Journal of Banking & Finance 37 (2013) 43–59

Contents lists available at SciVerse ScienceDirect

Journal of Banking & Finance

journal homepage: www.elsevier.com/locate/jbf

# Asset financing with credit risk

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ARTICLE INFO

*Article history:*
Received 9 January 2012
Accepted 9 August 2012
Available online 23 August 2012

*JEL classification:*
C51
G12
G13
G18

*Keywords:*
Credit risk
Asset-backed finance
Equipment finance
Leasing
Bankruptcy law

ABSTRACT

This paper develops a model for the unified valuation of all forms of real asset financing, such as bank loans, leases, securitization vehicles, and credit guarantees, secured by assets that generate a stochastic service flow to the operator, or a rental stream to the lessor, and depreciate over a finite economic life to their scrap value. Examples include mobile equipment, such as aircraft, railroad equipment, ships, trucks and trailers, as well as energy generation assets, heavy factory equipment and construction equipment. In the event of obligor default, after a repossession delay and incurring costs of repossession, maintenance, re-marketing and re-deployment, the lender repossesses the asset and sells it on the secondary market and is, thus, subject to the risk of decline in the market value of the asset. The model we develop in this paper treats all forms of asset financing in a unified fashion as contingent claims on the collateral asset and the credit of the borrower. As an application, we estimate the collateral asset model on historical secondary market data for aircraft values and calibrate the financing model to the Enhanced Equipment Trust Certificates (EETCs) issued in 2007 by Continental Airlines and secured by a fleet of new aircraft. We then apply the calibrated model to value private market financing, including bank loans, leases, and credit guarantees, consistently with the capital market financing, and assess the impact of repossession delays on credit spreads. This analysis leads to a policy insight suggesting that bankruptcy laws limiting asset repossession delays lead to lower costs of asset financing.



## 1. Introduction

This paper develops a stochastic model for the unified valuation of all forms of financing secured by assets that generate a stochastic service flow to the operator, or a rental stream to the lessor, and depreciate over a finite economic life to their scrap value. Examples include mobile equipment, such as aircraft, railroad equipment, ships, trucks and trailers, as well as energy generation assets, heavy factory equipment and construction equipment. The problem is of major economic importance.

The paper focuses on the aviation sector as a representative example. According to the 2010 forecast by The Airline Monitor (2010), new commercial aircraft deliveries are projected to reach over 3.3 trillion US dollars over the 2010–2030 period. Assuming the orders are financed with 15% airlines' own equity and 85% financing, the total amount of commercial aircraft financing will reach 2.8 trillion US dollars over the next 20 years. In the aviation sector, forms of commercial financing include secured bank loans, operating leases, and public debt issues secured by aircraft (in particular, Enhanced Equipment Trust Certificates (EETCs)). In addition to commercial financing, governmental Export Credit Agencies (ECAs) provide export credit financing support either in the form of direct export credit loans or export credit guarantees that support commercial financing. In some cases manufacturers also provide financing.

A typical bank loan financing a purchase of a new commercial aircraft might have a twelve year financing term, an initial loan-to-value (LTV) of 85%, mortgage-style principal amortization, and quarterly payment schedule. In the event of default, the secured lender repossesses the aircraft and sells it on the secondary market or leases it to another operator. In either case, the lender faces the risk of declining market prices or market lease rates for used aircraft, as well as a variety of possible costs and delays associated with aircraft repossession and re-marketing.

An aircraft is a depreciating asset that has a typical useful economic life of between 30 and 35 years. During its economic life it generates a stochastic revenue stream for the airline owner-operator or a rent stream for the owner-lessor, while its economic value depreciates as the aircraft ages. At the end of its useful life the aircraft is salvaged for its scrap value. When forecasting used aircraft

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http://dx.doi.org/10.1016/j.jbankfin.2012.08.010

values, practitioners use the *residual value curve* (RVC) that represents an estimate of the expected economic value of a used aircraft as a function of its age. However, market prices of used aircraft realized in secondary market transactions have substantial volatility around these expected residual values. The secondary market for used aircraft is an over-the-counter market with a reasonable amount of liquidity, at least for popular aircraft models with substantial market penetration and during non-distressed market conditions. For example, Gavazza (2010) reports that, in the twelve months between May 2002 and April 2003, of the total world stock of 12,409 commercial aircraft used for passenger transportation that were at least two years of age, 720 traded. That represents a turn over of more than 5% of the total world commercial fleet in one year. Thus, in addition to the expected economic depreciation, the lender who repossesses a used aircraft in the event of default faces a significant risk due to secondary market volatility. Furthermore, as discussed in Marray (1999), the lender also faces costs and delays in the repossession process. The expected economic depreciation, market volatility, as well as costs and delays of the repossession process, measured against the loan amortization, determine the lender's *loss-given-default* (LGD).

The present paper develops a model for the unified valuation of all forms of asset financing, including leases, loans, export credit guarantees, and securitization vehicles, subject to the risk of default. Our goal is to present a practically useful model that can be calibrated to the available market data. This goal requires a balance between the model complexity, tractability, and the realities of market data availability. Our model is developed within the framework of continuous-time dynamic asset pricing theory.

