Using Financial Options to Hedge Transportation Capacity in a Deregulated Rail Industry

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The market for capacity in the rail industry, like many other industries classified as "natural monopolies" in earlier regulatory regimes, appears poised for change. This paper presents one predictive description of what a fully deregulated rail capacity market may look like and how it will function. Of particular interest is the potential for financial instruments, such as derivatives on rail freight capacity, to play a role in logistics decisions. We examine how hedgers may find this evolving market both useful and profitable. Markets for rail capacity and markets for infrastructure capacity in other competitive network-based industries share important similarities; hence, the framework developed in the context of the rail industry will be readily applicable elsewhere, such as in markets for electric transmission capacity.

1. Introduction

The North American rail industry is in the midst of a major restructuring. Mergers and shipper complaints about the exercise of market power by railways in many lucrative shipping markets have produced strong calls for improving competition in the rail industry (Larson and Spraggins, 2000). Conversely, railways maintain that they operate in a competitive, multi-modal transportation environment (Gallamore, 1999). But it is clear that the rail industry in North America today has become extremely concentrated. When the U.S. rail market was first liberalized in 1980, there were 39 large (Class I) carriers in operation (Kwoka and White, 1998). As of this writing, there are now just four Class I carriers; in effect, the U.S. rail shipping market has been partitioned into roughly four quadrants, with little inter-rail contact between major carriers in vast portions of the country. Since the Canadian rail industry was liberalized in 1987, it has followed a similar path to the American industry (Bonsor, 1995). Especially since regulations were modified in 1996, the two Canadian Class I carriers have streamlined their network operations and consolidated their respective operational areas.

In our view, the recently lifted moratorium on rail mergers in the US[1], combined with a recently completed government policy review in Canada recommending increased infrastructure access in the rail industry indicates that the entry protected rail industry will be forced to adapt to increased inter-rail competition at some point in the future. This paper gazes into a crystal ball and maps out some intriguing aspects in the evolution of rail provision in North America. In particular, we will describe the formation of new markets to manage freight transportation risk, with emphasis on the demand for, creation of and use of derivative securities for which the underlying asset is freight capacity.

The remainder of this paper is organized as follows. The next section describes in detail the rail industry in North America, drawing distinctions between the existing market structures in Canada and the US where relevant. One interesting feature of the current market situation in Canada and the US is the existence of car capacity auction contracts that resemble the sort of derivative on rail capacity that we envision existing on a more widespread and standardized basis as the future unfolds. The rail market of today is outlined in the third section. We sketch the features of the market setting that we expect will evolve following deregulation, noting both the characteristics of the existing market that will be retained and those that will be entirely new.

The fourth section of the paper describes the market for derivative securities within a new rail industry. We draw links between this type of market and the path followed by other network industries for which markets have altered substantially in recent years. Next, we describe the risks faced by players in this market. This leads to the conclusion that under certain reasonable conditions, there will be sufficient demand for such instruments. We postulate that buyers and writers of these contracts will exist, and that there will be sufficient liquidity in this market. This section also provides a description of possible losses for both providers and users of rail capacity if the market fails. The cost of these failures indicates that there is a potential market for hedging instruments that mitigate or eliminate

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[1] The STB has recommended much stricter criteria for its approval of mergers, the need for which has been publicly acknowledged by the railways themselves.

the risk of such losses from the viewpoint of individual players in this market. The fifth section describes the derivatives written on rail capacity and outlines pricing arguments for such derivatives. We find the underlying asset can be sufficiently well-defined and that it is feasible to employ usual arbitrage pricing arguments. Next, we use actual U.S. rail rate data to construct hypothetical call options for commodity movements from 1997-1999. The existing regulatory structure of the industry means that the options are not particularly valuable, but the exercise illustrates the feasibility of computing such options. The sixth section concludes this paper, summarizing our findings and providing directions for the application of our findings to other network industries.

2. Historical Rail Transportation Markets

After almost 70 years of government oversight, the U.S. rail industry was partially de-regulated with the passage of the *Staggers Act* in 1980. While the original reason for regulating the rail industry was to protect shippers from the potential of railways (the so-called "robber barons") to abuse market power, it was recognized through the 1970s that economic regulation was hampering the ability of railways to compete with the growing trucking industry. In addition, the bankruptcy of several major U.S. railways (notably Penn Central in 1977) led regulators to concede that regulation was ruining the industry (Gallamore, 1999).

Since *Staggers*, U.S. railways have thrived and continue to serve an important role in the North American economy. For instance, as of 1999, U.S. railroads carried more than forty percent of the nation's intercity freight, over sixty percent of the nation's coal (generating thirty-six percent of U.S. electricity) and over forty percent of the nation's grain. In addition from 1981 to 1998, railroads invested over $75 billion in capital expenditures (AAR, 2000).

Railway economics have evolved since the lifting of rate regulations. Railways have always known that they could minimize operating costs by moving larger and larger trains between high density origins and destinations. Through the era of rate deregulation, U.S. railways have sought various methods to improve productivity and profitability in this manner. The clearest example of this is the abandonment of thousands of miles of low-density rail lines throughout the United States. And given the large economies of scale and scope that exist in rail, efforts at cost reduction through mergers between mid-sized to large rail firms have also been commonplace. While mergers have had a notable impact on the organization of the industry, efficiency problems with recent mergers (notably between the Union Pacific and Southern Pacific Railways) are indicative that this method of cost reduction has likely run its course. While minimizing logistics costs are obviously an important factor behind these cost-reducing policies, less attention has been given to developing specific business strategies and incentives to streamline the interaction between railway and shipper.

Historically, rail cars (including boxcars, flat cars and hopper cars) were allocated on a first-come, first served basis. This method, while seemingly equitable and therefore favored by many shippers, does not allow either the railway or the shipper to forecast accurately logistics and capital usage. Until recently, railways were not perceived to be capable of useful reliability in delivery when compared to other modes such as trucking. This can be at least partially attributed to the bulk, homogenous nature of the goods (such as grain and coal) that are still the mainstay of railway business.

Intermodal competition has had a strong impact on the development of the rail industry. The deregulation of interstate trucking in 1980 brought trucks into many transportation markets that were traditionally thought to be the domain of rail. Recent empirical work has shown that trucking deregulation decreased costs in the trucking industry (McMullen and Lee, 1993). This decline in trucking costs has increased the modal switch point (the point at which the least transportation cost mode shifts from trucking to rail) in recent years. This distance has been variously estimated be somewhere in the range of 800 to 1100 kilometres (Wood and Johnson, 1996), and is enough to ensure that trucking handles a substantial proportion of intercity, interstate and inter-provincial traffic. Increasingly, these movements represent a valuable part of the transportation market that railways do not want to lose. Combine these shifts with increasing inventory costs and the dawn of just-in-time delivery systems for many industries, and it is no surprise that process changes in rail markets are underway in the North America.

