Research on Valuation of Photovoltaic Power Station’s Earning Right Backed Securitization

Changhui Yang*, Yifei Liu
School of Management, Hefei University of Technology, Hefei, Anhui, 230009, China
yangchanghui@hfut.edu.cn

Abstract. The high cost of financing has always been a problem that hinders the construction of grid-connected PV power station. As a new type of structural financing, asset securitization can help PV power station achieve low-cost financing and effectively solve the problem of financing difficulties. This paper takes the BOC-Shenneng Nankong Assets Special Plan as an example to design a photovoltaic power station’s earning right backed securitization product. It uses data comprised of the income from the on-grid electricity charges of six ground-based photovoltaic power stations, issued by Shenneng Nankong during the years between 2016 to 2021, as the underlying asset of ABS. Taken the characteristics of PV into account, Monte Carlo model is used to predict the distribution of future cash flow of the asset pool, and the NS model is used to fit the term structure of the interest rate, thereby determining the overall issuance amount of ABS products; then the underlying asset, according to the stability of the cash flow of the asset pool, is divided into three tranches with different credit ratings; finally, the issuance scale and coupon rate of different grades of bonds are determined.

1. Introduction
The high cost of financing has always been a problem that hinders the construction of PV power stations. Bank loans used to be the main channel for PV power projects to raise funds. However, due to the large scale of initial investment, long payback period and subsidy arrears in the course of operation, the risk of PV power projects in the early stage is fairly high. As for large power companies, they can rely on their own high-quality assets and high-grade credit ratings to secure loans from commercial banks at benchmark interest rate level. But for small and medium-sized PV power generation enterprises, most of which fail to meet the credit level to raise funds by general means such as bank loans and security issuance. In order to make up for the credit risk premium, the financing cost will rise accordingly. Furthermore, the main source of funds for commercial banks is the short-term or medium-term deposits as well as some financial products with short-term preference, so it is difficult for them to provide huge and long-term funds. Also, the cycle of PV power projects is generally around 20 years, which is likely to result in mismatch between loan term and investment return period, so the bank is reluctant to provide loans in account of prudence.

The construction of PV power stations requires stable, continuous, and low-cost funding to meet the capital demand of the entire project life cycle. PV power generation companies can sell stable and reliable future cash flow (ie, access to electricity tariffs) generated by power stations to SPV(Special Purpose Vehicle),and SPV repackages it into asset-backed securities to be issued to investors, which not only helps achieve the exit of the initial investment capital, but also to ease the financing pressure of originators. Researchers have conducted many useful explorations on the effect of asset securitization upon reducing financing costs of PV. Drew Hyde and Paul Komor found that high financing costs has
largely limited the scale promotion of distributed PV. Due to the lack of low-cost funding sources, it is difficult for photovoltaic power generation to provide affordable and adequate power supply. However, through asset securitization, the stock assets of PV power stations can be converted into standardized securities that are circulated and transferred in the capital market, so that the PV industry has access to sufficient and low-cost capital supply from asset pools such as pension funds and hedge funds[1]. Alafita and Pearce analyzed the feasibility of asset-backed securities and modeled the securitization process of PV projects. The results show that under reasonable assumptions, asset securitization can significantly reduce PV project financing costs[2]. Gao proposed that asset securitization is one of the effective methods to connect the capital market, which contributes to reduce the financing cost of PV power generation projects and revitalize existing assets[3].

In the context above, this paper will focus on design of asset-backed securities with the earning right of PV power stations as the underlying assets. Since the current ABS products of domestic infrastructure earning rights are mostly non-publicly issued on the exchanges, the pricing method lacks a systematic model that can be directly used. Also, there are few scholars in China who have conducted detailed research in this field, so the results of this paper will supplement the existing pricing theory of asset securitization products in China and provide a theoretical basis for the valuation when trading solar ABS products in the future.

