The Economic Policy Risks of Cap and Trade Markets for Carbon Emissions:

A Monetary Economist's View of Cap and Trade Market and Carbon Market Efficiency Board Designs

The U.S. Climate Task Force

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(The views expressed in this paper are the author's only.)

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Abstract

The two major schools of thought among academics studying how to limit climate change are delineated primarily by whether policymakers should control (1) the quantity of emissions via cap and trade policies or (2) the price of carbon emissions via direct taxation. The lack of theoretical "fit" between carbon pollutants and cap and trade, however, has given rise to notions of a management board design that can manipulate the carbon market to achieve the economic ideal. The idea is that something like a central bank, most recently referred to as a "Carbon Market Efficiency Board," in the U.S., can manipulate contract supply, smoothing price volatility and dynamically adjusting carbon permit supply to policy goals. But manipulating carbon permit supply via a Carbon Market Efficiency Board that is charged with restraining emissions without unduly harming economic growth necessarily decreases the benefit certainty that is the hallmark of cap and trade. Without that benefit certainty, the convoluted carbon permit market design and risk of market collapse is both theoretically and practically unnecessary. At the extreme, the Carbon Market Efficiency Board pegs the price of carbon while allowing benefits to fluctuate, which is exactly the result of a carbon tax.

Recent scholarship on climate change begins with the assumption that some adjustment mechanism is needed to limit carbon emissions.[1] There are two major schools of thought among academics studying how to limit climate change.[2] They are delineated primarily by whether policymakers should control (1) the quantity or (2) the price of carbon emissions. The first school is commonly associated with command-and-control "cap and trade" policies, whereas the second school is usually associated with incentive-based carbon taxes.[3]

Cap and trade, as its name suggests, focuses on achieving an absolute cap on carbon emissions using special tradable carbon emissions permits. Policymakers control the total number of permits, so that total emissions can be set by fiat. Many policymakers and environmental theorists believe that cap and trade provides "benefit certainty" because it achieves a hard cap on carbon emissions.[4]

The primary alternative to the cap and trade scheme is the flat "carbon tax" proposal, which sets a stable positive price

1. Related research has also been conducted to examine the political development of environmental regulation, the interaction between state and federal pollution control policies, and avenues of future positive research. See, e.g., Robert W. Hahn, Sheila M. Olmstead, & Robert N. Stavins, Environmental Regulation During the 1990s: A Retrospective Analysis, 27 Harvard Environmental L. Rev. 377 (2003) (discussing the political and economic development of thought on environmental policies during the 1990s); Meghan McGuinness & A. Denny Ellerman, "The Effects of Interactions between Federal and State Climate Policies," Center for Energy and Environmental Policy Research Working Paper, May 2008 (exploring the interplay between state and federal policymaking); Robert W. Hahn & Robert N. Stavins, Economic Incentives for Environmental Protection: Integrating Theory and Practice, 82 AEA Papers and Proceedings 464 (1992) (exploring avenues of research).

2. Weitzman's seminal work was among the first to examine the dichotomy between price-based and quantity-based pollution regulations. See Martin L. Weitzman, *Prices vs. Quantities*, 41 Rev. Econ. Studies 477 (1974).

3. A discussion of both the cap and trade and tax approaches to pollution abatement is available in William J. Baumol & Wallace E. Oates, *The Theory of Environmental Policy* (Cambridge University Press, 2d ed. 1988).

4. See Reuven S. Avi-Yonah & David M. Uhlmann, *Combating Global Climate Change: Why a Carbon Tax Is a Better Response to Global Warming Than Cap and Trade*, 28 Stanford Environmental L. J. 3, 8 (2009), and Robert N. Stavins, *Addressing Climate Change with a Comprehensive U.S. Cap and Trade System*, 24 Oxford Rev. Econ. Policy 2 (2008). For related work, see Nicholas Brozovic, *Prices vs. Quantities Reconsidered*, University of California Working Paper, Sept. 12, 2002; James K. Boyce & Matthew Riddle, *Cap and Dividend: How to Curb Global Warming while Protecting the Incomes of American Families*, Political Economy Research Institute Working Paper, Nov. 2007; Sergey Paltsev, John M. Reilly, Henry D. Jacoby, Angelo C. Gurgel, Gilbert E. Metcalf, Andrei P. Sokolov, & Jennifer F. Holak, *Assessment of U.S. Cap and Trade Proposals*, MIT Global Science Policy Change Report No. 146, Apr. 2007; Richard G. Newell, Adam B. Jaffe, & Robert N. Stavins, *The Effects of Economic and Policy Incentives on Carbon Mitigation Technologies*, 28 Energy Econ. 563 (2006).

for carbon emissions. Proponents believe that this price based mechanism provides greater policymaking flexibility.[5] The "price certainty" arising from a carbon tax would allow businesses to plan efficiently, because an increase in the tax rate beyond any foreseen adjustment would require a vote in Congress that would adjust only slowly, better smoothing business investment plans, employment, and economic growth.[6]

The economic debate has led researchers to theoretically describe conditions under which a cap and trade approach is more efficient than a carbon tax.[7] Section I describes the economic foundations of cap and trade. While cap and trade can work for some pollutants, applications to carbon are less than ideal.

Section II goes on to introduce the experience with cap and trade using carbon contracts to date. Even though active markets for such contracts have begun to trade in Europe, the contract mechanisms and price dynamics do not fit any traditional financial economic contract design. Uncertainty about the nature of the contracts has therefore led to tremendous price volatility on European markets that threatens the viability of that system.

Environmental researchers and public policy economists have more recently argued that the lack of theoretical "fit" between carbon pollutants and cap and trade and the problems with European carbon price volatility can be overcome by implementing a management board design. The idea is that something like a central bank, most recently referred to as a "Carbon Market Efficiency Board," in the U.S., can manipulate contract supply, smoothing price volatility and dynamically adjusting carbon permit supply to policy goals. Section III, therefore, frankly discusses problems of managing central bank policy that are still unresolved after hundreds of years of monetary economics research and policy application. Hence, manipulating carbon permits' supply to restrain emissions without harming economic growth necessarily undermines the benefit certainty that is the hallmark of cap and trade policy, decreasing cap and trade efficiencies to levels no better than — and perhaps worse than — a simple carbon tax. Section IV provides a summary and a policy recommendation of a carbon tax as the most effective and efficient approach to pollution abatement.

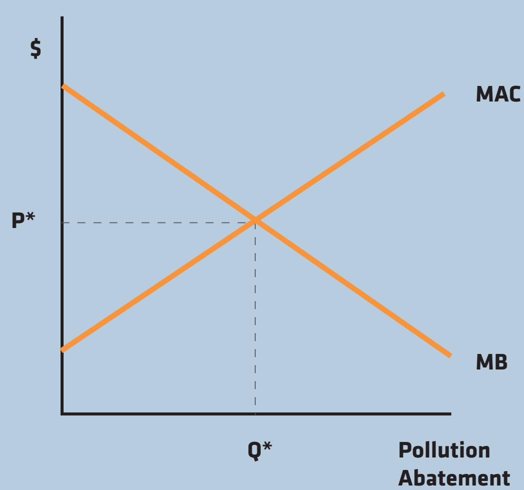
I. Cap and Trade Policy Vastly Oversimplifies a Tremendously Complex Market-Based Economic Theory

Economists first suggested cap and trade as an alternative to levying usage taxes to curb privately beneficial but socially undesirable action. In economic terms, the goal of both measures is to curb a recognized and measurable externality.[8]

Public finance, and more specifically the sub-discipline of environmental economics, defines the theoretical optimality of the choice between cap and trade and abatement taxes. The optimal level of emissions is found in Figure 1 at the intersection of the marginal costs with the marginal benefits of pollution abatement. Figure 1 graphically depicts the

Figure 1

The Socially Optimal Level of Pollution Abatement



5. William D. Nordhaus, *A Question of Balance: Economic Modeling of Global Warming 202* (2008). Karen Palmer, Dallas Burtraw, & Danny Kahn, *Simple Rules for Targeting CO_2 Allowance Allocations to Compensate Firms*, Resources for the Future Discussion Paper 06-27, June 2006, at 8 ("This part argues that both a carbon tax and a cap and trade system incorporate the necessary carbon price signal, with a tax offering 'price certainty' and cap and trade offering "benefit certainty," but asserts that a carbon tax would be simpler to implement, more transparent, and less vulnerable to abuse.").
6. See Avi-Yonah & Uhlmann, *supra* at 42.
7. Roberton C. Williams III, *Prices vs. Quantities vs. Tradable Quantities*, NBER Working Paper 9283, Oct. 2002.
8. Harvey S. Rosen, Public Finance 56 (McGraw-Hill Irwin 7th ed, 2005). See also Paul A. Samuelson, *The Pure Theory of Public Expenditure*, 36 Rev. Econ. Stat. 387-89 (1954), and Baumol & Oates, Environmental Policy, *supra* at 14-20.

intersection of these two curves and the resulting socially optimal equilibrium in the market.

In Figure 1, the horizontal axis indicates the amount by which emissions are reduced relative to their unregulated level, while the vertical axis represents the value society derives from reduced emissions measured in dollars. The curve labeled MB represents that marginal benefit to society of pollution abatement — that is, the additional value to society derived from an incremental increase in pollution abatement above and beyond the pollution that has already been eliminated up to that point. The curve has a downward slope because "the greater the degree of purity of air or water that has already been achieved, the less the marginal benefit of a further 'unit' of purification."[9] The curve labeled MAC represents the scarce resources society must expend to precipitate an incremental increase in pollution abatement above and beyond the pollution that has already been eliminated up to that point. The curve has an upward slope "because of the rising cost of further abatement as the zero emissions point is approached."[10] The optimal level of pollution abatement is represented graphically at the point where the MAC curve and the MB curve intersect. Conceptually, this point is optimal because at this level of pollution abatement, represented by Q^*, society has maximized the value of abatement relative to the cost of using society's scarce resources to further cleanse the environment, represented by P^*.

