the assumption that the second-order terms are constant or proportional (e.g., yield change per unit of time). Some of these techniques can be applied in pricing of economic derivatives on variables that can be postulated to have known functional or statistical relationships to traded assets. This follows the line of reasoning used in prepayment-dependent modeling of mortgage-backed securities. One part, yield curve risk, is hedgeable, whereas the other, prepayment, is not and, therefore, evolves according to a true statistical model.

Sometimes the insurance pricing approach fails too when there is no reliable link between the probability of a future event and actuarial experience or past data. In that case, the pricing resembles position control management of a bookmaker. In general, there may be three approaches to economic derivatives pricing with none fully explored by research. The challenges, suggested solutions, and their accuracy are reviewed in detail in Dubil (2007). Here we provide a brief summary.

5.1. Black and Scholes' modeling of options on continuously traded assets

Gold is a tradable asset; the spot price of gold can be observed through the a.m. or p.m. fixings. For a small investor, shorting and cash-and-carry arbitrage may be difficult, so the pricing has to allow for a storage cost and a convenience yield. A capped futures contract could be solved from the difference of two futures options prices struck at the cap and at the floor using Black (1976) equations. A $100 binary call B on gold struck at K, is derived using the hedge argument of Black and Scholes (1973), or the equivalent martingale, see Hull (2006), by discounting the risk-neutral expectation of the payoff

$$B = \$100 \times e^{-rt} N\left(\ln \frac{Se^{(r+s-y)t}}{K} / \sigma\sqrt{t} - \frac{1}{2}\sigma\sqrt{t} \right) \tag{2}$$

The value of a binary option is equal to the discounted probability of the option being in the money. The model applies not only to the price of gold, but also to economic derivatives on oil, gasoline, mortgage rates (?), that is, assets with continuously trading spot or futures markets.

5.2. Actuarial pricing of options on non-traded variables

Insurance pricing methods apply to underlying economic variables that can be observed over time, but are not traded. We can treat an inflation index or a regional real estate price average as a continuous variable, but because the hedge argument of complete markets does not apply, we cannot use the martingale transformation of the probability space. We need to model both the mean and the variance of the random variable and solve for the in-the-money probability using untransformed distribution:

$$B = \$100 \times e^{-rt} \times \Pr(Var > K) \tag{3}$$

The price is not equal to the present value of the hedge, but is the discounted value of a statistical expectation of the payoff. It is only correct on average and to the extent that the distribution assumptions are correct.

5.3. Odds-maker pricing of options on pure events

For economic derivatives on pure events, a subjective probability of the event's outcome merely aims to establish the initial price. After that, position inventory control is the predominant pricing factor. Sidney (2003) lays out the art of odds making in readable terms. The main principle in his approach is that the market maker's expected value of the "take" (cash received for contracts sold net of cash paid for contracts bought) has to exceed the expected liability at the contract's expiry:

$$-\sum_i n_{t_i} p_{t_i} e^{-r(t-t_i)} \geq E\left[-\$100 \times \sum_i n_{t_i}\right] \tag{4}$$

where n_{t_i} is the number of contracts bought or sold at time t_i, positive if bought and negative if sold, and p_{t_i} the price paid or received at time t_i. The left-hand side of Eq. (4) is equal to the expiry value of the total amount received from the net sale of options. The right-hand side is equal to the total expected payout a market maker will make at expiry conditional on being in-the-money. Because the market maker cannot evaluate this expectation, inequality Eq. (4) is a pure inventory control rule, without respect to the market maker's subjective probability estimates (buy back what you sold for a lower average price).

Since the 1950s, finance and economic literature has had little to offer in the area of

Table 1 A roadmap for future research on economic derivatives (EDs)

Research question	Currently related research areas
Area: EDs as risk factors in wealth portfolio optimization	
1. Role of EDs in optimizing stock-only portfolios	Indexing and portfolio optimization, non-cap weighted indexing, multi-factor risk models, time-varying risk premia, Fama-French model, factor analysis, macro factors
2. Role of EDs in optimizing multi-asset class portfolios	Consumption CAPM, human capital as risk factor, optimization across asset classes, retirement planning goals, inflation risk
3. Role of EDs in diversification as asset correlations increase	Global portfolio diversification, sector correlations, Extreme Value Theory (EVT), time varying correlations, crisis hedging, Value at Risk, contagion risk, regime shifts
4. EDs as substitute for/hybrid insurance	Human capital hedging, inflation risk, role of real estate in portfolio, weather derivatives, hurricane derivatives, reinsurance, insurance derivatives
Area: economic role and viability of ED markets	
1. Sustainability of continuous markets in EDs	Informed traders, liquidity trading, asymmetric Information, market microstructure, hedging motive, gambling motive, market clearing, continuous market making, call auction markets, insider trading, cash and carry, backwardation and contango
2. Behavioral biases–effect on pricing and trading	Informational bias, small probability, Allais paradox, mental accounting, conservatism bias, utility theory
3. Predictive power of EDs	Iowa market studies, election forecasting, futures as unbiased predictors of futures spot prices, exchange rate price formation, market efficiency, spread betting and gambling models
Area: pricing and valuation of event options	
1. Extending hedge-based Black-Scholes to economic variables	Risk neutrality, martingale approach, contingent claim pricing, market incompleteness, unspanned price space, model calibration, jump processes, non-lognormal distributions, joint jump-diffusion
2. Insurance (actuarial) pricing of EDs on non-tradeables and events	Parametric modeling, non-parametric modeling, Monte Carlo simulation, Brownian bridges, mortality tables, earthquake modeling, hazard insurance modeling, catastrpphe derivatives, Bayesian updating, Gibbs sampling, prior parametrization
3. Pricing options on pure events with no distributional assumptions	Inventory control, odds making, informational content, artificial intelligence, Bayesian updating, logistical modeling, operations research, discrete processes, compound bets, legging

inventory control models as attention has been devoted to actuarial probability modeling or capital market pricing using continuous hedge arguments. The only focus on inventory is in the context of stock market specialist or market-maker pricing as reviewed in O'Hara (1997).

Option market making from a perspective of short-term non-hedging speculators has not been much investigated.

6. Conclusions

We posit that the growth of economic derivatives markets is related to the incompleteness of the hedges for multiasset wealth portfolios. A market index fund is an insufficient hedge for systematic risk of a broad portfolio; economic derivatives serve as vehicles to gain exposure to additional factors. The greatest volume in retail derivatives in 2005 through 2006 occurred in commodities and currencies suggesting that constraints on small investor participation in these two segments have hampered their ability to diversify their risks. We also posit that the economic derivatives bridge the insurance-derivatives gap by personalizing the contracts enough to be able to serve lifestyle and peril insurance purpose. In addition, if the retirement saving problem is an intersection of individual risks and market risks, current and future economic derivatives may be able to provide a blended solution to both problems. The current setup is suboptimal as personal risks are handled by insurance whereas market risks are embedded into investment portfolios.

Yet the viability of the economic derivatives markets is by no means assured. If liquidity traders do not have a strong enough hedging motive or suffer from behavioral biases that will skew prices away from true event probabilities, the market may not be able to sustain continuous trading over time. The theoretical conditions to answer this dilemma need to be worked out. Pricing of economic derivatives also poses challenges as it blends option pricing, insurance pricing, and odds making.

Table 1 contains the summary of research challenges juxtaposed against current streams of inquiry. The good news is that the theoretical and empirical agenda we have outlined is large, multilayered, and extremely fascinating. Researchers, start your engines now.

Notes

1. *Flow of Funds Accounts of the United States*, Board of Governors of the Federal Reserve System, 2006.

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