2. Literature Review

The theoretical basis for the valuation of asset-backed securities is discounted cash flow model. Therefore, in order to obtain accurate valuation results, it is necessary to make a reasonable forecast of the future cash flow distribution of the underlying assets as well as to properly select the discount rate. Based on the research of relevant scholars, there are two methods to calculate the discounted value of future cash flow: the relative pricing method of risk-free cash flow and credit curve or the absolute pricing method of risk cash flow and risk-free curve.

The relative pricing method includes the static spread method and the option adjustment spread method, which focus on determining the spread corresponding to the risk premium in the yield curve. Yan et al. used the static spread method to valuate the highway earning rights-backed securities, assuming that the interest rate of the ABS product is equal to the risk-free rate plus the risk premium[4]. Ma et al. used data comprised of 49,970 loans, issued by a rural commercial bank during the years between 2012 and 2014, as the underlying asset of ABS and adopted Monte Carlo model to predict the future cash flow of the asset pool, and applied SV model to fit the yield curve[5]. Dunn and McConnell proposed the option adjustment spread method. They found that interest rate fluctuations have an impact on the original debtor's early repayment behavior and default behavior. Through a large number of simulations of different interest rate change paths, the probability of borrowers' prepayment and default behavior under each path is estimated, so as to predict the future cash flow distribution under various interest rate changes[6]. Compared with the static spread method, the option adjustment spread method better compensates for the hypothesis that the original debtor's prepayment rate is a fixed value.

Different from the relative pricing method, the absolute pricing method focuses on the impact of risk on cash flow, and it uses the risk-adjusted cash flow as well as risk-free rate curve to calculate the present value of future cash flows. The main risks include prepayment risk, default credit risk and interest rate risk.

Based on previous studies, Brent and Michael incorporated the borrowing period and seasonal factors into the factors affecting the prepayment risk, which makes the prediction of cash flow distribution more accurate[7]. Qian et al. assumed that the prepayment function obeys the stochastic process, and the interest rate obeys the CIR model of the term structure. The decrease of the interest rate level causes the increase of the prepayment rate, and the formula for estimating the MBS value is derived by solving the partial differential equation[8]. Hürlimann et al. assumed that the borrower has the right to repay the loan in advance, and he acquired a more accurate result of valuation using a simplified binary tree estimation model[9]. Fan et al. found that default is a Poisson jump process determined by the mortgage credit rating information function. They used higher-dimensional Brownian motion to capture the
attribute values of system risk and trait risk to evaluate CDO[10]. Fermanian modeled the portfolio loss process and the repayment process, and he found that the bond tiered product could be valued through a simple "top-down" path[11]. Zhao et al. made a corresponding change based on the single-factor Gaussian Copula model, taking into account the characteristics of the Kaiyuan credit asset securitization product and constructed a new pricing model[12]. Zhang et al. designed ABS products of commercial banks with multiple credit assets and obtained an analytical solution for the value of different grades of bonds based on the optimal capital structure of the cash flow of the asset pool[13]. Cao et al. considered the unique attributes of cultural assets when valuating cultural creative assets. They established a G-Bass random diffusion model to predict the acceptance rate of cultural products, thus solving the problem caused by the unstable cash flow of cultural assets[14].

Since the future cash flow is affected by the features of different asset pool, product pricing should be based on the characteristics of assets to choose an appropriate method. The cash flow of PV power stations mainly comes from grid-connected electricity tariff income. Generally, the operating income of infrastructure follows a certain natural law and is stable, predictable and will not fluctuate greatly year by year. Therefore, PV projects entering the operation period can provide stable, predictable and controllable cash flow. In addition, the power grid company, as a high-credit transaction subject, is the only transaction party for the power producers to settle electricity bills, so the credit risk of future cash flows is extremely low, and there is almost no prepayment for electricity or default risk on electricity bills. Based on the above-mentioned characteristics, the following of this paper puts forward the pricing thoughts of solar ABS products.

3. Model

Assumed that the solar ABS bonds, with annual interest payments and principal repaid at the end of the year, the pricing thoughts and ABS product design are as follows:

The first step is to predict the net cash flow $NCF_t$ of the underlying assets.