An important point to note about the result presented in Figure 1 is that the optimal outcome can be achieved either through cap and trade or through a pollution charge. Specifically, capping the amount of emissions that can be produced at Q^* results in the equality of marginal abatement costs and the marginal benefits of abatement. On the other hand, by creating a charge of P^* for every unit of carbon that is emitted, producers have incentive to reduce emissions by Q^* units of carbon. Specifically, because P^* lies above the cost of reducing emissions for all points to the left of Q^*, it is less costly to simply reduce pollutants by Q^* than to pay the tax. Therefore, an emissions charge of P^* has the same effect on the market as an emissions cap that results in emissions abatement of Q^*.

In reality, once P or Q is set as a policy variable, MAC and MB can fluctuate, similar to supply and demand curves. Hence, when setting P, Q may fluctuate due to market and other economic forces. Similarly, setting Q will result in P fluctuating due to similar influences. Setting either costs (P) or benefits (Q) with certainty is key to the environmental debate around carbon policy.

It is not clear, from a purely theoretical basis, whether cost certainty or benefit certainty is more important in the carbon abatement debate. Some scholars have argued that a focus on benefit certainty is superior because it puts the emphasis on the environment rather than on the economics.[11] But it could also be argued that the benefits of any policy to reduce greenhouse gas emissions are worldwide, while the cost of any policy adopted by the United States will be confined to the United States.[12] Moreover, small taxes can have disproportionately large effects on economic behavior. As a result, a cap and trade system may, with perfect hindsight, be overkill, were a moderate tax on emissions found to achieve substantial effect.[13]

9. Baumol & Oates, Environmental Policy, *supra* at 59.

10. *Id.*

11. Baumol & Oates, Environmental Policy, *supra* at 74.

12. Avi-Yonah & Uhlmann, *supra* at 36.

13. The Federal Reserve's policy toward daylight overdrafts provides an example of how a small change in policy can have a dramatic effect on economic activity. A daylight overdraft occurs when a bank transfers funds that exceed its reserve balance at a Federal Reserve Bank early in the day and then eliminates the overdraft before the end of the banking day. In this manner, daylight overdrafts serve as intraday credit for banks. To curb daylight overdrafts, the Fed imposed a small fee on this activity in 1994. Originally, the Fed planned to double this fee in 1995 and increase it again in 1996. However, the Fed ultimately decided to increase the fee by 50 percent in 1995 and then monitor activity for two years before taking further action. (Heidi Willmann Richards, Daylight Overdraft Fees and the Federal Reserve's Payment System Risk Policy, Federal Reserve Bulletin (Dec. 1995)). No additional increases were made, as the small fee sufficiently reduced overdrafts to manageable levels.

Another example of the implementation of a small cost by policymakers resulting in a dramatic shift in economic behavior exists within the design of spectrum auctions in the United States. In early auctions, the Federal Communications Commission did not apply a fee to bid withdrawals that occurred during the auction. As a result, withdrawals were frequent, as bidders used them to signal one another in an effort to divide up the market at low prices. To curb this activity, the FCC imposed a relatively small fee on withdrawals. The result was a dramatic decline in the number of withdrawals in spectrum auctions. (For example, there were more than 780 withdrawals during the FCC DEF block auction in 1996. By contrast, there were only 16 withdrawals during the AWS-1 auction in 2006, which occurred years after the FCC imposed only a small fee on withdrawals. Data on prior FCC auctions is downloadable from the FCC's website at http://wireless.fcc.gov/auctions/default.htm?job=auctions_home.) The experience in FCC auctions again shows that the imposition of only small costs on an activity that is deemed undesirable can have large effects on the market. Such examples suggest that imposing a usage tax on carbon emissions rather than cap and trade may have immediate and profound effects on emissions while helping policymakers better understand the effect of environmental policy on economic behavior.

The negative consequences of environmental advocates capturing cap and trade programs are likely to be exacerbated by Wall Street investment firms. A recent article in *Environment: Yale Magazine* quotes Peter Fusaro, an energy consultant, who notes the climate change finance sector includes 90 hedge funds and 80 private equity funds, in addition to a large number of venture capitalists. Fusaro maintains, "It's the most complex financial market ever created." Fusaro counts 38 distinct markets in the United States dealing in everything from acid rain emissions permits to California's mobile emissions reductions credits — that is, credits for reducing tailpipe exhaust. Mutual funds and ETFs (exchange-traded funds) specializing in climate change issues have sprung up in Europe and the United States. Nonetheless, in 2007, $64 billion in assets was traded on the global carbon market, and in 2008 that number was projected to exceed $100 billion.[14]

Of course, there is nothing wrong with financial firms profiting from making markets for stocks, bonds, and other valuable commodities. However, when a market is created and operated according to government fiat, it is all but certain that vested interests, financial firms that operate and make markets in this case, will lobby for socially inefficient provisions that increase their profits to the detriment of society as a whole. This phenomenon, where well-coordinated interest groups manipulate government programs meant to provide for the common good, is known as public choice theory.[15]

As far as cap and trade proposals are concerned, both Wall Street investment firms and environmentalists have similar goals — to restrict the number of carbon permits such that marginal cost to society of pollution abatement exceeds its social benefit. Environmentalists' motivations are obvious. What is less apparent in the emotion of the environmental debate is the fact that financial firms that make markets for tradable pollution permits will be able to make higher commissions the scarcer the permits are. An alliance between environmentalists and Wall Street presents a particularly intractable problem as far as public choice theory is concerned.

Although systematic academic analysis of nascent cap and trade programs is only beginning, the initial results suggest that special interests have succeeded in "capturing" the European program.

The empirical evidence indicates that these public choice concerns are well-founded. Indeed, two companies infamously associated with corporate malfeasance and financial manipulation, Enron and AIG, both lobbied for cap and trade programs so that they could reap profits by making markets for the permits.[16] In 2007, Martin Sullivan, CEO of AIG at the time, explained that the firm would seek to "help shape a broad-based cap and trade legislative proposal, bringing to this critical endeavor a unique business perspective on the business opportunities and risks that climate change poses for our industry."[17] Although systematic academic analysis of nascent cap and trade programs is only beginning, the initial results suggest that special interests have succeeded in "capturing" the European program. Looking at the greenhouse gas (GHG) market, a recent article in the journal *Energy Policy* concluded "Here, we find that the dominant interest groups indeed influenced the final design of an EU GHG market."[18]

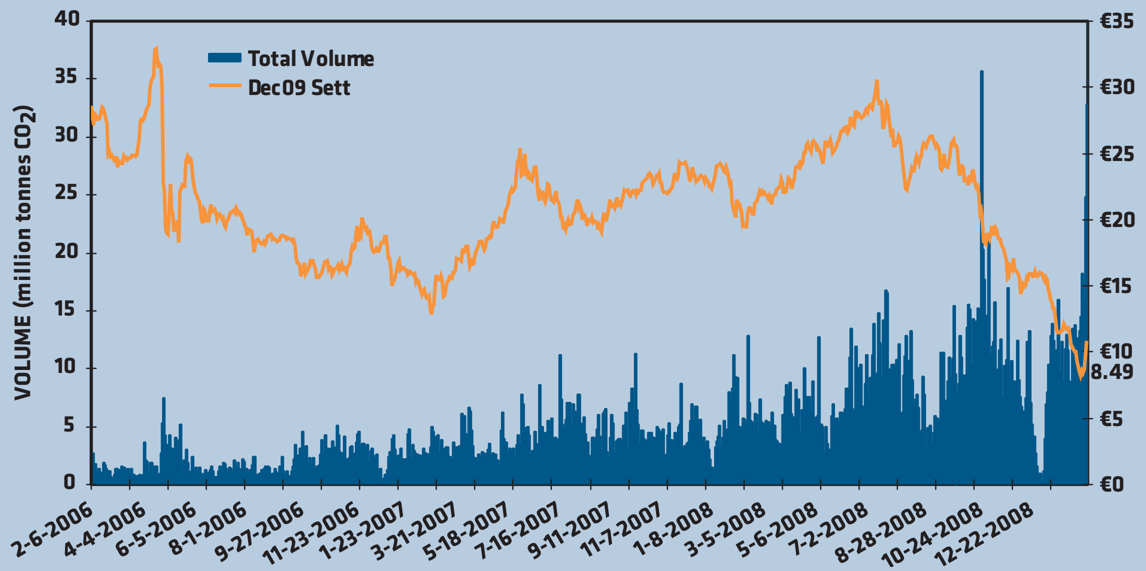
II. Cap and Trade Contracts Are Susceptible to Numerous Pricing Anomalies That Remain to Be Understood

A significant problem with cap and trade that has become apparent in recent years is that carbon prices under cap and trade systems have been far more volatile than originally envisioned. Part of the problem is related to carbon permit demand that fluctuates with weather conditions that are highly correlated with electric power generation. Furthermore, although monetizing and trading in various assets and commodities often helps to improve economic efficiency, financial market applications created additional volatility in carbon permits.

14. *See* Richard Conniff, *Wall Street's Carbon Conversion*, Environment: Yale Magazine 7 (2008).
15. *See, e.g., generally* Mancur Olson, *The Logic of Collective Action* (Harvard University Press Revised ed. 1971); James M. Buchanan & Gordon Tullock, *The Calculus of Consent: Logical Foundations of Constitutional Democracy* (University of Michigan Press 1962).
16. *See* Phil Kerpen, *Cap and Trade for AIG?*, Washington Times, Mar. 25, 2009, available at http://washingtontimes.com/news/2009/mar/25/cap-and-trade-for-aig.
17. *Id.*
18. *See* Peter Markussen & Gert Tinggaard Svedsen, *Industry Lobbying and the Political Economy of GHG Trade in the European Union*, 33 Energy Policy 245 (2005).

Figure 2

Price and Volume of Exchange Futures Contracts for 2009 Settlement



The underlying problem is that ill-understood pricing anomalies in the price of carbon credits have undermined the ability of the market to properly internalize both short- and long-term price dynamics. As a result, a firm's incentives to invest significantly in newer, cleaner technologies for the *long-term* are undermined when prices of emissions credits are extremely volatile and therefore cloud long-term price signals in the short-term.

