

Part I

The Role of Financial Innovation in Society and Investing in Climate Change

The History of Financial Innovation

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at Yale

Chapter 1

The History of Financial Innovation

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EDITORS' REMARKS

This was the opening talk in the speaker series, chosen to frame the subsequent year-long discussion about the role of finance in helping to solve the climate issue. Professors William Goetzmann and K. Geert Rouwenhorst skillfully construct this framework, taking us through several historical examples of financial innovation and putting finance and its ability to solve problems in context. As Professor Goetzmann states, “it seem[s] clear that in order to make this experiment in carbon finance work, it would be useful to understand the foundations of financial innovation.” Indeed, watching finance emerge as a tool to solve problems associated with the large scale urbanization of Mesopotamia or the illiquidity of international debt instruments in the 18th and 19th centuries, one readily gains the valuable perspective that finance “is something that was invented and elaborated on over time” as a powerful means to solving problems of a broad nature.

Professor Goetzmann begins the talk by illustrating, through a big picture lens, the essence of finance and financial innovation, highlighting the relevancy of certain historical developments and lessons to the burgeoning carbon markets. Picking up about midway, Professor Rouwenhorst presents some interesting examples that serve to demonstrate the “incredible ingenuity” of financial technology, corroborating Professor Goetzmann’s claim that “financial markets have incredible potential for implementing change . . . [and] are at least worth a gamble in terms of being a tool that we might be able use to solve environmental problems.” After an insightful conclusion, the presentation ends with a question and answer session mostly concentrated on the general structure of carbon markets.

The foundation built by this opening talk was one that we enjoyed so much that a signed copy of the book upon which much of its material is based became a standard token of appreciation to all of the presenters that followed.*

*To gain further context, read related articles, order a bound copy of this publication, or download pdfs of the publication or the recorded version of this presentation, please visit: www.yale.edu/cbey/carbonfinance2008

William Goetzmann

Thank you for inviting us to be the opening speakers in this really innovative series. As you can see from the title of our talk, it is not directly focused on carbon finance, and we were a little taken aback that our topic was of interest to this group. But as we got interested in looking at these connections, it seemed clear that in order to make this experiment in carbon finance work, it would be useful to understand the foundations of financial innovation – how innovation takes place, what kinds of instruments might fail, and so forth. The lesson for us in many regards comes from experience and the history of financial innovation over time. So today you will hear about financial history and, though we will not explicitly make this link for you, you can think how this history relates to carbon markets.

I will begin the presentation by speaking about some general topics in finance and some historical episodes in financial innovation. Professor Rouwenhorst will follow with some really fascinating additional examples from the golden age of finance that can also be found in our book¹. A lot of the information we're going to talk about today comes from this book, which was a great experience for us in terms of learning about financial history – most of the topics you can find in the introductory chapter and in later chapters as well. We'll conclude the presentation with some questions and answers.

¹ Goetzmann, W. N and K. G. Rouwenhorst. *The Origins of Value: The Financial Innovations That Created Modern Capital Markets*, Oxford University Press, 2005

WHY FINANCE?

Finance is really a technology about the future. It is not an ideology, but rather a set of tools that are increasingly being used to solve problems. It's a peculiar technology in that it is not a machine that performs things in the present tense, but is a way of passing value back and forth between the future and the present. The essence of finance is a time machine – you put some money in a box today, you turn the crank, and it appears at some time and place in the distant future. We call that a loan, but it is a strange slight of hand. It is something that was invented and elaborated on over time and it is endlessly fascinating in terms of financial engineering and technology.

The thing that makes this particularly interesting with regards to carbon finance is that a lot of what we are trying to do is to change the future. Given the status quo of the present, we are looking for a technology to affect future environmental outcomes. Finance is first a way of passing economic value through time, but maybe it is also a way of passing *environmental* value and characteristics through time.

Driven by the fact that there are financial markets, finance is also a mechanism for allocation; free capital markets are classic mechanisms for efficient allocation of capital. One of the interesting things about carbon finance is that it is a proposal for letting the invisible hand solve some of the problems that one might otherwise consider regulatory issues to be addressed by a central planner. This is one of the most important issues that connects finance with the topic of carbon finance. It is a thing that will subtly and, I hope, inevitably enlist a broader community of interested people in the problem at hand. It's a way, in some sense, of slowly seducing an ever increasing circle of agents into solving the problem together. And it does this by creating economic incentives as well as philanthropic incentives.

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If carbon markets work, if the financial technology applied to environmental problems works, it will enlist an unusual and eclectic community of economic players, from hedge funds to savers to speculators and so on, into thinking about forecasting and estimating the effect of environmental carbon. That will be a good thing. The question is, what mechanisms will help us achieve that?

WHY FINANCIAL HISTORY?

Financial markets have incredible potential for implementing change. They have been extraordinary catalysts at certain points in history. As a result, they are at least worth a gamble in terms of being a tool that we might be able use to solve environmental problems.

What you will see is that crises, particularly warfare, have been the catalyst for these transformative innovations. And intermediaries, although they may seem like pesky problems at times of financial crisis, play a very important role in getting the prices right on the things that we would like to be traded and liquid in this market.

Finally, once you get markets started, they have this capability of stimulating and harnessing human ingenuity. If you think about the collective brainpower of all the students passing through Yale, and you push that back two hundred years, you had an immense number of people focusing on Bible studies and Greek philosophy. And now we have an immense number of people focusing on (among other things) what Goldman Sachs does and how to price derivative securities on Wall Street. I am being a little facetious here, but there are ways that the markets have transformed what really smart people are interested in spending their time thinking about and doing. If you create a viable market, such as a carbon market, it has the potential of getting some bright, creative people involved in solving these problems.

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A VERY BRIEF LESSON IN WHAT I THINK FINANCE IS

Finance has three key features. The first one is *time*. You can think about it as investing today and reaping the rewards tomorrow, or borrowing money from the

future to invest it today. Some people need to be savers, while others need the capital to build businesses. Financial markets and financial contracts and securities are just mechanisms for making that happen. Think about a bond – it's a time machine that passes money into the future for the saver. For the borrower, it's a way of promising what you do not have yet, something that you expect to get in the future in return for something you receive today. Stocks are a little bit like this – you have a stream of dividends that are going to stretch out into the future, but you pay your money in order to get those dividends today. The value of the stock is the present value of that future stream of dividends. Presumably because this future stream goes on forever, it is a discounted value. There is a time value to that stream. A lot of finance has to do with determining the appropriate discount for that time dimension.