From this just-in-time business environment have come railway and shipper contracts designed to minimize costs by ensuring delivery reliability. From the perspective of the railway, the more reliable are the forecasts of capital usage, the more efficiently will capital be utilized. From the perspective of the shipper, demurrage and delivery penalties mean that reliability of delivery at destination is paramount. In particular, the bulk handling system is a growing concern for railways because of the large amount of railway resources needed to move commodities such as grain or coal and the increasing need for reliable port delivery of these products.[2]

3. The Rail Market of Today

In order to move a commodity by rail in North America, shippers need to negotiate contract conditions with a railway specifying critical parameters of the transportation transaction. These parameters include when and where the railway will pick up the shipment, along with the shippers preferred destination. To facilitate this process, some industries (such as grain and coal) own railcars, but this is not common practice and many industries rely on railways to provide cars. For most commodities moving by rail, securing access to the appropriate type of rail car is critical. In this paper, we will focus on the rail car as the unit of capacity to be traded in the market.[3]

The increasing need for dependable and timely delivery systems in a de-regulated rail industry has already generated some innovative approaches to the rail logistics problem. In 1988, Burlington Northern Railway was the first to introduce a logistics planning system for grain movement known as COT, or Certificate of Transportation. Simply put, COT is intended to help the railway better forecast its massive logistics needs for the movement of grain in the United States. And the COT innovation bears a strong resemblance to a forward contract for rail cars.

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[2] For instance, most North American railways obtain well over 20 percent of their net revenues from grain movement.

[3] Some researchers overseas have begun to develop institutions to efficiently allocate track capacity (Nilsson, 1999). While conceptually similar to the model developed here, the merits of these institutions derive from the assumption that track and rail operations are vertically separated ("open access"). Variations of rail access policy have already been implemented in Australia, Great Britain and Sweden.

COT is a program to sell access to grain hopper cars by electronically conducted, sealed bid auctions. The cars are offered for sale up to five months in advance and are grouped by specific origins and destinations and by commodity; shippers who require a rail car submit their bids to BNSF. The submission of bids can now be done on-line. Successful bidders are scheduled to receive cars within a specified two-week window (Drew and Rosher, 1999). More importantly, if a shipper decides after winning a car bid that they do not need the car, then the shipper can re-sell the car space in a secondary market. One limitation to this process is that a decision to sell car availability on the secondary car market must occur before the two-week delivery window has opened. Financial penalties are imposed upon the shipper if the car is not used or re-sold, or if there is a need to change the initial origin or destination from the original bid specification. The penalty is extracted primarily from the funds put on deposit at the time the bid is successful. Conversely, financial penalties are imposed upon BNSF if a COT car does not arrive within a 15-day delivery window. Finally, we note that regulatory oversight dictates that only a portion of BNSF's fleet can be used for COT allocations. The rest are allocated on a first-come, first-served basis. A lottery is used in those cases where car demand exceeds car supply for a given time period.

The rail car bidding mechanism and penalty system also serves to apportion transaction risk between the railway and the shipper by minimizing the occurrence of so-called “phantom car orders”. Phantom orders were a byproduct of the first-come, first-served allocation procedure; historically, to ensure that enough cars were available for a given transaction, shippers frequently over-ordered railcars. The major costs to the railway of phantom orders are poor fleet utilization, which results in reduced or lost business. By charging the shipper for poor order forecasts, railways reduced the likelihood of phantom orders. In essence, the railways developed a system for sharing with shippers the risk and the opportunity cost of not using a rail car that has been allocated space in the rail system.

The implementation of COT generated considerable opposition among shippers. Various shipper representatives felt that such programs were worse for shippers than the traditional "first come-first served" order systems because they permitted more discriminatory pricing in those markets (such as bulk movement) where rail already enjoys considerable market power in transportation services. But after some debate, a favorable 1992 regulatory decision by the Interstate Commerce Commission cleared the way for other U.S. railways to develop their own car allocation programs.

The Soo line (owned by Canadian Pacific) introduced an allocation system known as PERX into grain transportation. Union Pacific updated its ACOS (Advanced Car Order System) program with a more comprehensive car allocation system based on the issuance of vouchers for guarantees of future shipments. This first wave of bid-car systems for grain movement has been so successful for the railways that almost all U.S. Class I carriers have adopted some kind of auction-based car allocation program for bulk agricultural commodity movements (Wilson *et al.*, 1998). See Table 1.

Table 1. Comparison of U.S. Car Bidding Programs (Vachal, 2001)

Railway	*# Auctions*	*Minimum # of Cars per Certificate*	*Bid Range*	*When Sold*	*Prepayment*
BNSF (COT)	Weekly	1, 26 or 72	(0, infinity)	4 months in advance	$300 + premium ($400 cancellation)
Soo Line/ Canadian Pacific (PERX)	Monthly*	5	(0, infinity)	4 months in advance	$250 + premium
Union Pacific (Vouchers)	Weekly	1, 25 or 75	(0, infinity)	6months in advance	$300 + premium

Railway	*Late Penalty*	*Sold on Secondary Markets?*	*Charge for Change of Origin*	*Max. #of Cars per Certificate*	*Guaranteed Rates?*
BNSF (COT)	$300	Yes	$30/car if order ($300 per car if corridor changed)	Siding capacity, existing service levels	Buyer's option to lock rates
Soo Line/ Canadian Pacific (PERX)	$50 per car per day, $250 maximum	Yes	$50 per car if within shipping period	Siding capacity	Not in terminals, no flax or edible beans
Union Pacific (Vouchers)	$50 per car per day, $400 maximum	Yes	$25/car, $250/car if corridor changed	Siding capacity, existing service levels	Up to 90 days in advance

*Bi-weekly during grain harvest

In Canada, the removal of freight rate regulation for grain movement in 1999 allowed Canadian Pacific to introduce a car allocation and logistics program for grain called matrix (Canadian Pacific, 2001). While it does not rely on a bidding mechanism for car allocations, MaxTrax offers considerable rate discounts for shippers who can assemble large trains for movement on CP lines.[4] Mostly, the set of MaxTrax programs rely on a penalty system for missed orders to ensure that commitment to a pre-ordered service is met.

As a car allocation mechanism, the sealed bid system appears to have been quite successful for the railways. The rapid adoption of similar systems by other railways is a strong indication of this. The benefits to shippers from improved logistics are significant, but are harder to quantify. There are still complaints, especially from smaller shippers, about the implementation of these auctions systems in a transportation market (bulk movement) with little or no inter- or intra-modal competition.