This section summarizes the European experience with cap and trade and reviews the complexity of emissions credit valuation and resulting pricing anomalies. As a whole, exhibited anomalies are the result of both weather and political uncertainties as well as idiosyncrasies in the carbon permit contract.

The European Union provides a wealth of information and data on markets that have developed from cap and trade programs. In the European Union's Emissions Trading Scheme ("EU ETS"), both cash and futures contracts are traded in a variety of markets. While trade with EU Allowances (EUAs) began in 2003, the official EU ETS began in 2005. Prices before 2005 are therefore forward prices on a not-yet-traded underlying asset. In the "pre-2005" period, the traded volume was quite low, at some days even zero as the highest bidder price was smaller than the lowest seller price. Daily EUA prices between August 27, 2003, and December 29, 2004, before agreement on EU-ETS, were generally stable. The price during this entire period was stable during any small time window, and fluctuated between 7 and 13 Euros over the entire 18-month period, with bid-ask spreads were quite large, often exceeding 4 Euros. By contrast, prices between early 2005 and December 29, 2006, fluctuated greatly. Prices spiked at nearly 30 Euros in July 2005 and again in April 2006, and fell to lows of about 6 Euros by December 2006.[19]

A review of daily EUA prices shows that prices were increasingly volatile after 2004. Figure 2 displays daily price and traded volume of futures contracts for December 2009 settlements between February 2006 and December 2008. The data in Figure 2 first confirms that the price of carbon futures fell significantly during 2006. The price then rose through 2007 and the first half of 2008, but plummeted after July 2008.

Important drivers of the market seem to be a combination of short-run weather and political policy announcements rather than any long-term economic fundamentals. Before the EU Parliament agreed on the introduction of the EU ETS in July 2003 and before the first suggestions for National Allocation Plans (NAPs) were published at the

19. Eva Benz & Stefan Trück, *Modeling the Price Dynamics of CO_2 Emission Allowances*, 31 Energy Economics 11 (2009).

A firm's incentives to invest significantly in newer, cleaner technologies for the long-term are undermined when prices of emissions credits are extremely volatile and therefore cloud long-term price signals in the short-term.

end of 2003, prices were stable. Both announcements led to an increase in prices. Because of the initially generous allocation of allowances to the countries, prices calmed down again between February and March 2004. Reviewing and accepting the NAPs in the second half of the year, prices increased to about 9 Euros. As the main framework of the trading scheme became defined, the price determinants became more fundamental after January 2005.[20]

Chief among those fundamentals, however, is the weather. For example, prices fell due to mild weather and high supply of wind energy from Scandinavia and North Germany. At the end of January 2005, cold weather and high gas and oil prices in the United Kingdom coupled with low coal prices resulted in a strong price increase of EUAs.[21] This effect was magnified by a dry summer in July 2005 in Southwestern Europe. Low rainfall depleted reserves and prevented full utilization of hydroelectric plants. The lack of cooling water for nuclear power plants resulted in greater utilization of high-emission-producing assets, which therefore increased the demand for carbon permits. By July 2005, prices peaked at 29.15 Euros. During the last four months of 2005, prices fell to 22 Euros. By March 2006, however, prices again increased to approximately 27 Euros, due to a long and cold winter between 2005 and 2006.[22]

May 2006 marked completion of the first full cycle of the EU ETS. By April 2006, however, it was apparent that a surplus of allowances of approximately 10 percent existed. As a consequence, EUA prices fell by 60 percent within one week, amid fears that emissions prices would drop to zero. The EUA market recovered during the summer of 2006 as the industrial sector began selling EUAs to utilities investors as a dry, hot European summer increased the demand for high-emissions assets.[23]

The European experience outlined above is important because the primary purpose of a cap and trade-based carbon market is to provide long-term incentives for firms to invest in clean-air technologies. Such technologies — nuclear assets or clean-air coal assets, for example — are extremely costly to build, and they are large base-load units that are technologically intensive. Private investment in these types of assets only makes sense if the long-term benefits of the investment are clear. With carbon permit prices fluctuating wildly, long-term signals regarding the carbon-reducing benefits of investment in clean-air technology are clouded at best and nonexistent at worst. Therefore, it is not apparent that a cap and trade system resulting in a market for carbon permits is helpful in aligning private interests with policymakers' long-term goals: the dissemination of technologies that will reduce carbon emissions.

In fact, numerous asset pricing anomalies can be expected to continue to frustrate long-term pricing signals in a market for carbon emissions, in addition to the volatility arising from weather and politics.

A. While Carbon Permits Are Usually Thought of as a Commodity Contract Because the Deliverable Is a Factor of Production, Price Dynamics of the Contracts Are Not Those Expected for Commodities

In many ways, cap and trade emissions contracts are commodity contracts. A commodity contract is a contract to deliver a raw product or primary input such as food, metal, or energy. In the case of cap and trade contracts, the deliverable is carbon emissions, which is a primary input for production. Emission allowances are classified as "normal" factors of production. Since the allowances are used for production, they are removed from the market as they are consumed. Therefore, the right to emit carbon can be compared with other commodities that are traditionally used as factor inputs in production, and standard commodity pricing models can be applied to the carbon emissions market.[24]

Commodity markets work on a *spot* and a *futures* basis.

20. *Id.* at 11-12.

21. PointCarbon, Carbon Market Monitor 2005 Review, Jan. 2006, *available at:* http://www.pointcarbon.com/research/carbonmarketresearch/monitor/.

22. Benz & Truck, *supra* at 12.

23. *Id.* at 12-13.

24. *Id.* at 4-15.

The spot market is the market for immediate delivery of the commodity. The futures market is the market for delivering the commodity at some point in the future. The futures market is a derivatives market, meaning that its value is derived from the current spot market for the underlying asset. The spot and futures market for the EU's current cap and trade contracts exists on a number of different commodity exchanges.[25] Empirical data from these exchanges can show whether the real-world pricing of cap and trade contracts conforms to price behavior of other commodities possessing similar characteristics.

The expected future value of a commodity is equal to the current spot price plus carrying costs. This can be stated as

$$[1] \quad F_t = Se^{(r-\delta)(T-t)}$$

where *F* is the future price, *S* is the current spot price, *r* is the risk-free rate, δ is the carrying cost, *t* is today, and *T* is the maturity of the contract.

The conditions just described are the result of what are commonly referred to as arbitrage conditions. If, for instance, the futures price was above the spot price plus storage, arbitrageurs could sell futures and buy on the spot market, storing the commodity for future delivery at a riskless profit. The opposite also generally holds true.

But in the case of carbon emissions, the optimal level of emissions is stochastic, so that a firm's demand for emissions allowance contracts is also stochastic.[26] Because of these uncertainties and costs, a firm benefits from holding an inventory of the commodity to hedge against any unexpected higher prices. Therefore, allowances for different vintages will have different spot prices at a given point in time.

The benefit that accrues from holding the underlying commodity rather than the contract for the future is known as the *convenience yield*. The convenience yield keeps spot prices higher relative to futures prices — a pricing structure known as *backwardation*. Backwardation can be expressed in [1] as a condition in which δ represents a positive convenience yield. In other words, the convenience yield is sufficiently large such that the future price is less than the spot price. In addition, the future price decreases as time to maturity increases.[27]

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The opposite of a backwardation structure is *contango* — spot prices are less than futures prices. Empirical evidence from the EU carbon market shows that the carbon futures market illustrates characteristics not of backwardation, but of contango, where spot prices are less than futures prices.[28] But the financial economics literature suggests that commodities with contango structures usually have readily available inventories that are easily accessed and stored and stable supply and demand functions. Those conditions contradict the performance of carbon markets to date. Even if cap and trade contracts have no cost of storage and are easily accessed, levels of supply and demand for carbon emissions are not easily predicted. In addition, the level of inventories for cap and trade contracts is dependent on current emission levels, which are stochastic and unpredictable.

Because the empirically observed convenience yield for cap and trade contracts does not conform to standard finance theory for commodities, a price analysis based on a historically consistent theory of future-spot parity is probably not very useful.[29]

B. While Carbon Permits Can Be Considered an Option Contract Because the Producer Can Choose Whether to Use the Allowances in Any Given Settlement Period, Price Dynamics of the Contracts Are Not Those Expected for Typical Options

A futures contract only allows for delivery at a specific date in the future. A carbon contract can be used for production at any time until expiration. A carbon cap and trade con-

25. Marc S. Paolella & Luca Taschini, *An Econometric Analysis of Emission Trading Allowances,* Swiss Finance Institute Research Paper Series (2006) at 5-6.

26. *Id.* at 13-14.

27. *Id.* at 14-15.

28. *Id.* at 15.

29. *Id.*; S. Trück, S. Borak, W. Hardle, & R. Weron, *Convenience Yields for CO_2 Emission Allowance Future Contracts*, School of Economics and Finance, Queensland University of Technology, Brisbane, Australia (2006).

The combination of the general anomalies of commodities, equities, and options valuation models with the anomalies in the carbon emissions market have the capacity to seriously complicate the valuation analysis of a cap and trade market.

tract may therefore be more like an option than a future.[30] An option is a contract between a buyer and a seller that gives the buyer the right, but not the obligation, to buy or sell an asset at a specified price on or before a specified date. The option to buy an asset is known as a call option, and the right to sell an asset is known as a put option. In the context of a carbon market, an emissions contract would be similar to a put option, because it allows the contract holder to exercise a right to emit carbon during a specific time period.

A multi-period cap and trade contract can be characterized as a sequence of European put options (options that can be exercised at a specific expiration date in the future) that come into effect sequentially through the life of a contract. The decision of when to exercise each put option is characterized as a real option, optimal-stopping-time problem, similar to the problem of early exercise on an American option. Consistent with common intuition, early exercise is optimal only when the holder's demand for emissions increases.