Futures contracts are pre-agreed compensation for the delivery of future commodities. With carbon futures, for example, you have a contract that allows the owner to expend so much pollutant at some time in the future for an agreed-upon price today. We often think about these things as financial contracts – stocks and bonds – but there are lots of ways for these inter-temporal transfers to happen. It used to be that the family was a mechanism for smoothing income through time or creating delivery of future value through present investment. Other institutions, such as banks or pension funds, the government or non-profits, can all be thought of as financial agents. It is not the institution that is as important as the basic function – the need for people to plan for their future retirement or the need for you to shift income that you have today into the future, for example. Or, for instance, if you want to buy a house, you can borrow the money today and offset it with future compensation.

The second dimension that is really important is *chance*. You have the future, and between you and the future is a veil of uncertainty. The future is inherently hard to predict. That veil of uncertainty creates interesting potential for financial technology. A lot of finance has to do with rating contracts depending on some outcome. Insurance contracts are a classic case. With life insurance, your beneficiaries only get paid when you die. With fire insurance, you only get paid when your house burns down. These things are called derivative securities and are ways of insuring against certain kinds of outcomes. There are institutions, such as insurance companies, that make that happen. There are also traded securities, such as options, which are securities that trade in a market, that allow you to hedge yourself against uncertain outcomes such as a drop in the stock market, for example.

When one thinks about how these things might relate to carbon markets, one of the problems one faces is what happens if these securities are suddenly worthless – if some erroneous calculation was made about a cap on emissions and suddenly the value of such securities expires. That is a disaster for investors who hold these things, and there may be ways of insuring or protecting against that kind of outcome through options or intermediaries that can take on that risk.

That kind of dealing with risk, parceling the risk out to someone willing to take that risk, is called a structured product in modern terms – chopping up the risk and selling it to the person or group that is best prepared to take it on. The current crisis

that we're in with mortgages suggests that it is not always clear that people understand how much risk they are taking on. But nevertheless, there is a technology for allocating that risk to those with the best expectation about it.

The third basic financial tool that I'd like to talk about is simply *markets*. Markets don't make finance, but they make finance better. They provide liquidity, but in some sense they also provide democratic access to these ways of moving money through time with different degrees of risk. This access goes beyond simply a notion of fairness and level playing field, to the process of comparison shopping – the ability to look at different prices for the same kinds of things and the ability to sell them to the highest bidder. This process has a certain magic to it. The prices that emerge from this process actually begin to incorporate available information. They aggregate knowledge. They create a market consensus, a market expectation. And that expectation is really an interesting thing. It's an expectation about the future. If one is thinking about trying to affect future outcomes, it is really useful to understand what most people think about them, particularly when we're imagining environmental outcomes. If you had futures instruments that predicted emissions out 10, 15 or 20 years, for example, you could compare these predictions with the current state of scientific knowledge. So markets play an important role and potentially a really important role.

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Finally, these are the ways that you are going to enlist larger and larger groups of players. You need a market that is going to bring in lots of people, and you need a broad market if you are going to bring in all these different players.

BACK TO FINANCIAL HISTORY

Origins in Mesopotamia

It was difficult to figure out which examples from our book to talk about, but I picked three. The first example I want to talk about is really the origins of finance, which began basically in Mesopotamia, in cities. Before urbanization in Mesopotamia, there wasn't writing and it is unlikely there was any serious form of finance. But very shortly, with the emergence of large scale cities, there also emerged accounting technology, financial technology, and recording technology. It is no accident that they

occurred together. They solved two basic problems: reciprocity and competition for land.

The problem of large scale urbanization was the problem of how to keep account of people's obligations to each other in a world where people were anonymous. If there are a couple of people who are neighbors and who know each other well, they can keep a mental account of who owes how many days to whom for what kind of favor. Once there is a large community, that capability is no longer there. There is a need for systems to record who has fulfilled their obligations and who hasn't. Very quickly these early Mesopotamian cities, around 3000 BCE or so, developed tools for recording those obligations and making future promises for delivery of goods and services. This is the reciprocity part.

The other thing that developed were contracts and property rights about land, because when you live in the city there is, almost by definition, a huge demand for space. One cannot just move a little further away so as not to bump up against one's neighbor. Very quickly people started to parcel out tiny bits of land and charge high prices for them and have lawsuits that stretched on for generations about spaces the size of a movie screen.

Out of those problems, finance emerged to solve both of them. Loans were developed to take care of the issue of reciprocity, and things like mortgages and land property rights developed to take care of the problems of land ownership and competition for land. For almost every instrument we have today, if you look hard enough at the cuneiform tablets, you can find some example of it. Let's take a look at one of them.

Figure 1 Cuneiform tables



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Figure 1 is a tablet that I believe is in the Yale collection. Yale has one of the greatest collections of cuneiform tablets, at least among universities in the world. It was a gift of J.P. Morgan, who endowed the Yale Babylonian collection. I thought this was a useful one to show because, although it's not a delivery for carbon, it's a promise to deliver wooden objects – it's as close as I could get to what we would like to talk about. It's just a contract for future delivery, a futures contract, and it involves wooden objects and silver. It is a transaction that introduces the dimension of time. What might have been a friendly promise between two friends has now been formalized in a contract.

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Paper money and traveler's checks in China

Let me skip on to China. I picked an example from China that is pretty straightforward. One of China's great challenges was a fight with the barbarians to the West, and in the Song Dynasty, two amazing inventions took place. One was the invention of paper money which provided a way to move value very quickly and very cheaply through time and space and also a way to produce a lot more money in a hurry when you needed to pay. Figure 2 shows a piece of paper money, again from the Yale collection. This is from the Ming Dynasty. For those of you who read Chinese, it's a Great Ming universally circulating treasury note.

Figure 2 Chinese paper money from the Ming Dynasty



Figure 3 is the other invention: a traveler's check from the Song Dynasty, 1208 ACE. I think it's really interesting, first of all because it has this little symbol that looks like a flying horse suggesting that money moves quickly through time. Also, just like a traveler's check, it requires the year, month, and day to be filled in and then stamped by the user to verify the expense. So, it is not just Western finance that is contributing to this tradition of innovation, it is also Eastern finance.