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[4] One of the CPR programs known as AdvanceMax uses an offer system for penalty payment. As part of an AdvanceMax order, a shipper must offer an amount per car that they would be willing to pay as a penalty for not meeting the order. In the event that a car shortage exists, the amount of this offer is used to determine car allocations (Canadian Pacific, 2001).

This last point leads us to speculate that if the rail industry in North America were to become more competitive through the implementation of third-party rail access policies, then capacity pricing mechanisms based upon railway controlled auction markets as used today would not survive. Instead, pricing mechanisms and associated markets will need to evolve to better fit with full economic de-regulation in rail. One mechanism that offers the potential to benefit both railways and shippers is a capacity or car allocation system derived from the theory of financial derivatives. The next sections of the paper will explore this idea in detail.

4. The Demand for Hedging Instruments in the Rail Industry

Given the success of auction mechanisms for rail car allocation, we now explore the conditions under which the industry would be willing to take the next step and develop a market for financial instruments where the underlying asset is freight car capacity. The answer almost certainly hinges on the future need for instruments that can be used to hedge risk. Therefore, we discuss and assess risk in this industry, including a characterization of what risk would be desirable to hedge as opposed to what risk is possible to hedge. Given the existing organization in the industry, it is clear that rail shippers would benefit more from a vehicle with which to shift their risks more than would rail transportation providers, who enjoy near monopoly power in many transportation markets. We will examine why there is reason to anticipate demand for capacity hedging instruments from both sides of the rail market.

At certain peak times of the year, it might be the case that for individual shippers using rail or for individual suppliers of rail transportation, the cost associated with the failure to obtain rail freight capacity or the failure to supply freight capacity might justify some mechanism for hedging away that risk. A derivative contract could be constructed to supply freight capacity for which the contract terms outlining failure to deliver were sufficiently harsh that the associated cost would warrant a hedge. An over-the-counter market could develop, a market willing to write particular hedging contracts with sizeable fees for just such situations. However, to justify our claim that the future rail industry is likely to spawn a well-developed liquid market with standardized derivative contracts on rail capacity, we must define the risks to players in the rail market, examine the costs of those risks, and show that there would arise sufficient demand for derivatives on both sides of the market.

In order to gain further insight as to the structure of forward/future markets for freight capacity, we examine the development of post-deregulation financial options markets in both the electricity and natural gas industries. We acknowledge that not all deregulation processes are created equal. Still, there are similarities in the basic structure of how these markets evolved that shed light on the future for the market for rail freight capacity.

4.1 The Development of Hedging Instruments in Other Industries

There has been dramatic growth in the exchange of financial instruments in some other network-type industries, such as natural gas supply. This process started with the exchange of long term fixed-price supply contracts in the 1970s and moved to the market exchange of futures contracts. As natural gas industry supply was gradually deregulated, volumes grew to the point where 19 million futures contracts were traded on the New York Mercantile Exchange (NYMEX) in 1999. Toward the end of the 1990s, the U.S. annual retail natural gas market of 60 billion USD was accompanied by the exchange of 300 billion USD in natural gas futures and a further 300 billion USD in over-the-counter derivatives (NYMEX; Spiewak, 1998).

However, this kind of growth has not been observed in all deregulated or partially deregulated network industries. Although there were predictions of strong growth in the trading of electricity futures, this market has not seen a comparable expansion. NYMEX launched electricity futures (California-Oregon Border and Palo Verde) in March of 1996, introduced more in 1998 (Cinergy and Entergy), and another (PJM) in March of 1999. Trading volume in 1999 on NYMEX was less than 200,000 electricity futures. Some contracts have fewer than 200 trades per day (e.g., PJM at 13 contracts per day) (NYMEX; The Electricity Daily (Vol. 14, No.22)).

There are a number of possible explanations for this situation. If rates are set or capped by a regulator, electric utilities would have little incentive to hedge using futures contracts. More generally, in the current less-regulated environment, utilities are reluctant to enter into hedging markets to manage risk, either because of a threat of re-regulation or due to a perception of financial derivatives as risky instruments.[5] The underlying commodity of electricity future contracts is unusual in that it cannot be stored, leading to greater uncertainty in pricing of the contracts (Bessembinder et al., 2000).

In fact, the highly time-sensitive nature of electricity is a characteristic partially shared by rail services. Ultimately it may be that the five years since the introduction of electricity futures has not been long enough for the full development of the necessary institutional capability (personnel, familiarity, contacts, training, controls, etc.). It is worth noting that if the same ratio of contract trading volume to commodity sales were observed in electricity as in natural gas, the resulting market would be very large. Annual revenues in electricity supply industry in the United States in 1998 were 270 billion USD (Borenstein et al., 2000). Derivatives markets in electricity would be on the order of 2.7 trillion USD, if a similar “ten-times-sales” ratio held for electricity as in natural gas. Obviously, these volumes have not yet materialized.

We expect that the prospect for trading in rail derivatives is likely to lie between the tremendous market for natural gas derivatives and the disappointing situation in electricity. While natural gas markets are unnaturally large – the 19 million contracts traded on NYMEX in 1999 exceeds even the 8.7 million unleaded gasoline futures traded – electricity options markets remain small despite optimistic predictions. However, some of the unusual pricing issues in electricity derivatives would not present themselves for rail derivatives. The learning curve to develop similar pricing institutions should not be as steep for rail, nor should the possibility of expensive mistakes while on the learning curve be as great.

4.2 The Costs of Financial Risks Faced by Railways and Shippers

In a standard forward contract, two parties (on their own or through an intermediary) negotiate the delivery of a particular asset for an agreed-upon price on a specified date at a specified location. No funds beyond margin requirements exchange until the delivery date.

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[5] “How Small Dealer Roiled Midwestern Electricity Market”, *Wall Street Journal*, Sept 1, 1998.

Each party is obligated to honor their side of the contract, unless they can find an alternate party who is willing to “step into their shoes” and assume all aspects of the obligation. Given that forward contracts are not normally highly standardized, finding an alternate party to fulfill this obligation is non-trivial.

While confidential contracting with various kinds of shippers in the rail industry is now commonplace, little is known about the structure of these contracts. More importantly, since they are specific to certain shippers, these contracts cannot readily be traded among shippers in any meaningful sense. For the tradable shipping contracts we do know about, the bid car allocation systems have some of the hallmarks of a basic forward contract.