One of the most common models to price options is the Black-Scholes model. According to the Black-Scholes valuation model, the value *p* of a European put on a non-dividend-paying asset is estimated by:

[2] $$p = Xe^{-r_f T}\Phi(-d_2) - S\Phi(-d_1) \text{, where}$$

$$d_1 = \frac{\ln(S/X) + r_f T}{\sigma\sqrt{T}} + \frac{1}{2}\sigma\sqrt{T}$$

$$d_2 = d_1 - \sigma\sqrt{T}$$

Φ = the standard normal cumulative distribution function;
X = strike price;
S = price of the underlying asset;
T = time to maturity;
r_f = discount rate; and
σ = volatility of the underlying asset value.

The Black-Scholes model is commonly applied to stock options. Since contracts give holders a put option to produce emissions until a given maturity date, the Black-Scholes model could similarly be applied to a cap and trade contract. This option can be traded, just as a stock can, and a market participant could value the put option using the Black-Scholes model. However, the Black-Scholes model has numerous shortcuts and anomalies that limit its use in valuing even common stock options.

Characteristics of the carbon market will most likely reveal further complications to the usefulness of the Black-Scholes model. The Black-Scholes model for valuing options already contains many important limitations. First, the model is only used to value an option if it will be exercised at expiration (European options). Therefore, it cannot value American options, which can be exercised at any point in time before expiration. Second, the model also assumes that the return on the underlying asset is normally distributed, which may not be the case for carbon emissions, and has certainly not been the case for stocks. (Historically, stock market returns have been skewed or *leptokurtic* — exhibiting more returns in the "tails" of the distribution than would be found in a normal distribution.)[31] Third, the model assumes a constant discount rate, even though the discount rate could change over the life of the contract. Fourth, the model assumes a constant volatility of the underlying asset, which market experience has already shown to vary substantially over time.

The empirical literature testing the accuracy of the Black-Scholes model is enormous. Although most studies confirm that market prices generally are close to the estimates resulting from Black-Scholes, several anomalies have been found. For example, because of the model's assumption of normally distributed returns when returns are in fact skewed or leptokurtic, Black- Scholes generally undervalues deep in-the-money call options (or out-of-the-money put options) and overvalues deep out-of-the money call options.[32] Figure 3 illustrates the difference between the normal distribution assumed by the Black-Scholes model and a skewed leptokurtic distribution that is commonly observed in stock returns.

As Figure 3 shows, "distribution B" — that is, the skewed distribution with thick tails — is asymmetric, which leads

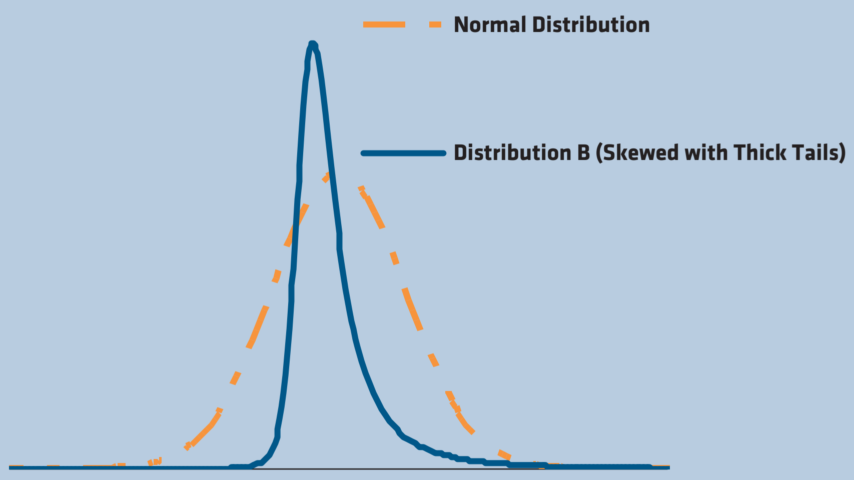
30. For a primer on financial options, see John Hull, *Options, Futures, and Other Derivatives 6* (Prentice Hall, 6th ed. 2006).

31. *See, e.g.*, B. Mandelbrot, *The Variation of Certain Speculative Prices*, 36 Journal of Business 394-419 (1963); E. F. Fama, *The Behavior of Stock Market Prices*, 38 Journal of Business 34-105 (1965); P. Theodossiou, *Financial Data and the Skewed Generalized T Distribution*, 44 Management Science 1650-1661 (1998).

32. M. Rubinstein, *Implied Binomial Trees*, 49 Journal of Finance 771-818 (1994).

Figure 3

Normal Distribution Versus the Skewed Distribution with Thick Tails



Other alternatives include the pure jump model, which assumes stock prices do not change continuously but jump randomly, and the jump diffusion model, which puts jumps together with geometric Brownian motion (also called a "random walk"). However, the pure jump model overprices out-of-the-money puts and in-the-money calls, and underprices in-the-money puts and out-of-the-money calls. The jump diffusion model underprices out-of-the-money and in-the-money calls and puts.

to deviations from outcomes common to the normal distribution. For example, if both tails in the distribution of asset returns are thinner than a normal distribution, then the Black-Scholes model overprices out-of-the-money and in-the-money calls and puts. If the left tail is fatter, and the right tail is thinner, then the Black-Scholes model overprices out-of-the-money calls and in-the-money puts, and it underprices out-of-the-money puts and in-the-money calls. If the left tail is thinner, and the right tail is fatter, then the Black-Scholes model overprices out-of-the-money puts and in-the-money calls, and it underprices in-the-money puts and out-of-the-money calls. If both tails are fatter, then the Black-Scholes model underprices out-of-the-money and in-the-money calls and puts.

Several alternatives to the Black-Scholes model exist, but they each have their own problems. For example, Geske's compound option model treats the equity in a firm as a call option on the value of the firm, making the option an option on an option. A second alternative model is the displaced diffusion model, which values an option based on the volatility of the percentage of risky assets held by the firm. A third alternative, the constant elasticity of variance model, assumes that volatility of a firm's value is a function of its fixed costs, and the volatility of firm value increases when stock prices drop. Each of these three alternative models, however, overprices out-of-the-money calls and in-the-money puts, and underprices out-of-the-money puts and in-the-money calls.

In addition to the established anomalies of Black-Scholes and other models in pricing stock options, the market for carbon emissions has its own anomalies that complicate the valuation of cap and trade contracts as options. As discussed above, cap and trade contracts leave holders with the risk of having too few abatement options at the end of the commitment term when they may need those options. On the other hand, a firm that holds more permits than it expects to need may still hold onto the surplus because those permits have some option value, given that purchasing options in the future may be costly. Illiquidity arises endogenously from the fact that firms cannot emit without having permits and thus fear that they may face a market squeeze at the end of the year. The combination of the general anomalies of commodities, and options valuation models with the anomalies in the carbon emissions market have the capacity to seriously complicate the valuation analysis of a cap and trade market.

C. Exhibited Characteristics of Carbon Permit Prices Confirm That They Are Tremendously Complex Financial Contracts So That Financial Economics Is Unlikely to Find the True Value of "Cap and Trade" Permits

Emission allowance prices have exhibited periods of high volatility, arising in part due to the correlation between CO_2 emissions and external events such as seasonal changes and environmental disasters. Those external factors increase the difficulty of modeling emission allowance values, making it difficult for market participants to plan ahead for their future carbon emissions.

Figure 4 **Daily SO_2 Allowance Prices, January 1999 – May 2006**

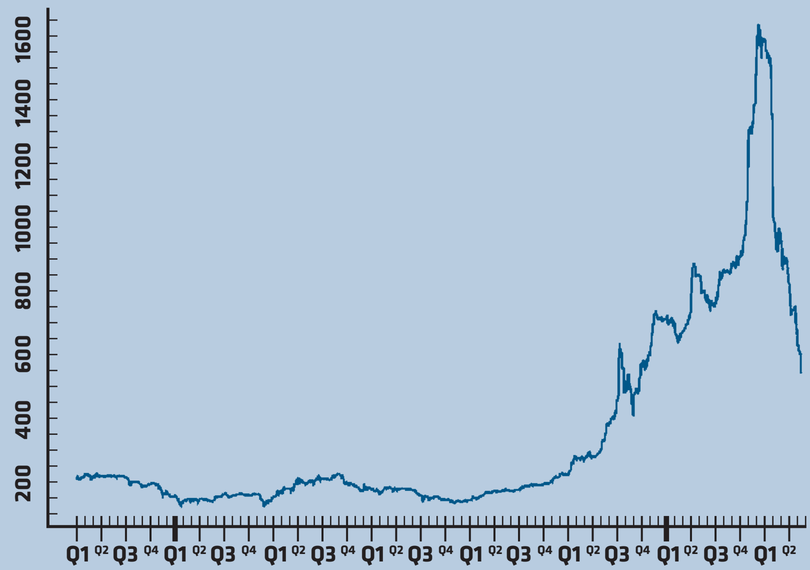


Figure 4 shows the daily allowance spot prices for sulfur dioxide (SO_2) from 1999 through May 2006. These allowances are traded on the over-the-counter market as well as through the Chicago Climate Exchange.[33] Producers of SO_2 emissions have been granted allowance permits through the United States Acid Rain Program since 1995.[34] The spot price for SO_2, at least from June 2003 until November 2005, could be consistent with a stochastic mean-reverting process with a constant positive drift, as desired by the stated cap and trade policy. The enormous price drop after November 2005, however, indicates that an assumption that the SO_2 cap and trade market was working correctly and that the policy was responsible for the gradual upward trend in price movement would most likely have been very wrong.[35]

Studies of the European markets for CO_2 allowances have also shown the difficulty in using cap and trade for risk-management purposes. In a paper discussing an optimal design for emission allowance derivatives, two financial economists from Universität Karlsruhe note that political and regulatory uncertainties, weather, and fuel prices were the most important *and* most volatile factors affecting allowance prices, according to surveyed market participants.[36] Weather changes (such as temperature, rainfall, and wind speed), fuel prices, and economic growth all affect CO_2 production levels. Unexpected events, such as power plant breakdowns or environmental disasters that shock the supply and demand balance for CO_2, and changes in fuel spreads shock the demand *and* supply side of CO_2 allowances and consequently market prices.[37]

For example, energy consumption (and hence CO_2 emissions) increases with cold weather. Non-CO_2 power generation is affected by rainfall and wind speed. In addition, the relative costs of coal, oil, and natural gas affect the decision to move forward with CO_2 abatement projects, and fuel switching costs can be high. These sources of price uncertainty have a short- or medium-term impact on liquidity, which in turn affects the volatility of emission allowance prices.[38] In addition, the prohibition on banking emission allowances between distinct phases of the EU ETS significantly affects futures pricing in that market.[39]

As a result of the complex fundamental dynamics, forecasting models based on fundamentals and future-spot parity of CO_2 yield implausible results due to market complexity and to the particular behavior of the allowances, such as

33. Marc S. Paolella & Luca Taschini, *An Econometric Analysis of Emission Trading Allowances,* Swiss Finance Institute Research Paper Series (2006), at 5.