Deposit banks, checks, and the first bond market in Venice

I'd like to provide one more example. This moves up into the European medieval period, but not too far distant in time, actually about the same time as that piece of paper money. Marco Polo

went to China and wrote an elaborate description of paper money – about how amazing it is that people peel off the bark of trees, mash it up, print this thing on it and then spend it like cash. When he came back to Venice, where he lived, he could do something equally amazing. Marco Polo could walk across the Rialto bridge from his house, go down to the Rialto market and deposit some money and write a check from that account to pay somebody else. The Venetians invented deposit banks and brought this whole idea of writing checks to the rest of Europe.

Figure 3 Traveler's check from the Song Dynasty



Figure 4 is a picture taken of a little statue looking at the church in the Rialto market. The statue is described as a figure showing the effect of not paying your debt obligations.

This was also the first bond market in the world. Venice's true innovation came when it was mired in a great war with Byzantium. At one point, it ran out of money, and then solved that problem by issuing debt. It forced all of its citizens to take on debt, and promised to pay them back, and to pay them an interest rate until such time. It raised a fleet, the fleet sailed off, the fleet had a disaster, came back, the doge was killed because of this disaster and they couldn't pay the money back. Instead, they had to keep limping along paying interest. That idea of limping along and paying interest and not paying the principal back – that became the first municipal bond. That was the first bond ever invented, and from that point on, debt finance took off – like a crazy financial innovation – all across Europe.

Figure 4 Statue showing the effect of not paying your debt obligations

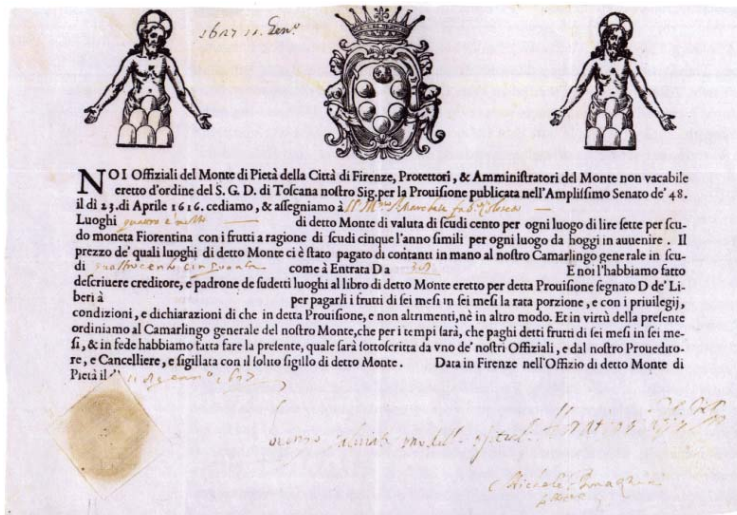


Figure 5 is a Florentine bond from 1627 where these things became traded instruments. This one pays 4.5% interest. The real lesson for me is that this was an innovation born from extreme adversity and the amazing thing is that these forced loans, instead of being a pain, became something that people really wanted. Europeans decided that it was a great tool for passing money from the present into the future. So bonds created a broad investor class all across Europe. Bond markets over the next several hundred years emerged in Europe like they emerged no place else.

I am now going to turn this over to my colleague Professor Geert Rouwenhorst because I'd actually like to hear him tell the story of this bond.

The real lesson for me is that this was an innovation born from extreme adversity and the amazing thing is that these forced loans, instead of being a pain, became something that people really wanted. Europeans decided that it was a great tool for passing money from the present into the future. So it created a broad investor class all across Europe.

Figure 5 Florentine bond

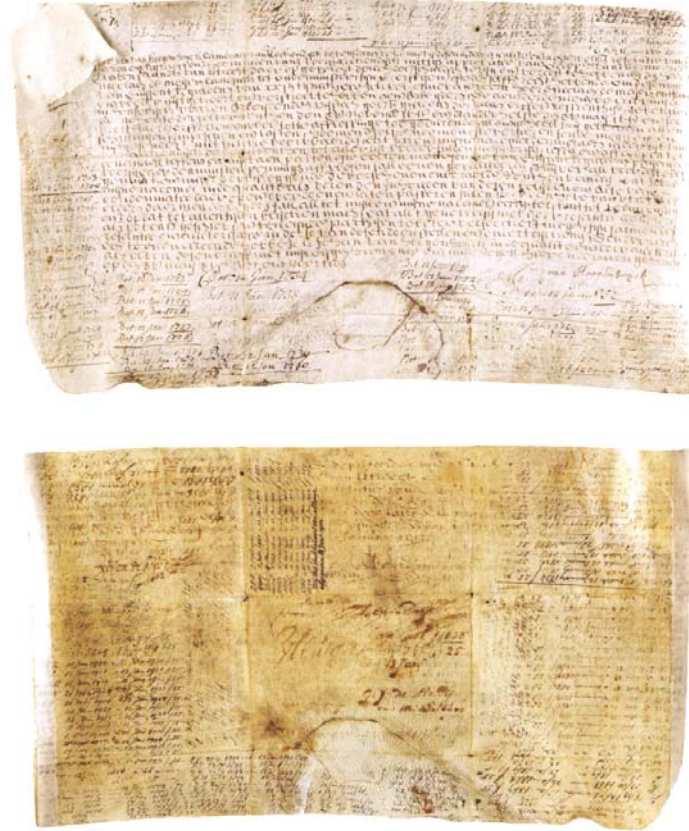


K. Geert Rouwenhorst

17th and 18th Century Holland: A remarkable time for finance

Thank you. Figure 6 is a remarkable security from the Yale collection – a perpetual bond. It is one of the oldest bonds in the world that has continued to pay interest until today. In fact I personally collected the interest on behalf of Yale in 2003, and will describe some of the details of the security. It was issued in The Netherlands in 1648 by what is called a water board. As you all know, Holland is a country with many waterways and dykes, and the maintenance of these systems has resulted in an unusual form of government organization, because floodplains of rivers don't necessarily coincide with state boundaries. More than 800 years ago, separate administrative organizations were set up to oversee the dykes. Those who were protected by a dyke had to contribute to its upkeep. People were taxed based on their proximity to the dyke and could be drafted to conduct repairs by participating in what was called the dyke army. The cost of these repairs was covered by the taxes levied by the water boards. In the event of a sequence of breaches, a water board might not have sufficient tax receipts, in which case it was allowed to issue bonds. The security in Figure 6 is an example of such bonds that were issued.

Figure 6 Dutch “water board” from 1648



Those who were protected by a dyke had to contribute to its upkeep. People were taxed based on their proximity to the dyke and could be drafted to conduct repairs by participating in what was called the dyke army. The cost of these repairs was covered by the taxes levied by the water boards.