The main profit model of ground-based PV power station is that the PV power generation enterprise sign the "Electricity Purchase and Sale Contract" and "Grid-connected Dispatching Agreement" with grid companies and sell all its power generation to them at on-grid price $P$. All PV power stations are capable of producing an annual output of $Q_0$ of electricity per year. Therefore, annual cash inflows can be written as the following:

$$CF_t = Q_0P = Q_0(1-d)^{-1} Mh \cdot PR \cdot P$$  \hspace{1cm} (1)

Where $d$ is a constant annual degradation rate of PV module, $t$ is the number of years, $M$ is the installed capacity, $h$ is the annual effective utilization hours of illumination, and $PR$ is the PV system efficiency.

The cash outflow in the whole life cycle includes initial investment cost, financial cost, operation and maintenance cost, depreciation and related taxes and fees. Assuming that the life period of PV power stations in the asset pool is 25 years and the residue value is 0, annual cash outflow $TC_t$ is given by:

$$TC_t = \begin{cases} -C_{inv} & t = 0 \\ C_{dep} + C_{ope} + C_{fin} + TAX & t = 1, 2, ..., 25 \\ C_{dep} = 25^{-1}C_{inv} \end{cases}$$  \hspace{1cm} (2)

Where $C_{inv}$ is the initial investment cost, $C_{dep}$ is the depreciation of fixed assets of PV power station, $C_{ope}$ is the annual operating cost, $C_{fin}$ is the annual financial cost of bank loans and $TAX$ is the annual tax payable.

The tax payable for ground-based PV power generation mainly includes enterprise income tax, value-added tax and urban land use tax. On the one hand, VAT involves the deduction of input tax, which makes its calculation more complicated. On the other hand, 50% drawback policy of the VAT for PV
power generation products is implemented during the Period of the 13th Five-Year-Plan, which makes the VAT have less effect on the cash outflows, so the VAT is not considered in this article. The annual amount of tax is equal to:

\[ \text{TAX} = (CF_t - C_{\text{ope}} - C_{\text{dep}} - C_{\text{fin}} - t_2) t_1 + t_2 \]  \hspace{1cm} (4)

\[ t_2 = s \cdot P_0 \]  \hspace{1cm} (5)

Where \( t_1 \) is the enterprise income tax rate, \( t_2 \) is the urban land use tax, \( s \) is the actual area of taxable land occupied by PV equipment, and \( P_0 \) is the unit tax applicable to urban land use.

When \( t=0 \), the PV project is in the initial construction period, and the net cash flow generated at this time is:

\[ NCF_t = -C_{\text{inv}} \]  \hspace{1cm} (6)

When \( t=1, 2, \ldots, 25 \), the PV project enters the operation period, and the net cash flow generated at this time is:

\[ NCF_t = CF_t - TC_t = CF_t - C_{\text{ope}} - C_{\text{dep}} - C_{\text{fin}} - \text{TAX} \]  \hspace{1cm} (7)

Using equation (1) (2) (3) (4) (5) (6) (7), annual net cash flows after tax are given by:

\[ NCF_t = \begin{cases} -C_{\text{inv}} \\ Q_0 (1-d)^{t-1} M \cdot PR \cdot P (1-t_1) - (C_{\text{ope}} + C_{\text{fin}} + s \cdot P_0) (1-t_1) + 25^{-1} t_1 C_{\text{inv}} \end{cases} \]  \hspace{1cm} t=0 \]

\[ = \begin{cases} -C_{\text{inv}} \\ Q_0 (1-d)^{t-1} M \cdot PR \cdot P (1-t_1) - (C_{\text{ope}} + C_{\text{fin}} + s \cdot P_0) (1-t_1) + 25^{-1} t_1 C_{\text{inv}} \end{cases} \]  \hspace{1cm} t=1, 2, \ldots, 25 \]  \hspace{1cm} (8)

The second step is to fit the curve of the yield to maturity curve. This article adopts the treasury bond interest rate as risk-free interest rate, and uses the NS model to fit the term structure of China's national debt interest rate. Nelson and Siegel were the first to use parameter fitting method to estimate the term structure model of interest rate and give the empirical equation of forward interest rate [15-16]:

\[ f_t(\tau) = \beta_{\text{01}} + \beta_{\text{12}} e^{(-\lambda_{t\tau})} + \beta_{\text{23}} \lambda_{t\tau} e^{(-\lambda_{t\tau})} \]  \hspace{1cm} (9)