The key part of our asset financing model is the model for market values of real assets with stochastic service flow and finite economic life. Since real assets, such as airplanes, derive their value from a (generally stochastic) service flow (revenue stream) to the owner-operator or a rent stream to the owner–lessor over a finite useful economic life, we take the instantaneous percentage lease rate (the *short lease rate*) to a default-free lessee as the fundamental state variable in our asset model. To gain analytical tractability, we model the short lease rate under both the physical probability measure and the risk-neutral probability measure by Ornstein–Uhlenbeck (OU) processes with time dependent long-run means (different under the physical and risk-neutral measures) and time-dependent volatility, similar to the extended Vasicek model in the interest rate modeling literature (as well as in credit risk literature). The parameter time dependence is required since the real asset dynamics has a strong dependence on the asset's age. Under these assumptions, the market value of the real asset with finite economic life follows a process similar to the zero-coupon bond price dynamics in interest rate models. While the zero-coupon bond price appreciates toward its face value at maturity, the asset value in our model depreciates down to its final salvage value at the scrap time ("maturity" of the asset) at the stochastic depreciation rate. This modeling approach to depreciating assets constitutes one of the innovations in the present paper, as it has never appeared in the literature before. Under the OU model specification, we are able to obtain an explicit solution for the asset value process. Under the physical probability measure, the asset value fluctuates around its expected *residual value curve* (RVC), with the fluctuations modeled by the exponential of an Ornstein–Uhlenbeck process. When valuing secured financing transactions under the risk-neutral probability measure, the *risk-adjusted residual value curve* (RA-RVC) plays the role of the *forward curve* and takes the place of the RVC as the asset value's mean under the risk-neutral measure. In the OU model we are able to derive an explicit expression for the risk adjustment factor in terms of the *market price of asset risk* (the asset's *Sharpe ratio*), as well as explicitly determine prices of call and put options on the asset that are given by Black (1976) type formulas with the risk-adjusted residual value curve in place of the forward curve and the age-dependent asset volatility in place of the constant volatility. The practical advantages of this model are its analytical tractability, as well as the ability to calibrate it to market data. In contrast to more complex modeling choices, the model does not include any unobservable parameters or hidden variables that cannot be directly estimated from data. This allows us to calibrate our asset model to historical secondary market aircraft data.

We employ our depreciating real asset model as the key component of our asset financing model. We assume that default arrives at the first jump time of a time-inhomogeneous Poisson process with the arrival rate calibrated to the Credit Default Swap (CDS) spreads on senior unsecured corporate debt of the obligor. The twin advantages of calibrating the credit component of the model to CDS are that, first, the latter already incorporate default risk premium and, second, CDS are natural hedging instruments against the risk of corporate default. We then develop the valuation of all forms of asset financing, including secured loans, leases, securitization vehicles, such as EETC tranches, and export credit guarantees, as hybrid contingent claims on the credit of the borrower and the collateral asset, taking into account the realities of the asset repossession process. The recoveries in the event of default for various forms of secured financing are seen as options on the asset, with strikes and expirations adjusted by costs and delays of repossession. The result is a model that allows us to determine in a unified fashion lease rates, secured loan spreads, and export credit guarantee premiums, consistent with the CDS spreads, historical asset value statistics, the market price of asset risk, and realities of the repossession process, including costs and delays.

We then imply the market price of asset risk that defines the risk adjustment from the physical to the risk-neutral measure from benchmark capital market financing transactions. Since EETCs are the only public capital markets aircraft financing transactions with publicly available data, with all of the other forms of private aircraft financing, such as bank loans and operating leases, being confidential, we take EETCs as the benchmark transactions and calibrate our model to imply the market price of asset risk from EETCs. In particular, we develop a case study of EETCs issued by Continental Airlines in 2007, imply the market price of risk, and apply our calibrated model to evaluate other forms of financing, including leases, loans, and credit guarantees. Thus, our model allows us to value all forms of financing *relative to and consistent with* the chosen capital markets benchmark. This is similar to how the concept of *implied volatility* is used in derivatives markets. The derivatives models are calibrated first to benchmark exchange-traded options, and then used to price over-the-counter derivatives consistent with these benchmarks. This approach is also supported by the fact that the benchmark capital markets securities can be used as hedging instruments. This makes our model useful to practitioners for consistent pricing and risk management across the entire portfolio of asset financing transactions.

To the best our knowledge, the program of developing a unified modeling framework for all forms of financing of real assets generating a stochastic service flow over a finite economic life undertaken in this paper, from the model through to the implementation and calibration to the market data, has never been attempted in the literature. The existing literature has focused separately either on the valuation of leases or on debt financing, with little overlap. Furthermore, virtually all of the existing literature has primarily focused on real estate. Moreover, the lease valuation literature until recently has focused almost exclusively on the asset value risk and largely ignored the possibility of lessee default, going back to the classic works of Miller and Upton (1976) for a single period, McConnell and Schallheim (1983) in a multi-period discrete time framework, and through to the recent works such as the continuous-time