Because water boards did not go to war and had the power of taxation, they were long-lived organizations. Combine this with the custom at that time to issue perpetual bonds, and you have the explanation for why these securities are among the oldest in existence. The face value of the bond in Figure 6 is for 1,000 guilders, and you can see that the interest payments were recorded on the document. When I mention that the bond did not default, I was actually not quite precise – at some point the water board cut the interest rate on the bond in half from 5 to 2.5 per cent per annum. It has continued to pay interest for over 350 years, and it currently resides in the Beinecke Rare Book & Manuscript Library at Yale.

There is an interesting story about storing the bond in the Beinecke Library because libraries typically only accept “dead” manuscripts and this bond was clearly a live security. So what to do? You can see this caused great consternation in the university. It was eventually decided that the library would store the original vellum document, but not the allonge, which is the piece of paper that was added to the bond to record additional interest payments after space on the vellum document had run out. So the dead portion would go to Beinecke and the live portion would be held at the International Center of Finance at the Yale School of Management. That was the compromise.

The 17th and 18th centuries in The Netherlands were a remarkable time for finance. Many of the financial products or instruments that we see today emerged during a relatively short period. In particular, merchants and bankers developed what we would today call securitization. Mutual funds and various other forms of structured finance that still exist today emerged in the 17th and 18th centuries in Holland. I’d like to take you through some of these examples. Some have survived until today, but others have not, as we will see. Financial innovation is about trial and error and not every innovation that initially takes off turns out to be a good idea.

The 17th and 18th centuries in The Netherlands were a remarkable time for finance. Many of the financial products or instruments that we see today emerged during a relatively short period. In particular, merchants and bankers developed what we would today call securitization. Mutual funds and various other forms of structured finance that still exist today emerged in the 17th and 18th centuries in Holland.

The 17th century in Holland was unusual because it marks the origins of financial markets in the sense that stocks and bonds were traded at a central, physical location. Two examples from that early period are a share in the Dutch East India Company and a bond which is held in the Beinecke library. Only three of the shares have survived and, unfortunately, Yale doesn’t own one.

Interestingly, though, the manner in which share ownership was transferred gave rise to the financial innovation of a forward market in shares. Formally shares would change hands only after the transfer was recorded in the registers held by the company. The company only opened its books once a month, but people wanted to trade every day. As a consequence investors would agree to buy or sell shares with the final delivery at a future time when the company would open its books. So as a natural by-product of stock trading, a forward market and options market emerged very quickly to facilitate trading. The technique of forward settlement was not new, as this had been used for centuries in agricultural commodities markets. The application, however, was new.

I mentioned that in the 18th century bankers learned how to securitize and pool risks. Let me show you one form of securitization that eventually led to the development of a mutual fund industry in the Netherlands. One of the predecessors of mutual funds are *tontines*. If you “google” the word tontine, you’ll see a long list of references to crime novels. To understand what a *tontine* is, I should first tell you how governments in the 18th century would borrow. Governments would mostly borrow in the form of annuities: investors would lend the government say \$100 and in return the government would pay investors an interest rate for the remainder of the life of the nominee; the principal was never returned.

A tontine is an annuity to a group. Each member of a group would invest one hundred dollars, and the interest on the entire capital would to be divided among the surviving members of the group. As members would eventually die from a group, the payout to the remaining people would go up. So now you understand why this becomes a topic for crime novels – as the number of participants in a tontine dwindles and they learn about each other’s whereabouts, it wouldn’t exactly provide the right incentive from a social point of view. This is one of the reasons why tontines were ultimately outlawed.

An interesting development occurred when individuals organized private tontines. These tontines resembled a form of a private pension fund. Investors would pool their money and collectively buy a number of shares of stock, never touch their invested capital, but divide the dividends from the portfolio amongst the surviving members of the group. As the group became small, there would be a liquidation rule to split up the fund and divide the shares to avoid the issues mentioned before.

Figure 7 18th century tontine

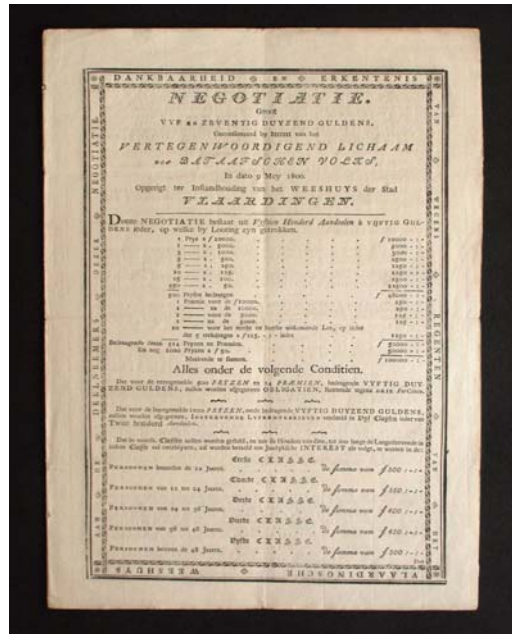


Figure 7 is an example of a tontine that was issued by an orphanage. It is unusual because the tontine was embedded in a giant lottery. In the 18th century Netherlands, many securities embedded lotteries. It was recognized that investors were attracted by long shot lotteries. This security starts out like a bond and, after all the securities were sold to the investors, a lottery would be held where some investors would be cashed out by receiving large prizes while most would get smaller prizes. If you were one of the remaining investors when only small prizes were left then, instead of getting a cash prize, you would receive participations in the tontine. According to

your age, you would be put into a group that would start receiving interest until all members of that cohort had died. Investors and nominees could be different persons. For example, I could participate in this tontine, but make Professor Will Goetzmann the nominee. Payments would then be based on his life and I would collect my dividend as long as Will survived. There would have been an annual coupon (bonds had actual coupons – this is where the word coupon-clipping comes from) that one would need hand over in lieu of the interest payment. However, as this was a tontine, I would only get my interest if Will was still alive. The back of these coupons had to be signed either by a Notary Public or someone from the Ministry, who would confirm “I, the undersigned, declare that I know so-and so and know him or her to be alive.” It had to be signed and this was the official auditing procedure for this tontine.

Financial innovation is about trial and error and not every innovation that initially takes off turns out to be a good idea.