Under BN’s COT system, a shipper has an obligation to pay for the capacity for which he has successfully bid, unless he can re-sell it in a secondary market. If a shipper wishes to extract himself from paying the entire agreed-upon price for freight capacity he knows he will not use and cannot re-sell the capacity, he can turn it back to the railway. The railway will then try to re-sell the capacity, but it extracts a penalty from the shipper who won the initial auction. Instead, if this were a full-fledged forward contract, the penalty would be exactly 100 percent of the agreed-upon price. The shipper would be obligated to accept delivery of the asset (rail freight capacity), and would be obligated to pay the full price. We conclude that the bid car allocation systems now in place are more generous than a standard forward contract to the shipper who wants to break the contract. As can be seen in Table 1, the present program prices for defaulting are considerably less than 100 percent.

There is a direct cost to the railway of not meeting the COT contract conditions in the form of the 15-day car delivery window. That cost (about $400 U.S. at the time of writing) is just a small fraction of the average total value of freight capacity. Of course, the cost to the railway of not “hedging” by selling forward under the present auction systems is uncertain revenue and uncertain plans for allocation of rail capacity with different origin-destination routings. This cost is reduced through auctioned contracts, but it cannot be eliminated entirely. The remaining costs to the railway are similar to those that would exist in a forward contract – the inability to fully participate in an upward price movement of the commodity being sold by the railway – as well as the cost associated with the generous nature of the penalties imposed by the present systems on the shippers.

The cost to the shipper of not “hedging” by bidding for rail capacity can also be characterized as uncertainty regarding both the price and availability of rail capacity at the time required. The cost of a forward hedge in which the prices moved the wrong way (i.e. the hedger would have been better off in a revenue sense had he/she not hedged) is the same as the cost to the shipper given similar price movements. However, unlike in the case of a pure forward contract, the shipper can extract themselves without being sued for default and without paying 100 percent of the agreed-upon price.

There are other costs to the bulk shipper associated with not being able to rely on timely freight capacity at stable prices. Using the Canadian grain industry as an example, if product cannot be shipped to its destination as agreed upon, the Canadian Wheat Board (CWB) incurs pre-contracted penalties and demurrage (storage) fees if volumes, grades and timing of grain delivery are not met.

Finally, with respect to the railway, there are considerable costs incurred if rail capacity is supplied but not demanded. The rapid action by U.S. railways to put in place mechanisms to avoid phantom orders is an indication of the magnitude of the logistics and operations costs associated with unused rail capacity and assets. Obviously, further development of transparent mechanisms to reduce imbalances between temporal and spatial transportation supply and demand will be looked upon favorably by major railways.

4.3 Suppliers of Rail Freight Capacity in a Derivatives Market

Under capacity hedging, railways would assume responsibility for the risk that trains will run from origin to destination with only partial capacity bought and filled. This may mean that empty cars are moved, or that an engine moves fewer full cars than optimal. Even the presence of advance contracting systems, such as COT, cannot completely eliminate this risk; indeed, a functioning capacity derivatives market may not necessarily achieve this. Similarly, in a situation where more than one supplier of rail capacity operates in the same corridor, the risk becomes either that the train will run under-filled or that the train will run with capacity purchased at prices below costs. An active and liquid derivatives market offers railways the opportunity to lock in future prices received and so completely hedge away future price uncertainty, or to purchase options that permit them to participate in upward price movements for rail shipments.

At present, the essential elements railway car capacity allocation systems are controlled almost completely by the offering railway. In advance of the actual auction, the railway determines most of the important features of the final contract to be bid upon (see Table 1). In particular, the bulkiness of a commodity like grain and the transportation captivity of many grain shippers make auction control of capacity useful. If this were not the case, then a capacity auction might not generate any bids in situations where the railway did not offer origin/destination pairings and routings that were favorable to most shippers. Control over the routings and capital utilization combined with the need for many bulk shippers to bid on virtually any details of the transportation transaction offered by a railway makes the existing bidding mechanisms very effective.

In this sense, we refer to existing rail car allocation mechanisms as being asymmetric or one-sided in a bargaining sense. In the markets served by these mechanisms, the bidder (shipper) is frequently obliged to bid on whatever cars/capacity is made available by the railway, whether it efficiently serves shipper needs or not. For capacity derivatives to prosper in the present rail regulatory environment in North America, a move to a more equitable situation between capacity supplier and demander is necessary. This means that the railways will need to perceive considerably more benefits under a forward contracting system than they obtain now under bid-car allocation systems.

As alluded to in the previous section, to facilitate the use of financial derivatives for pricing capacity in this industry, railways will need to be permitted to charge for the full cost of default in a forward shipping contract market. But if this is permitted, many shippers in turn will need leverage on derivative contracts offered by railways because of the existence of market power in transportation. One possible solution to this problem is for the rail regulator to fully enforce the existing laws regarding common carrier obligations.[6] This would allow most shippers to have more input into the process of setting parameters of transportation contracts than exists in the present car/capacity allocation process.

Another solution to the asymmetric bargaining power problem between railways and shippers would be a change in regulatory policy towards improved infrastructure access for third-party rail providers (DeVany and Walls, 1997). In fact, as of July 2001, Canada is in the process of officially considering just such a policy in order to make the industry more competitive and responsible to shippers (Fulton and Nolan, 2001). While a complete discussion of regulated rail access is beyond the scope of this paper, it is clear that the rail industry is going to have to consider more advanced capacity pricing options in order to adapt to changing regulatory environments.

If these policies are pursued on behalf of both shippers and railways, then a forward/futures market for freight capacity becomes two-sided and equitable to both. In this type of capacity market, both railways and shippers have the ability to freely enter into, trade for, or terminate shipping contracts, subject to the terms of the contract.

4.4 Demanders of Rail Capacity in a Derivatives Market

Presently, the auction systems used by railways to allocate freight capacity are mostly limited to grain movements. Thus in order to extend the concept of a financial market for rail capacity to a wider spectrum of rail service consumers, we note that some consumers would necessarily have greater value for on-time capacity. Higher values for a given shipper would arise when the shipped goods are perishable, storage costs are particularly high, contract penalties for late delivery are high, or opportunity costs of foregone sales are high (lost sales from delays may be costly if demand for the shipped goods is cyclical or unstable or otherwise time-sensitive).

Rail is still used predominantly by shippers of bulk goods over long distances. Traditionally, bulk commodity hauls were not strongly affected by strict on-time delivery needs. But more recently even for certain bulk movements, shippers are demanding more reliability in delivery in order to avoid demurrage fees either at intermediate port or final destination (Wood and Johnson, 1996). And as mentioned earlier, the rail industry has tried to become more competitive with trucking over shorter hauls. Since it is costly to move freight from firm to firm and from mode to mode, supply chain transaction costs dictate that many shippers increasingly desire “seamless” and reliable transportation services between origin and destination.