Where \( \tau \) is the term to maturity and \( \lambda \) is a positive time constant. According to the relationship between the spot rate \( R(\tau) \) and the forward rate \( f(\tau) \), the function of \( R(\tau) \) with respect to \( t \) is given by:

\[ R(\tau) = \beta_{\text{01}} + \beta_{\text{12}} \left( \frac{1-e^{(-\lambda_{t\tau})}}{\lambda_{t\tau}} \right) + \beta_{\text{23}} \left( \frac{1-e^{(-\lambda_{t\tau})}}{\lambda_{t\tau}} - e^{(-\lambda_{t\tau})} \right) \]  \hspace{1cm} (10)

Based on the overall credit rating results of underlying assets, find the data of corporate bonds with the same credit rating at the pricing time point, including face interest rate \( m \), maturity date \( N \), bond market price \( P \), spot rate \( r_t \) at time \( t \), and calculate Z-spread of bonds by equation(11):

\[ P = \sum_{t=1}^{N} \frac{m \cdot 100}{(1+r_t + Z)^t} + \frac{100}{(1+r_t + Z)^N} \]  \hspace{1cm} (11)

Superimposing the credit spread on the yield to maturity curve of national debt and the yield to maturity curve corresponding to different credit ratings is obtained.

The third step is to adopt Monte Carlo model to simulate the net cash flows of asset pool and use yield to maturity curve to discount to calculate the \( NAV \) (net asset value).

\[ NAV = \sum_{t=1}^{N} NCF_t \cdot \exp(-r_t t) \]  \hspace{1cm} (12)

The fourth step is to stratify the asset pool through analyzing the fluctuation of cash flow in the asset pool and determine the issuance scale of bonds with different credit grades. Based on Fermanian’s "top-down" sequential bond repayment method, this paper divides the PV power station's earning right backed securities into priority A bonds, sub-priority B bonds and retained Z bonds, with credit grades from A to Z ranging from high to low. Among them, Class A bonds have the lowest credit risk and the
highest credit rating and have the priority to obtain all cash flow. Class B bonds have the second highest credit rating, but the cash flow guarantee for principal repayment and interest payment is not as stable as grade A bonds. Using the yield to maturity curve of bonds with different credit grades fitted by NS model, the issuance scale of A-class bonds and B-class bonds is determined according to equation (12). Z-class bonds are usually held by issuers to provide credit support for other asset-backed securities. After other higher credit-class bonds have distributed the current expected income and principal, the remaining funds will be fully distributed to Z-class bondholders as Z-class income. Therefore, the capital scale of Z-class bonds is the balance of the overall issuance scale minus the issuance scale of other classes of bonds.

The fifth step is to determine the coupon rate of bonds of different grades according to the credit rating results of underlying assets. Assume that except for Z-class bonds, A-class bonds and B-class bonds are issued at par, the issue price is equal to the par value of 100 yuan, and interest is paid once a year. The issue period is consistent with the cash flow period of the underlying assets. The maturity date of the bonds is N, and the coupon rate is M. According to the term structure of the interest rate for bonds with the same credit rating, the yield to maturity at time t is determined as \( R_t \), and the coupon rate for bonds with different grades is equal to:

$$100 = \sum_{j=1}^{N} 100 \cdot m \cdot \exp(-R_j) + 100 \exp(-R_N, N)$$

4. Results and Discussion

On March 18, 2016, the "China's first single solar ABS product was officially listed on the Shenzhen Stock Exchange, with Bank of China Securities Dealer as manager and Shenneng Nanjing Energy Holding Corporation's five-year (from January 21, 2016 to January 21, 2021) income from on-grid electricity charges of six ground-based PV power stations as underlying assets. The total amount of ABS products issued is 1 billion yuan, and the overall credit rating of underlying assets is AAA. The installed capacity involved adds up to 226,800 kilowatts.