A true securitization that happened during the 18th century is related to the dark side of European capitalism, closely tied to the slave trade. The slave trade is closely tied to the development of what we call “mortgage-backed securities” today. Dutch merchant bankers in the 18th century were truly merchants and bankers at the same time. Situated in Amsterdam they would send ships to Africa, where slaves would be picked up to be brought to the West Indies to work on plantations. The plantation owners would then ship their goods back to Western Europe. The way these merchant bankers tied up these plantation owners was to lend them money in the form of mortgages, and in return, plantation owners would be required to send their goods to Amsterdam to be sold by the merchant banker. Rather than put up his own money to finance these mortgages, the merchant banker would actually issue securities in the capital market to raise the money to make these mortgages and then use the proceeds from the sale of the goods to pay off the bondholders. This was a true securitization because the underlying asset was the mortgages that became the backing for bonds which were freely tradable in the Amsterdam market.

The reason we know about the details of these arrangements is because, when you bought a bond or a stock at that time, your bond certificate was a numbered version of a prospectus that described in great detail how the security worked – how people got paid and what their rights were. For example, we can read that property owners in those days were able to mortgage not just their house or land, but also their slaves and animals. It was a very different time than today.

Figure 8 is one of these mortgage-backed securities that I described to you; this one being from 1768.

Figure 8 Mortgage-backed security from 1768

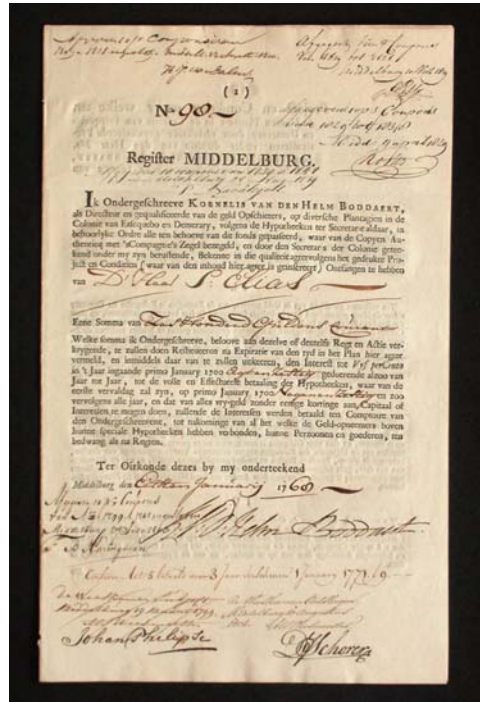


Figure 9 Share in a mutual fund from ~ 1774

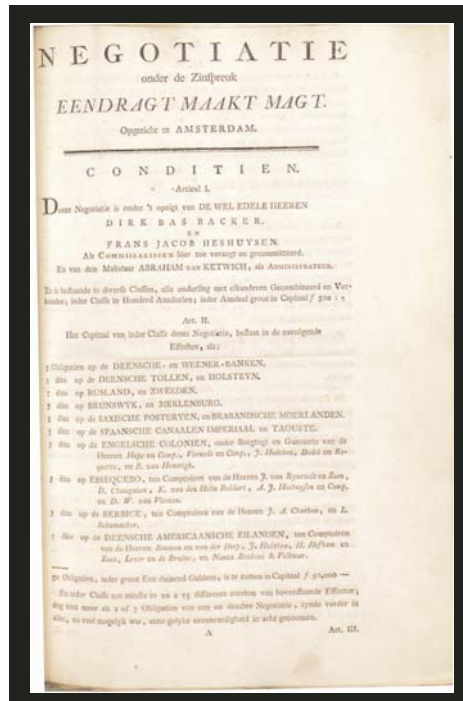


Figure 9 is a share in the first mutual fund that was developed in Holland in 1774, I believe. After financiers figured out that one could repackage mortgages and turn them into securities, it was a small step to just buy securities and repackage them into other securities. That was essentially how closed-end mutual funds worked. This is a copy of a share certificate in a fund named “Unity Creates Strength,” which was the maxim of the Dutch Republic at that time. Looking at the first page of the certificate, you can see what that mutual fund invested in – a sequence of international bonds issued by various European countries, as well as the plantation loans I described earlier. These mortgage-backed securities were also part of the portfolio of this mutual fund.

There are many interesting things about this mutual fund. It was basically designed to exist for about 25 years, and it also had an imbedded lottery to make it attractive to small investors. In modern times, securities and lottery tickets are sold in completely separate markets. In the 18th century, people thought of securities and lotteries in very similar ways; if you look at 18th century investment portfolios, you can see lottery tickets held side-by-side with securities. Financial engineers of the 18th century understood that investors like risks that have small chances of very large payouts. The way this was implemented in the mutual fund was by investing the capital in bonds that earned 5 percent interest per year, and only promising a dividend of 4 percent to shareholders. The difference of

1 percent was held behind to build up a capital reserve inside of the fund. At the end of every year, the fund managers would hold a lottery and one shareholder would win the pot and receive his initial investment back plus the prize. This would all be done in a way that would keep the fund portfolio intact. In the subsequent years, this would leave the same investment income to be divided among fewer shareholders: this meant the fund manager could hold a larger lottery. So there was an escalating lottery embedded in the mutual fund.

This leads to the question: *why was this mutual fund set up this way?* Surprisingly, the whole notion of diversification was well understood at that time. For example, in the prospectus of a similar fund of 1776, we find written that it is prudent to spread your money, as much as possible, over good and solid securities. Since everything is uncertain and subject to fluctuation, you should not put all your money into a single security. The prospectus further pointed out that for small investors, it was difficult to buy a variety of bonds (one had to be wealthy to be able to buy enough bonds at a face value of 1000 guilders to be diversified). Here is where the attraction of the fund came in, because for 525 guilders you could participate in this fund and achieve diversification with a relatively small amount of capital.

The prospectus mentioned that if you were a pessimist and thought that all securities in the fund could cease to pay off at the same time, then you should never have invested your money. 18th century investors seem to have understood the notion of uncorrelated risks as well.

The Dutch set up a large number of mutual funds at the end of the 18th century. I want to briefly talk about one more that would invest in stocks that, based on a sufficient decline in price, merited speculation. This is the earliest reference to what we today would call “value investing” – trying to buy securities at a discount relative to their “intrinsic values.” Another interesting aspect of this fund is that investors seemed to understand the perils of delegated money management. Since the fund is going to buy securities on another’s behalf, what guarantees can be given that the money manager is not going to run off with the money? The share certificate stated that all the stock certificates of the fund would be placed in iron chests with three different working keys, one of which belonged to the notary public and the others in the possession of the directors of the fund. Financiers understood well that if you want to take investor’s money and manage it, you should prevent stealing.