34. *Id.* at 2.

35. *Id.* at 7-8.

36. Marliese Uhrig-Homburg & Michael Wagner, *Success Chances and Optimal Design of Derivatives on CO_2 Emission Certificates* (2006), at 23.

37. Eva Benz & Stefan Trück, *Modeling the Price Dynamics of CO_2 Emission Allowances*, 31 Energy Econ. 4, 6 (January 2009).

38. *Id.*

39. George Daskalakisa, Dimitris Psychoyiosb, & Raphael N. Markellosa, *Modeling CO_2 emission allowance prices and derivatives: Evidence from the European trading scheme*, J. Banking Fin. (forthcoming 2009).

inconsistent behavior of CO_2 allowance convenience yield.[40] Other studies have also shown that CO_2 emission allowance prices are nonstationary and exhibit abrupt discontinuous shifts, short periods of high volatility, with heavy tails in the distribution.[41] One study analyzing the dynamic behavior of CO_2 emission allowance spot prices for the European emissions market demonstrates that a steep price increase will occur when the end of the trading period is approaching, in contrast to a smooth approach to spot prices demonstrated in typical commodity markets.[42]

The institutional and financial characteristics described above make the choice of a proper statistical model crucial (albeit perhaps impossible) for purposes of risk management and carbon permit securities valuation. Given the interrelationship of carbon prices with both fundamental and policy variables, emission allowance prices and returns will exhibit different periods of behavior that include price spikes, volatility spikes, and heteroskedastic returns. The "jumpiness" of price series necessitates using not only traditional time series models, but jump and jump-diffusion models to analyze the statistical properties of the series.[43]

The dynamics discussed above are not limited to the EU. In addition to the EU cap and trade emission allowances, which are government-issued offsets that are limited in supply, other "low cost" emission credits that will assist the countries that are signatories to the Kyoto protocol in meeting their emission reduction targets include Certified Emission Reductions (CERs) and Emission Reduction Units (ERUs). CERs are created from projects in developing countries such as Brazil, Mexico, China, and India that reduce greenhouse gas, whereas ERUs are allowances that have been allocated to mainly Eastern European countries that have already met their emission reduction targets. CERs and ERUs are both fully fungible with the EU emission allowances and can therefore be banked and traded within the EU ETS. According to an early 2006 report, some project developers had already sold forward their CERs for delivery in 2006 and 2007, while others were banking their CERs until the price became more favorable.[44]

An important lesson from the EU's experience with CERs and ERUs is the arbitrage opportunities that have arisen due to the significant price difference between EU allowances and CERs. Funds and other entities finance energy projects that result in CERs. Then, those entities aggregate the CERs that are produced and create pools of carbon credits that are diversified across projects and countries.[45] These arbitrage opportunities mitigate both credit and country risk, but further complicate efforts to price emission allowance contracts alone.

Given the interrelationship of carbon prices with both fundamental and policy variables, emission allowance prices and returns will exhibit different periods of behavior that include price spikes, volatility spikes, and heteroskedastic returns.

Given the number of pricing anomalies that exist in financial markets, and the fact that carbon permits would share properties, at least in part, with many financial assets whose prices exhibit similar — but not identical — anomalies, valuations driven by financial markets are unlikely to uncover the true price of carbon permits in the multiple sources of statistical noise in market prices. Should a market for carbon permits in the United States emerge, one can be sure that investors will use the most innovative — and therefore untested — valuation techniques available to value and to trade what would be, arguably, one of the most important contracts in the economy and the environment. Although uncertainty may surround the value of such contracts *ex ante*, one can be sure that market participants will soon discover weaknesses in either the contract terms or the market structure and will seek to exploit any arbitrage opportunities that present themselves. Consequently,

...valuations driven by financial markets are unlikely to uncover the true price of carbon permits in the multiple sources of statistical noise in market prices.

40. Marc S. Paolella & Luca Taschini, *An Econometric Analysis of Emission Trading Allowances*, Swiss Finance Institute Research Paper Series N°06 – 26, 2006.

41. George Daskalakisa, Dimitris Psychoyiosb, & Raphael N. Markellosa, *Modeling CO_2 emission allowance prices and derivatives: Evidence from the European trading scheme*, J. Banking Fin. (forthcoming 2009).

42. Jan Seifert, Marliese Uhrig-Homburg, & Michael Wagner, *Dynamic behavior of CO_2 Spot Prices*, 56 J. Envtl Econ. & Mgmt. 180 (2008).

43. Eva Benz & Stefan Trück, *Modeling the Price Dynamics of CO_2 Emission Allowances*, 31 Energy Econ. 4, 14 (January 2009).

44. Ronald S. Borod & Madeleine Tan, *Carbon: Is It Just Hot or Is It a New Asset Class?*, 9 INTL. Securitization & Fin. Rep. 11 (February 15, 2006).

45. *Id.*

the nascent market will have to be monitored closely and carefully regulated. Market regulation itself, however, is far from efficient and fraught with difficulties.

III. Managing the Supply of Carbon Permits Is Like Central Banking, and Central Bank Policy Has Not Been Working Well Lately

Theoretical mathematical and economic models have been designed to show that a cap and trade program with sufficient banking and borrowing can, in principle, deliver a better outcome than taxing emissions. This conclusion has been recognized to some degree in papers that extended the prior work on optimal carbon permit banking and borrowing. More recently, public policy work for Resources for the Future by Richard Newell et al. (2005) showed how inter-temporal banking and borrowing would allow firms to smooth abatement costs across time, offsetting the traditional disadvantage of cap and trade relative to taxes.[46]

The results of Newell et al. (2005) in particular, however, rely crucially on several mechanisms borrowed directly from central bank policy. Using those features, Newell et al. (2005) claim to have written a theoretical economic model that, for the first time, suggested cap and trade (with appropriate dynamic modifications adopted from central bank theory) can achieve greater economic efficiency than tax-based approaches.[47]

The problem is that — as demonstrated in markets today — central bank policy rarely achieves those ideal efficiencies because central banking is far more complicated than it looks.

As a result, most recent carbon market development proposals now routinely borrow institutional features from central bank design and organization that are thought to be able to effectively regulate and constrain carbon markets to achieve environmentalists' objectives. It is those institutional features, *working optimally according to assumptions embedded in the economic models*, which generate the models' efficiency gains over straight carbon taxes. The problem is that — as demonstrated in markets today — central bank policy rarely achieves those ideal efficiencies, because central banking is far more complicated than it looks. In fact, given the theoretical and practical difficulties of central bank policy and application, Newell et al. (2005), style carbon market manipulation is more likely to *undermine* the benefit certainty that is the hallmark of cap and trade policy, decreasing cap and trade efficiencies to levels no better than — and perhaps worse than (depending on political volatility) — a simple carbon tax.

Like carbon contracts, money is a necessary input to production, and can be used to store value for the future and as a source of income. The fundamental source of value for both carbon contracts and money lies in the necessity of their use as a production input by government fiat. Hence, it makes sense to think of carbon permit supply management in the same light as managing a fiat money supply.

The section below shows that monetary theory — the branch of economics that concerns itself with attempting to achieve the simultaneous objectives of maintaining a valuable fiat currency without stifling economic growth, typically through central bank operations — separates three sources of demand for money: consuming, investing and speculating. Those demands are analogous to the uses of carbon permits as inputs to production, savings for future production, and options on expanding production in the future.

Those three demands create great complexity in monetary system design. Traditionally, three common ways of addressing the different needs are through discount window operations, reserve requirements, and manipulating the supply of fiat contracts. Contemporary carbon market proposals also include such features, but rarely acknowledge the limits to economists' knowledge with regard to best practices and effectiveness.

Last, therefore, I discuss the central bank's role in monetary policy, actively monitoring hitherto unknown dimensions of the economy in attempts to smooth economic growth by manipulating the money supply to stabilize the relative

46. Richard Newell, William Pizer, & Jiangfeng Zhang, *Managing Permit Markets to Stabilize Prices*, 31 Environ. & Resource Econ. 133-57 (2005).

47. *Id.* at 149 ("We demonstrate that permit systems incorporating banking, borrowing, and adjustments to the quantity of outstanding permits can replicate price-based regulation. The methods do not require any monetary transfers between the government and the regulated firms, thereby avoiding a politically unattractive aspect of price-based policies.").

value of the fiat contract against the production, investment, and speculative demands for the contract. While it is one thing for a central bank to try to operate such a system with a relatively-well-established instrument called money, whose supply can be both expanded and contracted over time, it is quite unreasonable to expect to efficiently manage innovative financially engineered markets of financial instruments with a long-term objective of decreasing supply *and* maintain reasonable economic efficiency in the short-term without substantial and sometimes repeated economic disruption.

The section stresses throughout how little is really known by economists about monetary theory and central banking, even after hundreds of years of academic research and policy application. Indeed, the current credit crisis is a manifestation of those limits to knowledge. Hence, the section proposes that applying the principles and practices of monetary economics to a new fiat instrument with unknown properties can have crucially important unintended consequences. While it may make sense to experiment with carbon market design in a relatively constrained application in order to learn how to harness that market, reducing carbon emissions can best be attained in the short-term through taxes rather than cap and trade policies.