Taking the "BOC-Shenneng Nankong" asset special plan as an example, this paper, according to the research thoughts put forward above, is to valuate the securities backed by PV power station's earning right and determine the ABS issuance scale and coupon rate.

The first step is to forecast the net cash flow of the underlying assets in future periods. According to the difference of light conditions, China divides the country into three types of resource areas. The six ground-based PV power stations under the asset special plan are all located in type III resource areas, where the light resources are relatively poor and annual effective utilization hours of illumination is between 1,200 and 1,400. Due to the influence of various factors on the effective utilization hours, there will be certain fluctuations every year. Through the analysis of illumination conditions in the areas where the PV power stations are located, this paper finds that the peak sunshine hours in Jiangsu and Hebei provinces will keep fluctuating up and down within a stable range. Therefore, it is assumed that the effective utilization hours follow normal distribution, with an average of 1,320 hours and a standard deviation of 60 hours. When t= 1, 2, ..., 25, 10,000 groups of \( h \) over the years are randomly generated, and the distribution of one group of \( h \) is shown in figure 1.
This paper further summarizes the variables that affect the net cash flows of PV power generation, and the values are listed in Table 1.

| Variable | Definition | Units     | Value                  |
|----------|------------|-----------|------------------------|
| $P$      | Price of on-grid electricity | yuan/kWh | 1.0                    |
| $M$      | Installed capacity | MW        | 226.8                  |
| $PR$     | PV system efficiency | %/year   | The initial year is 80%, and increases at a rate of 1% per year, and remains unchanged after reaching 90% [17] |
| $d$      | PV system degradation rate | %/year   | 0.5                    |
| $C_{inv}$ | Initial investment cost | yuan     | 1,701,000,000          |
| $C_{ope}$ | Operational cost rate | %/year   | 2                      |
| $C_{fin}$ | Financial expenses | yuan     | Bank loans account for 70% of the initial investment cost, and the loan interest rate is 5% of the industry average |
| $t_1$    | Enterprise income tax rate | %        | 25%, the first 3 years free and the next 3 years reduce by half |
| $s$      | The actual area of taxable land occupied by PV equipment | $m^2$    | 1,882,440              |
| $P_0$    | Unit tax applicable to urban land use | yuan/$m^2$ | 2                      |

The second step is to fit the yield to maturity curve. (1) Fitting the yield to maturity curve of national debt. This paper selects the data of treasury bonds trading on January 31, 2016, and obtains the information of its value date, maturity date, coupon rate, net price (closing price), interest rate, duration, etc., and uses NS model to fit the yield to maturity curve of treasury bonds, as shown in Figure 2. (2) Calculate the credit spread. In this paper, the closing prices of interest-bearing and non-weighted 15 AAA-rated and 15 AA-rated corporate bonds on January 31, 2016 are selected as fitting data, and the Z-spread of each bond is calculated by using Equation (11). The average Z-spread of AAA-rated bonds is 135.34bps, and the average Z-spread of AA-rated bonds is 269.92bps. (3) Overlay the credit spread on the benchmark interest rate to obtain the yield to maturity curve corresponding to different credit ratings, as shown in Figure 3.
The third step is to determine the overall issuance scale based on the net present value. Bring distribution function of annual effective utilization hours of illumination and the values of relevant parameters into equation (7) and use Monte Carlo model to simulate the net cash flow distribution of the asset pool in the next five years. Bring the yield to maturity curve into equation (12) and calculate 10,000 NAVs of underlying assets, and the average value $E(\text{NAV})$ of 10,000 net present values is calculated to be 1.163 million yuan. Since the total amount of funds raised for the special plan is equal to the consideration for the transfer of underlying assets plus the securities issuance fee and the commission of the plan manager and custodian, it is assumed here that the securities issuance fee and commission are ignored, thus determining the overall raising scale of the special plan to be 1.163 billion yuan. Figure 4 shows the distribution of the present value of future cash flows of underlying assets during the existence of the special asset plan.
Figure 4. Distribution of the present value of future cash flow’s simulation results