Revolutionary bonds from the United States

Let’s take a sidestep to what happened at that point in time in the United States. The United States was at war with England, trying to win independence. Benjamin Franklin was sent to Europe to negotiate loans on behalf of the United States in order to finance the American Revolution.

Figure 10 shows the signature of Benjamin Franklin on one of those loans that he negotiated in France. It is an interesting security that unfortunately is not in Yale’s possession. I am only showing half of the loan document. The entire loan agreement consists of two identical “twin” copies with a marbled middle between them. The two bonds would be cut apart, one being given to the borrower and the other to the

lender. The bonds would be unique because of the marbling boarder, which would prevent counterfeit of the contract. Benjamin Franklin actually developed this technology and printed these bonds himself – he was a remarkable man.

Figure 10 Franklin bond



At the time of Franklin's loans, inflation ran high in the United States, partially because of the war. States were printing paper money with which you could supposedly later pay your taxes, but there was too much of it printed and it was issued by a variety of states and by the colonial Congress. The public became very reluctant to accept paper in lieu of transactions, and over time it became increasingly more difficult to pay interest with other forms of paper. The U.S. government decided to make interest payments through hard currency raised by the loans of Benjamin Franklin in Paris. The only problem was that the hard currency was in Paris where the loans were negotiated. So what happened?

When you got your interest payment, you got something which is called a *bill of exchange*. The bill of exchange in Figure 11 indicates that at 30 days sight of this bill, 1st, 2nd, and 4th not paid (I'll explain this in a minute), one would be paid \$24 or the equivalent in Livres Tournois for interest borrowed by the United States payable in Paris. But if you were not a frequent visitor to Paris, how would you ever collect your interest? From here, active securities markets came into play. People started to trade these bills of exchange with merchants who traveled to Paris.

Figure 11 Bill of exchange from 1779



One had to show this bill of exchange in Paris in order to collect the interest payment and there was risk – risk of piracy, risk that your ship would sink, etc. – which explains why these bills were issued with four copies. If the first bill was lost, one could cut off the second copy and send it to Paris. The first copy to make it to Paris would be paid, invalidating the others. That's why this document states "This is the 3rd bill of four, the 1st, 2nd, and 4th not paid." It's an interesting security from the United States.

Figure 12 Massachusetts Bay bond 1780



It was also during the revolutionary war that the first commodities bonds were created in the U.S., and very much like today, inflation was the motive. The bond in Figure 12 was issued by the State of Massachusetts Bay to pay a soldier – it was a deferred payment to a soldier. Apparently people thought about various ways to try to protect the value of these payments against inflation. One of the ways was to make them payable in hard currency in Paris, but another way was to explicitly link them to prices. This is a commodities bond where the final repayment is linked to a price index, or commodities acting as a price index – consisting of corn, beef, sheep’s wool, and sole leather – to determine the repayment. This is the oldest commodities bond of which we know.

Russian debt and liquidity

Let me step a bit forward. The same bankers who figured out how to repackage securities in the form of mutual funds also helped to securitize the debt of Russia. The way the Russian government borrowed at that time was through inscriptions in the *Book of Public Debt of Russia*. Basically, the government acted like a savings bank. The lender showed up, was inscribed in the register of lenders, lent the money, and then returned to St. Petersburg every year to collect interest. The lender would be issued a certificate that would be stamped every time the interest was collected. It was not very practical for international investors to lend to the Russian government in this manner.

Investment bankers in Amsterdam helped out and bought these loan certificates in their own name, placed them in a safe and then issued bonds that were backed by the original certificates. These bonds were structured as “bearer certificates,” meaning they were freely traded in the Dutch capital market and were not linked to the identity of holder. Any person who presented the coupon (the bearer of the coupon) would be paid the interest. Again, this is an example of creating a liquid market out of something that was inherently illiquid.

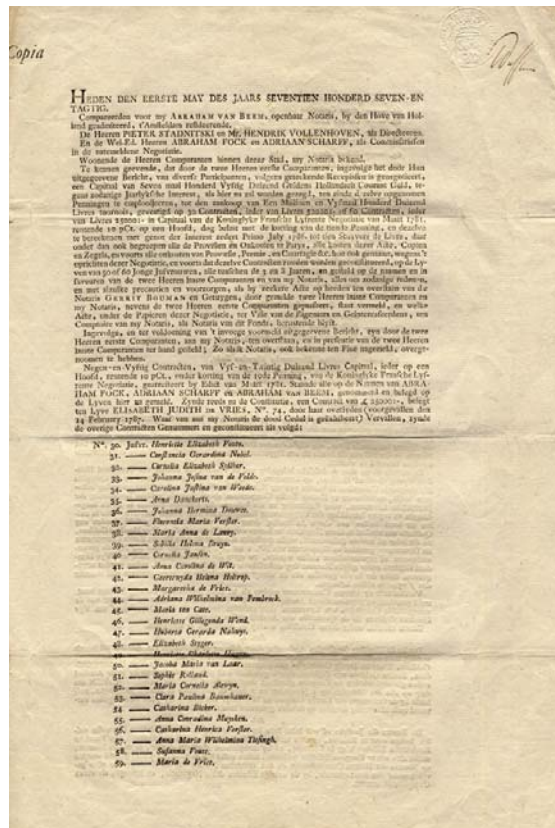
This was initially a technology that was applied to Russian debt, but subsequently in the 19th century became very popular for cross-listing U.S. railroad stocks in Europe. Like the early Russian debt, U.S. stocks were not traded in bearer form but

were transformed into bearer securities by Amsterdam bankers using the same mechanism that we would today call a depository receipt.

French annuities and Swiss investment bankers

When the French government started to issue annuities in the 18th century, statistics were not so well developed. Calculating life expectancies was complicated and certainly there was no good data to figure out what people’s life expectancies were. As a result, there was confusion about the terms that should be offered on these annuities. The French government, for a long time, issued annuities on the same terms to the young as to the old. If your life expectancy is shorter, I should give you a much higher interest rate than to the young. But the government did not initially distinguish. It will come as no surprise that old men would show up at city hall to buy annuities on the lives of their grandchildren. However, there was still a chance that a child would die young, and what seemed to be a great investment initially, would potentially not pay off.

Figure 13 Dutch share of a Swiss annuity



Enter the Swiss investment bankers, who would buy annuities in the names of young girls, pool them in a fund, and then sell shares in the fund to the public. The risk of any girl dying young would be diversified away and one could lock in the mispricing by the French government.