The usefulness of a call option for rail freight capacity to shippers is clear. Call options allow the shipper flexibility to purchase rail freight by specific dates at prices that are potentially advantageous relative to spot market prices. Unlike forward and futures contracts that lock in the future price to be paid for rail shipment, the shipper holding such an option can participate in favorable price movements and avoid unfavorable ones. Of

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[6] A common carrier obligation for a railway means that it has a legal obligation to serve all customers who request services. Furthermore, a common carrier as defined also assumes the following basic obligations to shippers for all transactions: 1) delivery, 2) service, 3) reasonable rates, and 4) avoidance of price discrimination (Wood and Johnson, 1996). These legal definitions are the same in both Canada and the U.S.

course, there is a cost to this increased flexibility in the form of the option premium paid at the time the call option contract is purchased. But a deregulated rail market will almost certainly evolve to the point where intermediaries would be willing to write (and hedge themselves) option contracts.

Considering these factors and the possibility of regulatory changes in rail, we anticipate that shipper demand for a forward or a more stable futures market for tradable rail freight capacity will continue to grow. As outlined above, bid-car systems are a step in this direction, but financial markets have specific features that distinguish them from auction markets. We will outline these features and their implications for the structure of the rail industry in the next few sections.

5. The Existence of Derivatives for Rail Freight Service Capacity

The previous section outlined those conditions under which we would reasonably expect a well-functioning and liquid market for standardized derivative contracts on rail capacity to develop together with the new market for the underlying asset itself. There will be substantial demand for and supply of "derivative-type contracts" for rail capacity under deregulation, since these contracts can solve transportation coordination problems, providing cost-savings and significant profit opportunities.

We apply an appropriate derivative pricing model for rail capacity. The exercise is conducted to show that it will be relatively straightforward to compute call options for transportation. Furthermore, our results provide a good illustration of the effect of entry regulation, manifested through low (unregulated) rate volatility, on the rail industry. We postulate that one of the immediate benefits of entry deregulation in rail will be an increase in price volatility and the subsequent development of advanced pricing mechanisms to help manage traffic coordination along with other forms of transportation risk.

5.1 Pricing Issues: The Binomial Asset Pricing Model

To price options using the binomial pricing model, we begin by reviewing the model in its simplest and most unrealistic form. Then we make appropriate and standard modifications in order to apply the model to the rail capacity market.

Suppose we know the price of the asset underlying the option, the maturity date of the option and its exercise price. In the one-period binomial model, there are only two possible prices for the underlying asset on the maturity date of the option. These two prices determine the two possible future payoffs from the option. For example if we consider a call option, it will be worthless if the underlying asset price at maturity is below the exercise price: we say that the call option is out-of-the-money. At maturity, *T*, the call option will payoff the (positive) difference between the spot price on the underlying asset at maturity of the option, S_T, and the exercise price of the option, X, if it is in-the-money. The payoff from the option can therefore be written as $\max(S_T - X, 0)$. Let $S_{T,1}$ and $S_{T,2}$ denote the two possible prices for the underlying asset at time T, and let $c_{T,1} = \max(S_{T,1} - X, 0)$ and $c_{T,2} = \max(S_{T,2} - X, 0)$ denote the associated two possible call option payoffs at maturity. This evolution of prices for the underlying asset and associated payoffs of the option between the time at which the option is being evaluated and the expiration of the option is illustrated for this one-step binomial model in Figure 1.

Using these instruments and our knowledge of their price evolution over the life of the option, we form a perfectly hedged portfolio, one for which the future payoff is known with certainty, regardless of which of the two prices materializes for the underlying asset. This portfolio is constructed by taking a short position in the option and a long position in a certain number of units of the underlying asset, Δ, the hedge ratio. The number of units is chosen so that the portfolio payoff at the maturity of the call option is identical no matter what happens to the price of the underlying asset, i.e. we set Δ such that $S_{T,1}\Delta - c_{T,1} = S_{T,2}\Delta - c_{T,2}$. The portfolio is risk free: we can use a risk-free rate of interest to discount cash flows. The cost of entering this portfolio must be equal to the present value of its expected future payoff, $e^{-rT}(S_{T,1}\Delta - c_{T,1})$,[7] where *r* denotes the continuously compounded riskless rate of interest. To construct the portfolio we took a long position in Δ units of the underlying asset and we sold the call option. We know the price of one unit of the underlying asset, S_0, so we can determine what we received for shorting the option. The option price is calculated as $c = S_0\Delta - e^{-rT}(S_{T,1}\Delta - c_{T,1})$, where *c* denotes the price of a (European) call option (Hull, 2000).

Applying the binomial model in more realistic settings requires some enhancement. This is necessary in order to overcome the problematic requirement of precisely narrowing future uncertainty to only two possible future prices for the underlying asset on the option's expiration date. In order to accomplish this, we construct a series of one-step binomial models and join them together in a tree. As a point of reference, the last nodes of the binomial tree correspond to the maturity date of the option. The length of each binomial piece is a fraction of the total time between the present and the expiration of the option, and each branch of the multi-step tree is of equal length. (The total remaining life of the option is divided into smaller units of time, each identical.) As the tree branches and fans out, the final nodes of the tree portray a multitude of possible prices for the underlying asset and so form a type of probability distribution for the underlying asset price. In fact, the number of prices displayed at the expiration of the option will depend on how many times the binomial tree was branched. The prices for the underlying asset corresponding to the final nodes of a multi-step binomial tree determine the possible payoffs from the option. Figures 2 illustrates a multi-step binomial tree for a call option.

To construct a binomial tree empirically, we need to decide into how many steps to divide the total time between the present and the time of expiration for the option. We also need to determine the amount by which the price of the underlying asset can move up or down from each node. This amount will be related to the volatility of the price of the underlying asset, and to the length of each time step. Choosing a higher number of steps will increase the accuracy of the option price (given the accuracy of the parameter assumptions input to the model), but will also increase the computational complexity and size of the tree. In the limit, the option price from the binomial model with many time steps will approach the well-known Black-Scholes option price (Hull, 2000). However, specifying the volatility of the underlying asset is a non-trivial exercise. Ideally, the volatility of the underlying asset

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[7] Since the portfolio has been constructed so that its payoff is identical regardless of which price for the underlying asset is realized, we may discount either portfolio payoff.

must be that prevailing over the future time period or the remaining life of the option. This will have to be estimated from historical rail rate data.

5.2 Defining the Contract Terms

We need to define precisely the underlying asset and the contract specifications for forward and futures contracts on rail capacity, as well as call and put options. We conduct our preliminary and hypothetical investigation of rail capacity derivatives by examining waybill data available on rail shipments within the continental US.

The underlying asset for our derivatives is a unit of rail capacity suitable for the transport of coal. The relevant price is the market price paid by the shipper to transport coal along the given route on the specified date. We collect these prices for each route and calculate each of the relevant input parameters to the option pricing model. The next subsection demonstrates the feasibility of these calculations, and discusses an interpretation of the resultant option prices. Finally, potential strategies for hedging by both shippers and railroads in this hypothetical market are also outlined.