The fourth step is to determine the issuance scale of bonds with different credit ratings. As shown in Figure 4, the expected net cash flow present value from January 21, 2016 to January 21, 2017 basically obeys normal distribution. The minimum value obtained by simulation is 215 million yuan, and the present value of underlying assets has a 90% probability greater than 10% quantile point 244 million yuan, indicating that the future net cash flow expectation is relatively stable. The most stable cash flow portion of the future income from electricity tariffs should be used as a priority to support Class A bonds, therefore the minimum present value of 215 million yuan simulated is confirmed as the issuance scale of priority Class A bonds to ensure sufficient interest payment. The credit rating that constitutes this portion of cash flow is AAA. The cash flow fluctuation of sub-priority B-class bonds for repayment of capital and interest is larger than that of A-class bonds, so the cash flow with credit rating of AA-grade constitutes the underlying asset of sub-priority B-class bonds. The issuance scale of sub-priority B-grade bonds is determined by subtracting the issuance scale of A-grade bonds from the 10% quantile point. The remainder is retained by the sponsors as C-class bonds. Similarly, simulate the distribution of the present value of expected net cash flows for the next four years and it can be seen from figure 4 that the results of the annual simulation basically obey normal distribution. The distribution of the expected future cash flow NPV simulation results is shown as Table 2.

| Simulation Results | Average Value(yuan) | Minimum Value(yuan) | 10% Quantile Point(yuan) |
|--------------------|---------------------|---------------------|-------------------------|
| 2016.1.21–2017.1.21 | 261,097,799.86      | 215,113,531.15      | 244,607,543.40          |
| 2017.1.21–2018.1.21 | 252,521,541.55      | 208,086,248.01      | 236,586,757.61          |
| 2018.1.21–2019.1.21 | 243,717,714.86      | 200,868,359.16      | 228,351,658.50          |
| 2019.1.21–2020.1.21 | 206,954,794.88      | 170,865,402.80      | 194,012,905.24          |
| 2020.1.21–2021.1.21 | 199,057,542.70      | 164,371,754.88      | 186,618,994.64          |

The fifth step is to determine the coupon rate of bonds of different grades. Assuming that both Class A and Class B bonds are issued at par, using equation (13), the face interest rate of priority Class A $m_A$ is calculated to be 4.687%, and the face interest rate of sub-priority Class B $m_B$ is calculated to be 5.938%.

To sum up, the present value of underlying assets is 1.163 billion yuan, and the ABS product designs such as the issuance scale, proportion and coupon rate of bonds of different grades are shown in Table 3.

| Asset-Backed Securities | Credit Rating | Bond Size (billion yuan) | Proportion (%) | Coupon Rate | Maturity |
|-------------------------|---------------|--------------------------|----------------|-------------|----------|
| Class A                 | AAA           | 0.959                    | 82.46%         | 4.489%      | 3        |
| Class B                 | AA            | 0.131                    | 11.25%         | 5.938%      | 4        |
| Class C                 | None          | 0.073                    | 6.29%          | None        | 5        |

The last is to compare with the current status. The financing scale of the securitized products of Shenneng Nanjing PV power station’s earning right is 1 billion yuan, while the value of the ABS products should be 1.163 billion yuan according to the above calculation results. Through further analysis, this paper considers that the main reasons leading to its actual value higher than the final issue price are:

(1) Based on the structure of special plan as SPV (special purpose vehicle), the legal basis for the asset independence and bankruptcy remote is not strong enough. The risk of asset pool is still borne by
the originator. The expectation of return on investment does not depend on the quality of asset pool, and a true sale is difficult to realize. Secondly, unlike debt assets, entity assets need to take into account factors such as the sustainable operation ability of the underlying assets and intrinsic relationship with the sponsor. It can only realize a certain degree of risk separation, that is, the underlying assets cannot be completely independent of the bankruptcy risk of the originator, which is not conducive to the protection of investors' interests.