Figure 13 is a share of a Dutch version of one of these funds – you can see the names of all of the Dutch girls under which these annuities were bought. If you examine the names, you will discover that many of them belong to the same families or to the same social register of Amsterdam at that time. This was a way to diversify against the risk of early death. One might ask “Why young girls?” To begin, all these girls had survived small pox, which was a major threat in early life to life expectancy. My

further interpretation is that choosing girls instead of boys was a tradeoff of the risk of childbirth to the risk of going to war.

Let me wrap up by showing you one more recent example and then I'll ask Will to conclude.

German war bonds

Figure 14 is a much more recent example of an interesting contingent claim. It is a bond issued by Germany in 1930, at the time between World War I and World War II. If you remember, when Germany came out of WWI, it was charged to make reparation payments to other European countries, which ultimately led to an unraveling of finances in Germany and to hyper-inflation in 1923. To put Germany back on the gold standard, a commission was formed led by two Americans, Dawes and Young, that put Germany on the gold standard and gave it access to international capital markets again. Figure 14 is one of the bonds that Germany issued in the United States. Germany ultimately defaulted on these bonds during WWII.

Figure 14 German war bond



After WWII, when West-Germany wanted to go back to capital markets and wanted to borrow, investors held up the old bonds and demanded repayment on the old bonds. West-Germany claimed that the old bonds were actually obligations of Germany which did not exist anymore as such. This became a political issue which ultimately came to a resolution in 1953 at a conference in London where West-Germany agreed to honor these pre-war debts in the case that East and West Germany were ever reunified. One thought that was a distant promise. But West-Germany issued rights certificates that could be exchanged for bonds to compensate previous bondholders for past losses in the event of reunification – a claim that was contingent

on a political event. These certificates were issued in 1960 and infrequently traded on the French stock exchange for about 30 years to end up in the money in the 1990s. Issuing a security with payments tied to the realization of political events was a creative innovation.

THE BIG PICTURE

William Goetzmann

It is a challenge to wrap up all of that. Those are really interesting stories, and the take away is that incredible ingenuity went into the development of financial technology. How each one of these innovations led to insights that led to another innovation, and the accretion of this technology is the really fascinating lesson.

The big picture that we want to draw from this is that finance began in urban societies solving certain basic problems. These financial tools were not an add-on, they were integral to the development of urban life. All throughout our examples, you saw that war created challenges and problems, and that in turn led to innovative financial solutions, which, of course, is kind of sad. But in the wake of these crises, we've been given tools that we hope we can use for other things as well.

The biggest innovation in my mind is the creation of a whole class of people who learned that you could finance the future, invest in the future, create your own economic future through the use of these financial instruments – the annuities, perpetuities, loans, stock shares, and so on. These became the instruments by which we've been able to shape our own financial lives. It peels us away from having to depend upon family and government, giving us real independence.

That, I think, is enough to convince people that, when we face a huge problem like the environment, maybe these financial tools can be adapted, borrowed from other examples, and made to fit some of the interesting risks and long-term expected costs that the environmental crisis challenges us with.

K. Geert Rouwenhorst: With that we're happy to take any questions.

William Goetzmann: Yes, thank you very much.

Question and Answer Session

QUESTION 1: Carbon markets

Outside of the context of war, in terms of the environment, we're looking towards finance to help avert a potential crisis. Your examples show how problems beget solutions and I wonder, in your perspective, what technologies you are looking at in addition to the carbon markets.

William Goetzmann: Well, I am just recently interested in the carbon market itself and the different models that people are trying – the caps, sale of permits, and so forth. I think there is extraordinary potential and what we are going to see is that a few different models are going to be tried until one of them works. One thing that really worries me a bit is the possibility of a market emerging and then collapsing and disappearing. I am hopeful that some gentle experimentation without complete commitment to one particular model will allow us to learn. So I think that it's going to take some time and it's going to take a lot of pushing by different groups to create an environment where we could experiment for a while and then hopefully something will work. I think that a market alone is something that's worth exploring seriously.

K. Geert Rouwenhorst: I've seen people who are interested in commodities markets being interested in trading futures on the emissions rights in Europe. I see that it's on the radar of the larger investment banks. The market is small at this point, and needs to build investor interest into that market. Setting up futures markets is a complicated issue – we see many futures fail before we see one survive. I agree with Will that doing a little experimentation and seeing where we can create things that have a natural demand on the long and short side is important in order to create a market and facilitate trading, allowing price discovery and efficient allocation of these pollution rights.

William Goetzmann: Briefly to follow-up on that, I think the idea of creating mutual funds where people have interests in buying rights and even letting them expire is an interesting one.

I agree that doing a little experimentation and seeing where we can create things that have a natural demand on the long and short side is important in order to create a market and facilitate trading, allowing price discovery and efficient allocation of these pollution rights.

QUESTION 2: Internalizing externalities

I often hear the argument that the market will solve the problem – just let the market work, don't interfere at all – or, similarly, that technology will solve the problem. My limited understanding of economics is that when there are externalities such as CO₂, the

market doesn't solve the problem unless there's a price on that externality. Maybe you can share your point of view on that argument and whether you believe the market will solve the problem once it can interpret this externality through a price signal but not until then.

K. Geert Rouwenhorst: I think that's right, in that when producers produce goods, the price does not include the potential harm that is done to the environment. Internalizing that externality is important because when you think about how you are going to distribute these rights to pollute, you have to do it in a way that makes firms internalize these costs. So, for example, just issuing emissions rights to firms seems not to be such a logical solution as they will receive the rights for free. It is really the firms that should be bearing those costs. It seems that schemes where these rights will be auctioned off, where firms have to directly pay for these rights, is a much better mechanism. But even in designing these mechanisms, we have to think about doing it in a way so there will be efficient market allocation of these rights to pollute. I think the market can potentially solve those problems.

William Goetzmann: I have just a one word answer, which is "Russia." If you think of the privatization that Russia went through, the argument was "Hey, let's privatize the market, we'll solve things." What was discovered was that if you create a half-baked market without thinking through property rights and creating an institutional fabric for this to take place, then, the forces of the market not working could lead you grossly astray.