5.3 Application

The U.S. rail waybill data is a collection of public-use files on rail transportation movement made available by the U.S. rail regulator since the mid 1980s. Transportation waybills are filed with the Surface Transportation Board (STB) for every rail movement within the continental U.S., but the waybill data available to the public comprises approximately a 2 percent sample of all waybills filed (AAR, 1998). The sampled data are non-confidential and contain information on various commodity movements, including grain, coal and industrial chemicals. The individual data records include such items as origin and destination codes, type of commodity, number of cars, shipment tons, length of haul, and interchange locations.

While we acknowledge that the majority of rail car bidding programs in place are used with respect to grain movements, it is difficult to specifically identify grain movements in the existing waybill data. Since coal and coal shippers share many similarities with grain, we felt that coal was a useful and identifiable substitute to illustrate the basic options pricing model discussed below. Without a doubt, the most commonly sampled and easily identifiable transported good is coal. Goods are identified by a three-digit SIC code for the United States. As used in this study, commodity code #112 represents bituminous coal or lignite. The waybill sample contains extensive records for this commodity; the raw data on coal alone contains almost 2 million records over five years.

The waybill sample uses official U.S. Bureau of Economic Analysis (BEA) codes to identify shipment origins and destinations. For the purposes of demonstrating the binomial option pricing model applied to rail capacity, we collected a series of unregulated daily mill rates paid by shippers for transporting coal in selected rail corridors. While appropriate data was not necessarily available for each day, the sample was quite consistent over the chosen interval. The two transportation corridors chosen for this analysis represent coal movements from Lincoln, Nebraska to Corpus Christi, Texas and data from a busy corridor through lower West Virginia to the state of New York. Our sample covers the time period from January 1997 through December 1998, some of the most recent data available. In addition, each of these corridors not only contained enough data to compute the option pricing model, but we also confirmed that each origin was served by more than one railway; implying that some degree of rail competition was present for these movements.

Table 2. Sample Descriptive Statistics (Coal Movements)

Rate Series ($/ton)	Number of Observations	Mean	Standard Deviation
West Virginia to New York	278	18.79	2.94
Nebraska to Texas	1337	17.01	2.02

The data allows us to estimate the historical price volatility associated with shipping coal in different time periods. Considering these calculations along with a comparison to historical rates on Treasury bills of differing maturities, we are able to set prices on hypothetical call options on coal transportation by rail within these corridors. A summary of the input data for each of the two corridors is shown in Table 3, Panels A and B. Notice the low magnitude of the volatility numbers. By way of comparison, the implied volatility from three-month options on Microsoft Corporation and Enron stand at almost 46 percent and 45 percent respectively, while Research in Motion (arguably a highly volatile high-tech stock) volatility is 86 percent. In fact, typical values of stock volatility are in the range of 20 to 40 percent.[8]

Table 3: Inputs to Option Pricing Model

Panel A: Lower West Virginia to New York

Date	Maturity	Corresponding T-Bill Rate	Volatility
Jul 1997	Sep 97	5.000	0.03939
	Dec 97	5.095	0.07252
Jan 1998	Mar 98	4.940	0.06317
	Jun 98	4.980	0.10984
Apr 1998	Jun 98	4.957	0.06684
	Sep 98	4.039	0.09073
Jan 1999	Mar 99	4.382	0.08024
	Jun 99	4.420	0.09734

Panel B: Lincoln, Nebraska to Corpus Christi, Texas

Date	Maturity	Corresponding T-Bill Rate	Volatility
Jul 1997	Sep 97	5.000	0.06704
	Dec 97	5.095	0.08374
Jan 1998	Mar 98	4.940	0.06845
	Jun 98	4.980	0.09610
Apr 1998	Jun 98	4.957	0.07962
	Sep 98	4.039	0.10466
Jan 1999	Mar 99	4.382	0.07221
	Jun 99	4.420	0.10067

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[8] Hull, page 241.

Option value depends crucially on the volatility of the price or return from the asset underlying the option. Hedgers are particularly interested in hedging when the price uncertainty or volatility is high.

For comparative purposes, we have defined several hypothetical call options for rail transportation of coal. Each contract is defined by a standardized amount of coal to be transported (a full coal hopper car) from a defined origin to a defined destination, an exercise price for the contract and a time frame for the contract. These resultant option prices are illustrated in Table 4, Panels A and B. These prices were calculated using the binomial model with the time until option maturity divided into 50 sub-intervals.

Table 4: Call Option Prices

Panel A: Lower West Virginia to New York

	Option Maturity Date	Exercise Price of Call Option				Spot Price of Underlying ($/ton)
		16	17	18	19	
Jul 1997	Sep 97	1.119	0.205	0.000	0.000	16.92
	Dec 97	1.351	0.518	0.084	0.000	
Jan 1998	Mar 98	2.084	1.089	0.276	0.000	17.89
	Jun 98	2.281	1.451	0.687	0.336	
Apr 1998	Jun 98	2.345	1.357	0.465	0.010	18.15
	Sep 98	2.546	1.628	0.788	0.336	
Jan 1999	Mar 99	0.373	0.000	0.000	0.000	16.06
	Jun 99	0.632	0.249	0.000	0.000	

Panel B: Lincoln, Nebraska to Corpus Christi, Texas

	Option Maturity Date	Exercise Price of Call Option				Spot Price of Underlying ($/ton)
		15	16	17	18	
Jul 1997	Sep 97	1.789	0.825	0.158	0.000	16.603
	Dec 97	1.980	1.096	0.424	0.021	
Jan 1998	Mar 98	2.744	1.756	0.807	0.165	17.560
	Jun 98	2.929	1.960	1.127	0.496	
Apr 1998	Jun 98	0.000	0.000	0.000	0.000	13.929
	Sep 98	0.168	0.000	0.000	0.000	
Jan 1999	Mar 99	0.000	0.000	0.000	0.000	13.832
	Jun 99	0.104	0.000	0.000	0.000	

By way of example, the September 1997 contract on coal from lower West Virginia (origin) to New York (destination) with an exercise price of $16 priced on July 1, 1997 would permit the option holder to purchase coal transportation from origin to destination[9] at the end of September 1997 for $16. To purchase such flexibility, i.e. to buy the option, the shipper would pay $1.119 on July 1, 1997. If the hypothetical market price for transporting coal in September exceeded $16, the shipper would exercise his option and purchase rail capacity using the option. If the market price were below the exercise price of the option, the option would expire worthless and the shipper would need to purchase rail capacity in some other manner (presumably in some form of spot market).