A. Productive Use, Investment Use, and Speculative Use of Contracts Will Compete for Limited Supply of Contracts

Money is thought of as having three distinct uses whose relative importance varies over time: consumption use, investment use, and speculative use. First, and most straightforward, money is used to buy things, that is, for consumption. A carbon contract can only buy one thing, carbon emissions, but the analogy is still apt.

The second use of money is to store consumption potential over time and, more powerfully, until a time when that potential may be greater than today. Such activity is commonly called investment, and carbon permit holders can invest similarly when schemes involve banking provisions. Sometimes economies suffer from too much investment, that is, too little consumption. Some monies, typically in developing countries, may therefore have expiration dates to get consumers to use them more quickly. Usually, however, trade (legitimate or illegitimate) in different financial contracts can smooth individual inter-temporal consumption preferences despite such restrictions.

...it is quite unreasonable to expect to efficiently manage innovative financially engineered markets of financial instruments with a long-term objective of decreasing supply and maintain reasonable economic efficiency in the short-term without substantial and sometimes repeated economic disruption.

Investment differs from speculation in that investment targets some goal of future consumption. Speculation, in contrast, merely attempts to realize the maximum value of exchange either inter-temporally or across contracts of different types. If contracts are either mispriced or expected to be of far greater value in different times or places, speculators may demand some fraction of the contracts to take advantage of those relationships. Speculators have no use of the contracts for their own purposes, but may rent them from others to take advantage of speculative opportunities, creating leverage. While such activity is harder to observe with money (since money is fungible), it may be easier to identify among carbon permit holders with no emissions needs.

That fungibility is an advantage to fiat money over carbon permits. The "hard" carbon permit value makes the contract more vulnerable to demand shocks than the "soft" fiat money contract — just as money backed by gold was more difficult to defend than fiat currency. This is an important point, because what is envisioned as a tightly controlled supply of carbon permits will not just be used for consumption (producing carbon this period) but also for investment (producing carbon next period) and speculation (betting on the price of carbon).

Academic proposals for carbon market designs have acknowledged difficulties dealing with competing demands, even if they have not yet formally adopted the vocabulary of monetary economics. For instance, the ability to bank carbon permits may create a political problem akin to "undue wealth accumulation" or "hoarding" when some firms have a large residual supply of permits on hold. The second, some say greater, problem is that firms with large banked permit resources could corner markets and drive up prices. The risk lies in the way some authors think of rectifying the problems. The most simple proposals call for

Similarly, additional subsidized permits will only help insolvent environmentally value-destroying firms hold on a little longer at the margin and will destabilize the carbon regulatory authority.

an expiration date on the permits, much like Zimbabwe (annual inflation last year of roughly 10,000 percent), and other dysfunctional developing countries impose expiration dates on their currency. Others suggest imposing more stringent project requirements on firms with greater "wealth" in terms of banked permits. Nevertheless, authors admit that the permit demand function is largely unknown, noting "…there is little evidence concerning how large of an allowance bank firms might accumulate (it could, in fact, be much larger than one year's worth of allowances), how fast they might spend it down, and in turn how much this might affect any future tightening of the cap."[48]

B. Typical Ways of Managing the Competing Demands for Money Are Not at All Straightforward in Practice

Typical proposals maintain that uncertainties about the permit demand function can be addressed through a central bank "discount window" equivalent, imposing a "reserve requirement" on permit holders, or regularly intervening in permit markets to dynamically manipulate permit supplies in a manner similar to open-market operations. While such features appear attractive at face value, closer inspection quickly reveals the well-known — within the field of monetary economics — problems associated with using these tools to manipulate the money supply and how much more complex and potentially intractable the problems would be if implemented with carbon permits.

1. Discount windows do not work for the money supply, so why should they be expected to work for carbon contracts?

Accepted approaches to carbon permit supply management have evolved to allow some form of borrowing if permit costs are unexpectedly high or supply is otherwise unavailable. Notwithstanding the fact that such policies are generally frowned upon by staunch environmentalists who want emissions limits treated as rigid constraints, the question becomes when to intervene and how many permits to offer. Those are precisely the questions that have confounded monetary theory for hundreds of years.

The clearest advice that has been given for managing such discount window applications is Bagehot's rule, which suggests that liquidity crises should be addressed by "lending freely at a penalty rate." The idea is that financial market crises are accompanied by liquidity difficulties arising when investors cannot sort out weak firms from strong ones. Firms that are otherwise sound but lack temporary liquidity can, therefore, be helped through discount window lending by a monetary authority that has inside information about firm conditions. The carbon permit problem would be similar, if firms did not hold enough reserve permits to meet production requirements, say, in a cold winter. Hence, the policy approach is argued to be similar, as well.

Of course, operationalizing Bagehot's rule in central banking has been tricky. What constitutes a crisis? What constitutes lending "freely"? What is a penalty rate? Environmental authors are feeling their way around such policy problems, effectively reinventing the wheel. Some suggest allowing the regulator to "…react to specific high-permit-price circumstances by making special allocations." Far from applying the penalty rate, however, such authors suggest the regulator "…give away some volume of additional permits, thereby lowering permit prices," which is like a central bank dropping interest rates to zero. Of course, it would be desirable to only facilitate a temporary increase in permits (similar to facilitating only a temporary increase in the money supply to avoid inflation), leading some to suggest the permits be loaned instead of sold.[49] All the approaches will be applied in a highly politicized environment, detracting — perhaps substantially — from economic efficiency.

Moreover, the environmental debate ignores the fact that the importance of central bank discount window policy has waned considerably over recent decades. While discount window lending can help smooth typical small fluctuations

48. *See* Brian C. Murray, Richard G. Newell & William A. Pizer, *Balancing Cost and Emissions Certainty*, Resources for the Future Discussion Paper (2008) at 10.

49. Newell, Pizer, & Zhang, *supra* at 148.

in currency demand, discount window lending is not an advantageous way to address crises where solvency difficulties are often paramount, since more credit does not help firms become less insolvent. Similarly, additional subsidized permits will only help insolvent environmentally value-destroying firms hold on a little longer at the margin and will destabilize the carbon regulatory authority. Hence, after hundreds of years of experimentation, the discount window lies largely unused for significant policy purposes. The carbon market equivalent similarly holds little promise.

2. Reserve requirements help stabilize banks but are not used to actively manipulate monetary policy

Environmentalists have also come to advocate central bank reserve requirements as not only a means of smoothing permit demand, but also manipulating permit supply. As with other central bank applications, the principle is deceptively simple. Firms that use carbon permits to some substantial degree are required to hold a quantity of unused permits to accommodate normal production demand, perhaps based on a certain percentage of the allocation or based on a certain percentage of last year's emissions. "These reserves would be roughly analogous to the reserve requirement that the Federal Reserve places on banks, whereby they are required to always hold and not loan out certain percentage of deposits. As with the Fed's reserve requirement, firms not meeting the permit reserve requirement could be allowed to borrow from the regulatory authority in order to meet it."[50]

Again, problems arise when environmentalists read too much into central bank policy, unaware of the pitfalls that such policy options have demonstrated over the history of practical application. Some environmentalists suggest the reserves give "…the regulator an additional policy lever to stabilize permit prices by influencing the effective amount of permits in circulation, in the same manner that the Fed can adjust reserve requirements to influence the interest rate. Raising the reserve requirement, for example, would lower the effective amount of permits available in the market, thereby raising the permit price. Lowering the reserve requirement would have the opposite effect. The regulator could take this action any time it saw prices deviating from the target."[51]

Central bankers long ago, however, accepted that reserve requirements were too heavy-handed to be used as a policy tool. In the monetary world, reserve requirement manipulations required every bank, irrespective of its resources, to expand or — more importantly — contract reserves by a fixed amount to meet policy goals. Such broad policy is obviously detrimental to institutions with even idiosyncratically temporarily low reserves, penalizing such banks for what may be advantageous use of capital. Hence, the Federal Reserve moved away from actively using reserve requirements for policy purposes in the 1950s. While undergraduate textbooks still correctly teach that central banks still have the authority to change reserve requirements, reserve requirements are not considered a realistic central bank policy tool and are probably too heavy-handed for environmental policy, as well.

3. Open market operations are the current vanguard of monetary policy, but the effects and limits of open market operations are still largely unknown

Modern central banks influence markets primarily by purchasing and selling key market instruments, thereby affecting the supply of money and, secondarily, the price (interest rates). While overall supply is affected by open market operations, however, the supply of money related to consumption demand is most important for driving economic growth, the ultimate target variable of monetary policy. If money that is injected through open market operations is merely absorbed by investment or speculative demand, it is transformed back into securities and therefore does not drive growth as directly as does consumption. When the money injected is merely held in excess reserves (equivalent to "stuffing money in the mattress"), the link between open market operations and economic growth breaks down completely. To the extent such preference shifts are understood in monetary economics, the field refers to the conditions as a breakdown in the credit channel of monetary policy transmission, which can create a liquidity trap.[52]

A similar phenomenon can be imagined for carbon open market operations, where productive, investment, and speculative demand are more closely tied to the target variable of economic growth. If productive users do not receive

50. *Id.* at 147.

51. *Id.*

52. *See*, for instance, Ben S. Bernanke, *Nonmonetary Effects of the Financial Crisis in the Propagation of the Great Depression*, 73 Am. Econ. Rev. 257-76 (1983).

permits sold through open market operations — whether because productive users do not desire such permits or because speculators desire those permits more highly than productive users (who value the permits at the marginal cost of fuel substitution or production cutbacks) — the link between carbon permits and production will be broken.

Breaking a carbon market "liquidity trap" may involve increasing the supply of carbon permits dramatically. When the Federal Reserve embarks upon such action, it runs the risk of inflation. When the carbon market regulator embarks upon such action, it runs the risk of obviating the long-term carbon emissions restrictions it seeks to impose. Both invoke vast unknowns in the economics of engineering and manipulating markets for public benefit. Both are potentially damaging and even reckless, both economically and politically.