QUESTION 3: Durability of environmental markets

I wanted to ask a question about environmental markets in general. The rise of such markets, such as the carbon markets or the SOx and NOx markets, strikes me as some of the first markets created almost entirely by government fiat. We're saying these need to be traded, and this trading mechanism sort of arises around that which wouldn't otherwise exist. So, for example, with the acid rain pollutants, the market was created by the Clean Air Act. A multinational protocol like the Kyoto Protocol would have to arise to put some sort of price on carbon. Is this kind of market durable in the long-term in your opinion, and wouldn't the rise of large-scale players inevitably shape the policy decisions that would ultimately affect the prices of the commodities being traded?

K. Geert Rouwenhorst: I agree, as I said earlier, that you can create the markets, but markets don't necessarily make people trade. In order for there to be trade, for a mechanism to survive, I think both parties, on the demand side and supply side, must have an incentive to trade. Having caps in place, enforcing those caps, and monitoring the pollution I think would provide an incentive to trade these rights.

Specifically what I'm asking is whether these markets are durable given that the value of these commodities is being created solely by a regulatory structure – they don't have any intrinsic value, such as a bushel of corn.

William Goetzmann: Yes, I understand that argument, but let me give you a counter-example: tax obligations. They are purely created by government and yet they're a fundamental part of economic life. The only way they would go away is by the government saying that you don't have to pay taxes. One of the things that worries

me about this particular case, and I think it's related to what you're proposing, is the pre-commitment by the government to maintain a cap, when, for example, stresses and strains might cause the government to raise the cap and eliminate value. That's where it might lack some bite. If it always depends on government commitment, then it's hard to maintain.

One of the things that worries me about this particular case is the pre-commitment by the government to maintain a cap, when, for example, stresses and strains might cause the government to raise the cap and eliminate value. That's where it might lack some bite. If it always depends on government commitment, then it's hard to maintain.

QUESTION 4: 18th century French annuities

A quick comment on the previous question: there is a market somewhat like that – the market for the radio waves and satellites which are actually now primarily privatized. But I had a question of my own: If I were that Swiss banker and I were picking the young children to put the annuities on (I wonder if you know the history of these people), I would have picked little boys that were going to the seminary (very unlikely to go to war) or little girls who were already in the nunneries (very unlikely to bear children). Do we have any notion of who was picked? Were they clever enough to pick those kinds of people?

K. Geert Rouwenhorst: On the Dutch security I did look at the names and, at some point, try to do some amateur genealogy on them. It does seem that the names of these girls are actually connected to some of the wealthy families of Amsterdam at the time. Of course, on the other hand, one didn't want the children to grow up and run off, making it difficult to monitor whether they're alive or not. One would have wanted to keep an eye on them in a way, and one of the ways to do that is to put in the names of your own kids or the kids of your friends.

William Goetzmann: One really shocking thing is that this was the primary means by which France financed itself through the late 1600s and early 1700s. So every time they sold a bond it was mispriced. You would think that in the long-term they were just digging themselves deeper and deeper into a financial pit. You might think that this was one of the factors that contributed to the French Revolution – the financial crisis due just to mispricing this security.

K. Geert Rouwenhorst: At the time, the French government tried to hire statistics professors as consultants to try to help solve this problem of life expectancy. DeMoivre, for example, was one of the consultants to the French government, though I think it was just a little too late.

QUESTION 5: Reducing the risk of climate change through diversification

A lot of the time when you talk about diversification within a big portfolio of assets, you're talking about idiosyncratic risk that you can diversify out. But the problem with

climate change risk is that it is often very systemic, affecting lots of different parts of your portfolio and it's very hard to diversify away. From the perspective of a large pension fund or large institutional investor, how should they approach this big risk they are facing?

K. Geert Rouwenhorst: Part of it could indeed be systematic risk. I am not an expert on climate change, but from the talks I've attended my understanding is that there are going to be winners and losers when the climate changes. I think it was a few years ago that I attended the lunch seminar here at the Yale School of Management and someone said that the Northeast of the U.S. is going to be relatively well-off in this situation. So I think that means that part of the risk is going to be diversifiable. The rest I think will indeed be part of a global risk factor that we can't dodge.

William Goetzmann: The basic intuition of diversification is that yes, as you start to diversify, you keep reducing risk down. But at a certain point you hit a floor. You hit that systematic floor where, if the climate is going this way, there's no way to make that problem go away. At that point you say either it's fairly priced and I'm willing to hold that, or you cut up that part of the risk and sell it to the people who are willing to pay the right price for it. Diversification does not solve the fundamental problem.

QUESTION 6: Regulating a global carbon market

Within the context of a global carbon market, who do you anticipate would run it and make sure that it was free of corruption and working well? Who would create and enforce the rules? How do you think you could find a group of people to do that with the necessary clout on a global issue like this?

William Goetzmann: Look at the situation of the world stock market. We don't have one big world stock market where somebody is in charge and we trust them. We have a lot of stock markets that are regulated in different ways and we have different levels of quality of regulation, different levels of verification, different auditing standards, and what have you. That is actually a pretty robust structure. I think that we're probably going to end up borrowing that model. If this is going to work, it is probably not going to rely on a universal regulator, although coordination at some level like the Kyoto accord level can create standards that are enforceable. That may be the level of international coordination that is required.

QUESTION 7: Government investment to mitigate public risk of climate change

A lot of talk about carbon finance focuses on the private risk associated with carbon – so it's corporate risk associated with regulatory risks, reputational risks, legal risks, label and branding risks, etc. – yet a lot of the risk of climate change is a public risk. Who is going to take care of people who lose their homes? Obviously there are currently insurance tools for that, but it is not that difficult to imagine a future situation where such tools are inadequate or increasingly inaccessible. Putting aside a potential conflict of interest between making the rules as a regulator and investing in the market, should governments be investors in the carbon market at all in terms of using it to mitigate the public risk of climate change?

William Goetzmann: Here's a thought experiment: say that this proposed Northeast States memorandum of understanding were to happen, and all of a sudden it created securities that could be purchased. Let's say a state came in and just purchased them all. I'm not sure this is feasible, but it's a thought experiment. Should the government be allowed to speculate in these things? Maybe not the government that is regulating them or creating them, but this type of situation creates really interesting problems. I don't see an immediate answer, but it's an interesting problem where you have government competition. I think that could create a train wreck.

K. Geert Rouwenhorst: It seems especially difficult to me how to set these quotas across countries in ways that seems to be, I wouldn't say fair and equitable, but acceptable to all parties involved. The most important role that I could see a government play is choosing the right amount of pollution rights that should be traded. That problem by itself seems incredibly complex to me and so making good decisions on that end seems to be of first-order importance.