The most interesting feature of the option price table is the number of options with no value whatsoever. However, this is hardly surprising given the very low volatility of the price of the asset underlying these options. The value of an option at any moment in time depends on the current price of the asset underlying the option, the option's strike price and time to maturity, the current interest rate over the remaining life of the option, and the price volatility of the underlying asset. The option values recorded in panels A and B of Table 4 display characteristics that reflect these influences. The option prices are decreasing with increasing strike prices, and increasing with longer time to maturity or higher spot prices for the underlying asset. Finally, the option value is very sensitive to the last variable, volatility, and options on assets with low price volatility are not valuable.

In this hypothetical market for rail capacity, the data for coal movements comes from a period of stability characterized by rate deregulation coupled with entry regulation in the industry. That there is low price volatility associated with the price charged to ship coal in these two corridors during these times is not surprising. If the market for rail capacity were to completely deregulate (entry and rate deregulation), we would expect to see increased uncertainty in the prices charged to ship by rail. It is this increased uncertainty that players in this market would like to hedge. Derivative instruments that facilitate hedging activity become very valuable to those who would like to hedge when it becomes financially attractive. If one can reasonably expect price volatility for rail shipping to increase, one can reasonably expect options, if they were written, to have positive value.

In an environment of relative price instability, assuming the existence of a viable options market with rail transportation capacity as the underlying asset, how might a hedger take advantage of the existence of instruments to hedge price uncertainty and transportation capacity uncertainty? For our two sample corridors moving coal, if a shipper wished to hedge the availability or pricing of coal transportation along either of the corridors, they would necessarily rely on the option strategies defined earlier in this paper.

But suppose the shipper wished to hedge the price of coal movement along a corridor for which there was no derivative instrument available. This hedging situation would be treated by using the instrument available on the most closely correlated corridor. In other

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[9] As a conservative estimate of coal car capacity in this rail corridor (WV-NY), our sample movements amounted to 73,500 tons of coal moved in the month of September, 1997.

words, if one knew the correlation between price/availability of freight capacity on the desired corridor and a closely related corridor for which a hedging instrument was available, the correlation could be used to determine the number of contracts required to hedge the desired corridor using the available instrument on a related corridor. Thus, hedging is not restricted to corridors that are well-traveled and on which derivative instruments are most likely to be written.

6. Conclusions and Future Research

This paper has described the possibility of a new market for rail capacity in anticipation of regulatory changes that will help define a new future for the rail industry. Current capacity contracts (COTS, PERX, ACOS, MaxTrax, etc.) represent early forms of the instruments that will evolve into the kind of contracts commonly traded on forward/futures exchanges. These contracts, standardized and traded in a market with enough liquidity, would form the basis for the capacity options market we envisage.

During the sample period, there appears to have been insufficient price volatility to make such contacts desirable in sufficient number to generate the kind of market we predict will eventually develop. Greater price volatility in the future, along with greater experience with the trading of such contracts and the potential for future changes in regulation, would generate demand for these trades. This has already occurred in other industries where the characteristics of the underlying asset are sufficiently tractable (electricity being an example of a less tractable underlying asset).

Our findings in this paper naturally leads to future work as an extension of our framework to other network-based industries that share important features with rail. The industries of primary interest are electricity and natural gas that have already undergone deregulation, and options in cable and telecommunications for which a clear analysis of the network setting is crucial.

The existence of the capacity derivatives market we have defined would serve the interests of shippers and railway operators and, in addition, information from such a market could provide regulators with a firmer basis from which to evaluate proposed mergers. In summary, our analysis suggests that the growth of such a market will accelerate and that this growth is a favorable outcome.

References

American Association of Railroads (Railinc Business Services Division), 1998, “User Guide For the 1997 Surface Transportation Board Waybill Sample”, Washington, D.C.

American Association of Railroads, 2000, “Economic Impact of Railroads”, available on-line at http://www.aar.org.

Bessembinder, H. and M. Lemmon, 2000, “Equilibrium pricing and optimal hedging in electricity forward markets” Mimeo, Department of Finance, Arizona State University.

Bonsor, N., 1995, “Competition, Regulation and Efficiency in the Canadian Railway and Highway Industries”. Ch. 2 in *Essays in Canadian Surface Transportation*, Filip Palda, Ed., The Fraser Institute, Vancouver, B.C.

Borenstein, S., J. Bushnell, and F. Wolak, 2000, “Diagnosing market power in California's restructured wholesale electricity market”, NBER Working Paper 7868.

Canadian Pacific, 2001, MaxTrax Home Page. Available on-line at http://www.cpr.ca/Internet/Content/BusinessLines/Grain/..\MaxTrax\MaxTrax.asp.

DeVany, A.S. and D. Walls, 1997, “Open Access to Rail Networks”, *Transportation Quarterly*, 51, 73-78.

Drew, W., and P. Rosher, 1999, “U.S.-Canadian System Comparison: A Grain Shipper's Perspective”, *Going Beyond: Moving into the New Millenium.* Proceedings of the 34th Annual Conference, Canadian Transportation Research Forum, 569-584.

Gallamore, R., 1999, “Regulation and Innovation: Lessons from the American Railroad Industry”, Chapter 15 in *Essays in Transportation Economics and Policy*, J. Gomez-Ibanez, W.B. Tye and C. Winston, eds., Brookings Institution Press, Washington, D.C.

Hull, J. C., 2000, *Options, Futures & Other Derivatives, 4th edition*, Prentice Hall, New Jersey.

Kober, R. and C. P. Baumel, 1990, “Transportation Forward Contracting or Options: A Description and Analysis of an Application to Railroads”, *Transportation Practitioners Journal*, 58, 51-63.

Kranhold, K. and J. R. Emshwiller, 1998, “How Small Dealer Roiled Midwestern Electricity Market”, *Wall Street Journal*, September 1.

Kwoka, J. E., and L. J. White, 1998, “Manifest Destiny? The Union Pacific-Southern Pacific Merger”, *New York University Center for Law and Business Working Paper* #CLB-98-012.

Larson, P. D., and Spraggins, H. Barry, 2000, “The American Railroad Industry: Twenty Years After Staggers”, *Transportation Quarterly*, 54, 31-45.

McMullen, B.S. and M-K Lee, 1993, "Assessing the Impact of Regulatory Reform on Motor Carrier Cost Efficiency", *Journal of the Transportation Research Forum*, 33, 1-9.

Nilsson, J.E., 1999, "Allocation of Track Capacity: Experimental Evidence on the Use of Priority Auctioning in the Railway Industry", *International Journal of Industrial Organization*, 17, 1139-1162.