4. Regulatory credibility and optimal policy consistency are not easily obtained

Since the early days of Kydland and Prescott (1977) and many authors who followed, the risks that central banks assume in generating policy credibility, consistency, and openness have become well-known.[53] With central banks, such considerations arise out of investor concern for inflation and economic growth. With carbon markets, similar considerations can be expected to arise with respect to long-term carbon emissions goals and economic growth.

The main problem with central banks is that credibility, consistency, and openness are only measurable against long-term economic growth, which may take several years to evolve from any given policy shift. With applications to carbon markets, credibility must be maintained with respect to not only long-term economic growth but also long-long-term carbon emissions reduction targets, which may take decades to measure.

While both a carbon tax and a cap and trade system achieve the same goals in theory, a carbon tax would be simpler to implement, more transparent, and less vulnerable to manipulation or malfeasance.

The issue of credibility is central to academic discussions of whether central banks should set policy on the basis of rules or subjective judgment. Rules are attractive because investors can transparently weigh whether the central bank intends to meet their long-run policy goals by observing whether the central bank is following the rule to which it has committed.[54] The rule therefore helps investors filter through the noise of short-term economic fluctuations to determine policymakers' credibility.

Rules, however, do not fit every situation. Hence, central banks prefer to have discretion over how to address idiosyncratic issues affecting short-term economic growth. Discretion can also be used, however, to eviscerate policy goals. Hence, rules are stronger than discretion in establishing central bank credibility. Once credibility is established, however, mature central banks can usually be trusted to undertake some level of more discretionary and effective short-term policymaking.

Of course, setting rules precisely in the context of specific policy questions can be difficult. Monetary theorists have struggled with growth rules, inflation rules, and other monetary policy target rules. The well-published Taylor Rule is one example of an outside metric that is used to judge deviation from steady-state policy in a discretionary central bank.

What rules would an environmental regulator set? The simplest relates to the benefit certainty that is thought to be the hallmark of cap and trade: reduce carbon emissions over time. In the short-term, however, holding tightly to such a rule may impose substantial costs on economic growth. Furthermore, according to the now-famous Lucas critique, once traders figure out rules, they act accordingly. As with developing country central banks, the regulator may therefore be attacked by speculators buying contracts in hopes of driving prices up. As long as regulators hold tightly to their rules, speculators gain. Hence, while the regulator seeks to establish credibility, the speculator seeks to push prices to levels that break the regulators' resource constraints. Such was the case in the Asian and Latin American crises of the 1990s and George Soros' speculation against the British Pound in 1992.

53. Finn E. Kydland & Edward C. Prescott, *Rules Rather Than Discretion: The Inconsistency of Optimal Plans*, 85 J. of Pol. Econ. 473-91 (1977).

54. *Id.* Rules are credible precisely because they impose discipline in the face of economic upheavals. Inflexible rules regarding gold parity of the dollar and other worldwide currencies certainly helped cause the Great Depression. While inflation — dropping the rule — helped spur recovery in every country, each inflated with the objective of reestablishing pre-Depression gold parity sometime in the future. It was not until 1973 that countries moved to fiat currencies (not based on gold), and recent crises in Latin America and Asia remind us that economists' understanding of the relationship between rules and credibility is still in formative stages.

Once the regulator deviates from its rule, it must once again establish credibility. After the crises of the 1990s, more countries adopted other sorts of currency pegs and floating pegs to allow rule-based policy with greater degrees of discretion to guard against speculative incursions. Some countries maintained their rules-based policies and defended them through capital controls, prohibiting exchange between foreign and domestic currency in times of necessity. Overall, however, the problem of establishing central bank credibility has not yet been solved in monetary economics, and policymakers seeking to apply central bank paradigms to carbon markets should expect similar difficulties.

Once credibility is established, central banks are still not free to do as they wish. Policy inconsistency has been shown by many authors to be as disruptive as any financial crisis. The regulator cannot set a discretionary paradigm or an operating target and then change it without expecting economic disruption as businesses and investors try to understand the new "rules of the game." In fact, modern central bank policy has changed significantly across recent decades, and those changes have sometimes caused tremendous disruptions. Central banks have struggled over appropriate operating target variables for some time now, and ongoing financial innovation perpetuates the struggle.

Policy inconsistency was related to the 1970s stagflationary episode. In the 1970s, the Federal Reserve implemented monetary policy by targeting the federal funds rate. Interest rates rose dramatically, however, during the 1970s. The Federal Reserve responded to interest rate increases by increasing the money supply, which led to historically high levels of inflation (e.g., over 10 percent in the summer of 1979). With rapidly rising inflation, Paul Volcker (chairman of the Federal Reserve Board at the time) felt that interest rate targets were not doing an appropriate job in constraining the demand for money (and the inflationary side of the economy). Thus, on October 6, 1979, the Federal Reserve chose to completely refocus its monetary policy, moving away from interest rate targets toward targeting the money supply itself, and in particular bank reserves — so-called non-borrowed reserves, which are the difference between total reserves and reserves borrowed through the discount window.

Growth in the money supply, however, did not turn out to be any easier to control. For example, the Federal Reserve missed its M1 growth rate targets in each of the first three years in which reserve targeting was used. Further, in contrast to expectations, volatility in the money supply growth rate grew as well. In October 1982, the Federal Reserve abandoned its policy of targeting non-borrowed reserves for a policy of targeting borrowed reserves (those reserves banks borrow from the Fed's discount window).

With applications to carbon markets, credibility must be maintained with respect to not only long-term economic growth but also long-long-term carbon emissions reduction targets, which may take decades to measure.

The borrowed reserve targeting system lasted from October 1982 until 1993, when the Federal Reserve announced that it would no longer target bank reserves and money supply growth at all. At this time, the Federal Reserve announced that it would again use interest rates — the federal funds rate — as the main target variable to guide monetary policy (initially setting the target rate at a constant 3 percent). Under the current regime, and contrary to previous tradition such as in the 1970s, the Federal Reserve now announces whether the federal funds rate target has been increased, decreased, or left unchanged after every FOMC meeting — previously, the federal funds rate change had been kept secret.

Some signs of policy inconsistency have already shown up in European carbon markets. The trading period break between 2007 and 2008, institutionalized in first-generation carbon contracts, prohibited continuous spot trading between the two trading periods. The result has been two separate markets over time, and the potential EU ETS transition into a third trading period would create further disruption. According to European writers, the break has made "…planning or risk management a lot more difficult for companies active in the EU ETS. Policy makers should thus think about a smoother transition into a potential third trading period."[55]

In summary, therefore, central bank operating paradigms are not as simple as they seem. The Federal Reserve retains one of the most impressive staffs of economists worldwide not because the governors are fans of economic research, but because that research is necessary to guide monetary

55. *See* Marliese Uhrig-Homburg & Michael Wagner, *Futures Price Dynamics of CO_2 Emission Certificates.*

policy on a path through great unknowns. That is also why the governance structure of the Federal Reserve is constructed to provide consistent policy across long periods of time, so that knowledge and experience can potentially be buffered from political demands across time.

C. A Carbon Market Efficiency Board modeled on central bank operations will operate with all the above constraints plus additional uncertainties and political interference

Policies to date have suggested that the supply of carbon permits be constrained to meet environmental goals. Problems arise, however, when considering that — as with monetary policy — the price of those contracts will be left to vary widely in response to market conditions. Indeed, analysis in the previous sections showed that we have already seen incredible price volatility in European markets, obviating efforts to push carbon prices to levels that will stimulate green investment.

A further advantage of money market manipulation over carbon market manipulation is that there is no intended fixed constraint on money supply or consumption that can be used to influence economic growth. In fact, the U.S. is unique among countries worldwide in that roughly two-thirds of the money supply is estimated to be held outside the country. Hence, there is no worry about running into a hard constraint on the amount of money necessary to facilitate consumption while accommodating investment and speculative demands. Whereas central bankers are allowed to raise the money supply above a prespecified ceiling, the stated ideal is for carbon permit supply to remain constrained, which — adding complexity — will be decreased over time.

More importantly, even central banks have learned over time that they can target either the price of money (interest rates) or the quantity of money, but not both. If the money supply is the target, variable interest rates must be allowed to fluctuate. By contrast, if an interest rate (such as the fed funds rate) is the target, then the money supply must be allowed to fluctuate relatively freely.

...in adopting a cap and trade system we are hinging economic growth on a complex contract and a convoluted market design, both of which have yet to be tested in the real world.

In summary, carbon permit supply will need to be dynamically controlled to adjust for numerous unobservable influences, just like the money supply. If investment or speculative demand rises, there will be fewer permits available for production. If, on the other hand, investment or speculative demand falls, carbon overproduction may result. Hence, managing a carbon permit market will be far more complex than managing the money supply, which — indeed — is already tremendously complex, leading to cyclical booms and busts that remain the focus of an entire body of economic research.

Managing a carbon permit market will therefore rely even more crucially on economists who can staff a Carbon Market Efficiency Board with the courage to stanch booms and the talent to mitigate busts, much as the Federal Reserve is expected to accomplish today. According to environmental researchers, all policy proposals "…run into a barrier of establishing some type of management board to manage the reserve allocations and otherwise administer the program."[56] It is *that* board that is crucially responsible for the dynamic optimality of the implemented cap and trade solution over a carbon tax alternative.

Like a central bank, the important issues would be the precise governing mandate for such a board, the tools available to it, and the degree to which it operated subject to legislated rules versus having complete discretion. Even the Federal Reserve faces multiple conflicting goals, including seeking "to promote effectively the goals of maximum employment, stable prices, and moderate long-term interest rates." In steady-state economic growth, those goals all work in tandem. But in economic booms and busts, the goals may conflict with one another. For instance, the only way to bring high inflation down is to restrain economic growth, resulting in higher unemployment. In such a situation, "those responsible for monetary policy face a dilemma and must decide whether to focus on defusing price pressures or on cushioning the loss of employment and output."[57]

A Carbon Market Efficiency Board is expected to face similar conflicts, at once protecting the environment and containing costs to firms of doing so. The board will therefore have

56. *See* Murray, Newell, & Pizer, *supra* at 21.