Nolan, J. and M. Fulton, M., 2001, "Competitive Access: The Next Step for the Canadian Rail Industry?", *Journal of the Transportation Research Forum*, 40, 81-95.

Spiewak, S., 1998, "Power marketing: price creation in electricity markets", Power Marketing Association and The Edison Electric Institute, Washington, D.C.

Vachal, K., 2001, "Comparison of Guaranteed Equipment Programs", mimeo, Upper Great Plains Transportation Institute, North Dakota State University.

Wilson, W. W., S. R. Priewe and B. Dahl, 1998, "Forward Shipping Options for Grain by Rail", *Journal of Agricultural and Resource Economics*, 23, 526-544.

Wood, D.F. and Johnson, J.C., 1996, *Contemporary Transportation*, 5th Ed., Prentice Hall, New Jersey.

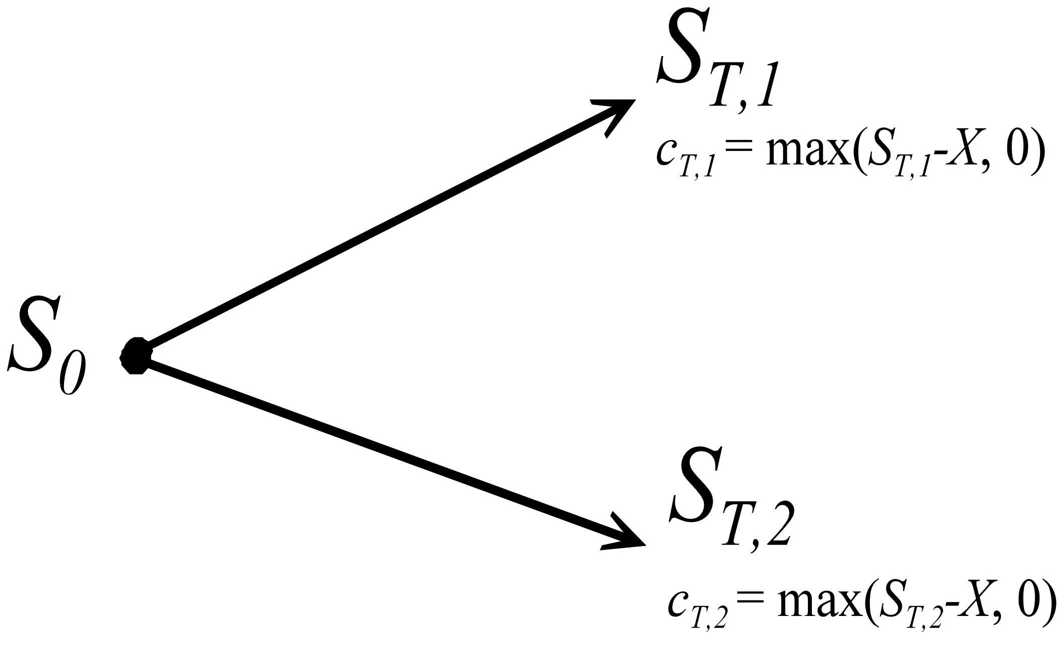

Figure 1 The One-Step Binomial Model

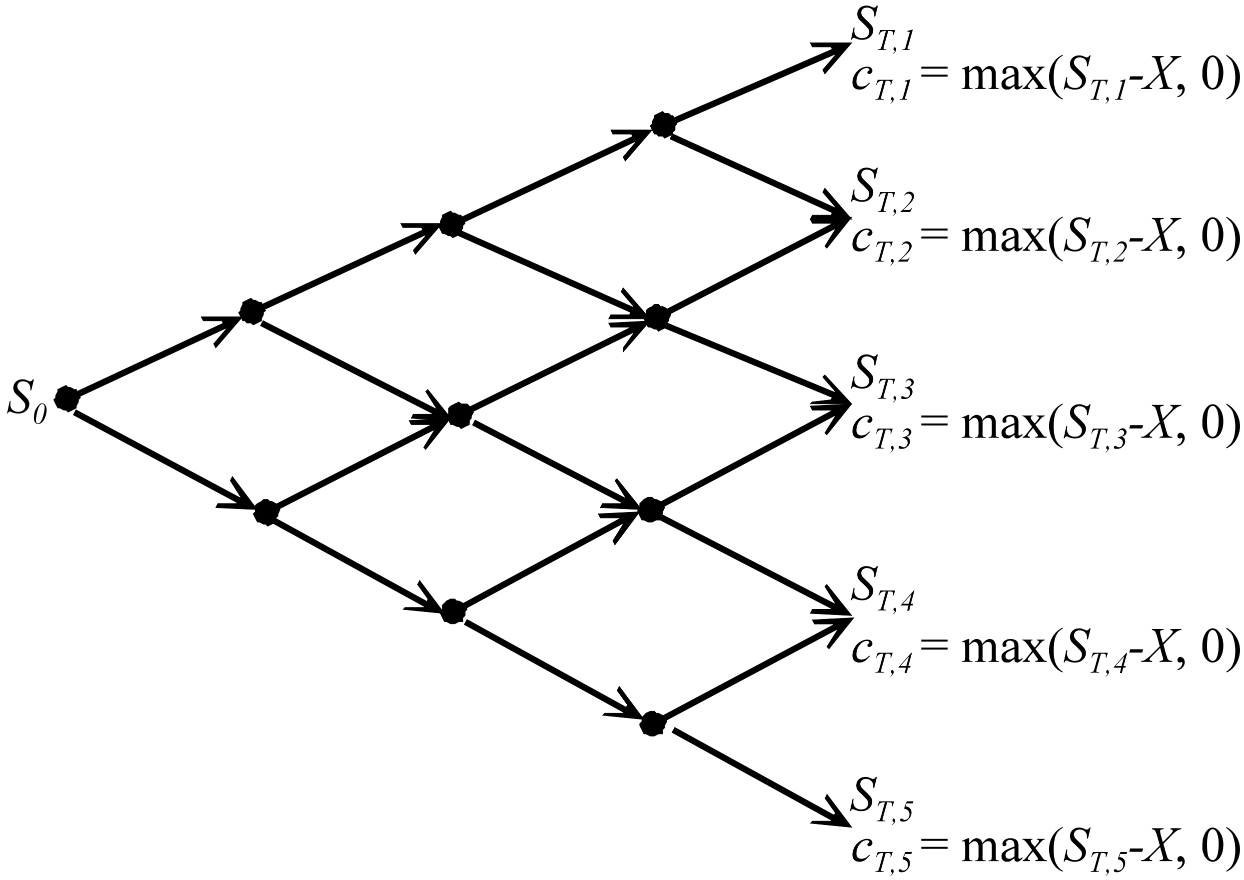

Figure 2 A Multi-Step Binomial Tree