57. *See* Purposes and Functions of the Federal Reserve, available at http://federalreserve.gov/pf/pdf/pf_complete.pdf, at 15.

to not only maintain, but define, an appropriate balance of "contract demand" and "contract supply," which will take considerable time and resources in an environment of great political and economic demands. Even the Federal Reserve was politically captured during its first 40 years of existence to serve the Treasury by keeping interest rates low, ultimately being released from such duty only in the Treasury-Federal Reserve Accord of 1951.

But what of the Carbon Market Efficiency Board's mandate to restrict carbon emissions and contain costs to preserve economic growth? Balancing both long-run costs and long-run growth makes the Federal Reserve's job look simple, in comparison. When both emissions and economic growth targets are long-term, the management of the two takes on an air of supposition beyond even that managed by central banks. Operationalizing the Carbon Market Efficiency Board's mandate will require settling on a measure of emissions among the vast number of possibilities, as well as settling on a measure of costs. Like a central bank, unable to directly measure either, the board will have to choose target variables it thinks are related — to one extent or another — to the ultimate policy variable and manage to those targets while trying to make sense of the targets' relationship to the ultimate policy measure.

None of this is new: central banks still struggle with a proper definition of economic growth, since classic measures like GDP, for instance, exclude services and other key segments of productive activity. Central banks also struggle with the definition of inflation, relying on CPI and PPI measures that — classically now that we have experienced another asset bubble — exclude financial market prices and housing prices. With greater integration of financial markets and commercial banks, central banks are not even sure anymore what money is. Indeed, those uncertainties are why economies still experience financial crises, recessions, and depressions. With theoretical economic certainty, there would be no credit crisis, nor 10,000 percent annual inflation in Zimbabwe, nor any of the booms and crashes that inexorably repeat themselves through history.

Instead of certainty, modern economies rely on central bank representatives who are thought to be wizened individuals with industry knowledge and economic backgrounds that can help them make creative and meaningful policy even where economic theory falls short. Members of the Federal Reserve Board of Governors are chosen in a manner that attempts to balance conflicting interests, coming from diverse backgrounds such as banking, monetary economics, and law, with practitioners and academics represented in the mix. Furthermore, the governors can rely upon a staff of some of the best economists in the world to undertake market and economic studies that help create strong central banking principles that serve as guideposts to our ever-evolving understanding of central banking and its relationships with markets and the economy. The diverse board composition and economic might are crucial to a well functioning central bank because, even after hundreds of years, central banking is still more art than science. We would expect no less in the present (infant) application of a Carbon Market Efficiency Board.

Hence, managing a carbon permit market will be far more complex than managing the money supply, which — indeed — is already tremendously complex, leading to cyclical booms and busts that remain the focus of an entire body of economic research.

In summary, in adopting a cap and trade system we are hinging economic growth on a complex contract and a convoluted market design, both of which have yet to be tested in the real world. In theory, therefore, cap and trade systems predicated upon a market stabilized by a Carbon Market Efficiency Board may be able to generate efficiency levels greater than a flat tax. In practice, however, cap and trade plans that rely crucially upon idealized applications of central bank operations with an unlimited supply of benevolent governors and a full and complete understanding of market characteristics and functions are rare, at best. Practical difficulties, therefore, will detract significantly from the theoretically ideal benefit certainty thought to be conferred under a cap and trade system for the foreseeable future. With such policy uncertainty, it is hard to imagine a Carbon Market Efficiency Board will be more efficient than a carbon tax, which is — in effect — the ultimate policy rule.

IV. Policy Recommendations and Conclusions

The crux of current greenhouse gas emissions policy debates is whether to implement a cap and trade system or a carbon tax. Economically, the question comes down to which program provides the most effective means of catalyzing pollution abatement while limiting economic distortions.

Based on economic research and the available empirical evidence, the most efficient policy approach would be to impose a carbon tax…

Based on economic research and the available empirical evidence, the most efficient policy approach would be to impose a carbon tax on all coal, natural gas, and oil produced domestically or imported into the United States. While both a carbon tax and a cap and trade system achieve the same goals in theory, a carbon tax would be simpler to implement, more transparent, and less vulnerable to manipulation or malfeasance.[58]

The present paper shows myriad benefits associated with implementing a carbon tax over a cap and trade program. In terms of simplicity of administration, carbon taxes are both easier to enforce and can more readily be adjusted if the policy is too weak or too aggressive. A carbon tax also reduces the time lag between the promulgation of a pollution target and its achievement, as a tax can be administered immediately. A cap and trade system, in contrast, requires extensive administrative and market infrastructure that will take decades to develop.

Additionally, a carbon tax would result in an immediate revenue inflow, as it would rely on the existing federal tax structure for collection. This revenue could then be used to promote further environmental protection in the form of research grants for the development of alternative energy sources, which are not forthcoming from carbon permit market revenues. Carbon tax revenues could also be used to offset any regressive effects of the carbon tax, especially where small businesses will be adversely affected by additional production costs in a positive-carbon price world.[59]

The most important drawback of cap and trade programs is that they do not work in practice. The tradable permits program initiated by the European Union has been subject to administrative folly and disappointing results. On the other hand, carbon taxes have been successfully introduced in a growing number of countries, including Canada, Denmark, Finland, Italy, and the Netherlands.[60] The simplicity and efficiency of carbon taxes render their use less ripe for regulatory capture than a cap and trade program.

Nevertheless, if policymakers decide to ignore the clear benefits of a carbon tax and opt to implement a cap and trade program instead, the most direct route to preventing speculative abuse and protecting economic growth is to guard the market through attentive monitoring and regulation. The carbon market regulator — referred to in U.S. proposals as the Carbon Market Efficiency Board — must have the power to stanch speculative abuses and attempts to corner the market, whether by domestic or foreign traders, by requiring market participants to be registered with the board and giving the board adequate powers to rescind registration in cases of domestic or international abuse.

The board also must have macro-prudential authority to play a substantial role in decisions about how to value and report carbon contract holdings for accounting purposes in order to ensure sufficient transparency in financial statements of businesses that use the contracts for production, investment, and speculation. The board must have the power to provide an adequate stock of carbon contracts to "lean against the wind" of global warming while ensuring economic growth and employment.

Last, the board must have the power to change the terms of the carbon contracts if the original design proves flawed or ineffective. Alternative contract designs, such as a carbon fee or tax structure, may yet prove superior, and transition may be necessary if the present "cap and trade" carbon contract proves crucially flawed. Just like the Federal Reserve can choose its monetary policy tools and targets, limiting the Carbon Market Efficiency Board to one tool or target may ultimately prevent it from accomplishing the task for which it is established: cutting carbon emissions and helping the environment.

A carbon tax confers far greater economic efficiency than an ill-defined, unstable, and environmentalist – and Wall Street – driven cap and trade market design.

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58. Avi-Yonah & Uhlmann at 4-6.

59. *Id* at 4-5.

60. *Id* at 33.

Proposed U.S. cap and trade policies are attempting to implement something far different from the original cap and trade theory using complex financial contracts and convoluted market designs to mitigate price uncertainty at the cost of the benefit certainty that is the hallmark of cap and trade. But such mechanisms and designs will not only substantially reduce the policy's impact on the environment; they may also pose significant risks to U.S. economic growth and competitiveness. In a world where economic outcomes are couched in uncertainty and the optimal level of pollution abatement cannot be established with precision, a carbon tax provides the flexibility policymakers need to grapple with the problems presented by climate change.

In summary, manipulating carbon permit supply via a Carbon Market Efficiency Board that is charged with restraining emissions without unduly harming economic growth necessarily decreases the benefit certainty that is the hallmark of cap and trade. Without that benefit certainty, the convoluted carbon permit market design and risk of market collapse is both theoretically and practically unnecessary. A carbon tax confers far greater economic efficiency than an ill-defined, unstable, and environmentalist–and Wall Street–driven cap and trade market design.

About the Author

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Dr. Mason's consulting practice provides firms with advice on financial, political, and legal risks in banking and finance. He has consulted on issues ranging from mortgage, home equity loan, home equity line of credit, auto, and credit card servicing, and securitization, to discrimination and disparate impact in consumer lending and insurance pricing, valuing distressed securities, the investor recoveries and efficient liquidations of bankrupt firms, and economic valuations of complex investment and lending arrangements involving asset-backed securities, collateralized debt obligations, and hedge funds. In litigation, he regularly serves as testifying or non-testifying expert on matters related to a wide variety of financial market-related claims. Dr. Mason has consulted for and advised investment firms, corporations, and research institutions, including The Conference Board, Inc., Coventry First, Deloitte, Fannie Mae, the Federal Deposit Insurance Corporation, the Federal Reserve Bank of Philadelphia, The Group of Thirty, Pricewaterhouse-Coopers, and The World Bank Group.

Dr. Mason's academic research focuses primarily on investigating liquidity in thinly-traded assets and illiquid market conditions. Current academic research projects analyze default risk, including both immediate and cross-default risk, and default resolution costs in the contexts of asset-backed securities, in systemic and non-systemic environments, as well as the efficacy of bailout and resolution policies through the history of financial markets. His research and economic commentary has received hundreds of national and international press citations in publications such as the *Wall Street Journal*, *New York Times*, *Washington Times*, *The Economist*, *Financial Times*, *Barron's*, *Business Week*, *die Zeit*, *Neue Zürcher Zeitung*, *Financial Times-Germany*, *Roll Call*, *Los Echos*, *Forbes*, *Fortune*, *Portfolio Magazine*, *Bloomberg Magazine*, *American Banker*, and on press syndicates such as Associated Press, Reuters, Bloomberg, KnightRidder, and MarketWatch-Dow Jones Newswire.

Dr. Mason received a B.S. in economics from Arizona State University in 1990 and a Ph.D. from the University of Illinois in 1996.