(2) The operating cycle of PV power generation projects is generally 20-30 years. However, this plan only takes the net income of five years as the underlying asset, and it cannot cover the capital needs of the whole operating cycle of the project. As a result, the mismatch between long-term assets and short-term funds will aggravate the enterprise’s financial risks. In order to reduce the probability of a risk event, the solar ABS product is priced at a discount. Therefore, its issuance scale of 1 billion yuan does not really correspond to its value of 1.163 billion yuan.

(3) The underlying asset income includes the electricity tariffs income and the national renewable energy power generation subsidy income. The electricity tariffs income is settled on a monthly basis, while the national subsidy income is obtained through declaration, which is settled on a quarterly or semi-annual basis. The allocation period is relatively long, and when the state subsidy allocation fails to be distributed in time, the net cash flow may be insufficient to cover the various expenses payable by the plan as well as the funds for repaying the capital and interest. In order to ensure that the future cash inflow can still cover the expected payment under pressure, the sponsors and security underwriters intentionally reduced the issuing scale of this ABS product.

5. Conclusion
With the continuous decline of PV manufacturing costs and subsidies for PV power generation and the promotion of renewable energy power quota system, the demand of PV power generation enterprises for long-term sources and low-cost capital is becoming more and more increased. Asset securitization, as a new financing tool, has the potential to reduce financing costs and is a feasible way for photovoltaic power generation enterprises to raise funds in the future.

In this paper, the basic structure of ABS is designed, with the income from the on-grid electricity charges of six ground-based PV power stations as the underlying asset. In the empirical study, we take BOC Securities-Shenneng Nanjing Electric Power Earning Right Asset Support Special Plan as an example, analyzes the expected cash flow income generated by the asset pool in the future, and determines the overall financing amount of ABS products, the issuance scale and coupon rate of bonds of different credit grades.

Subsequent research combined with practical problems could improve the valuation model in the following three aspects: Firstly, the tax cost of asset securitization should be considered. Whether the transfer of underlying assets is determined as sales or financing will lead to different tax results, which will affect the pricing of solar ABS products. Secondly, in determining the issue interest rate, it can be designed as a floating interest rate that changes with the benchmark interest rate, which is more in line with the future trend of changes. The last but not the least, the binomial interest rate path of forward interest rate generated by data simulation can be used to calculate the option adjustment interest rate spread in order to make the prediction result more accurate.

Acknowledgment
The National Natural Science Foundation of China Grant No. 71771076

References
[1] Drew, H., Paul, K. (2014) Distributed PV and Securitization: Made for Each Other. J. Electricity Journal, 27(5):63-70.
[2] Alafita, T., Pearce J.M. (2014) Securitization of Residential Solar Photovoltaic Assets: Costs, risks and uncertainty. J. Energy Policy, 67:488-498.
[3] Gao, Y. (2017) Discussion on Asset Securitization of Photovoltaic Power Station. J. Finance and
Accounting for International Commerce, 04:29-31+34.

[4] Yan, Y., Gu, Y.L., Zhu, X.W. (2016) Research on Asset Securitization of Highway Earning Right. J. Financial Research, 05:111-123.

[5] Ma, J.G., Gong, X.Y., Yan, Y. (2018) Research on Feasibility and Pricing of Securitization of Farmers’ loan assets. J. Journal of Management Science, 21(05):81-89.

[6] Dunn, K., McConnell, J. (1981) Valuation of GNMA Mortgage-backed Securities. J. Journal of Finance, 36(3): 599-617.

[7] Ambrose, B.W., LaCour, M. (2001) Prepayment Risk in Adjustable Rate Mortgages Subject to Initial Year Discounts: Some New Evidence. J. Real Estate Economics, 29(2):305-327.

[8] Qian, X.S., Jiang, L.S., Xu, C.L., Wu, S. (2012) Explicit Formulas for Pricing of Callable Mortgage-backed Securities in a Case of Prepayment Rate Negatively Correlated with Interest rates. J. Journal of Mathematical Analysis and Applications, 393(2):421-433.

[9] Hürlimann, W. (2012) Valuation of Fixed and Variable Rate Mortgages: Binomial Tree versus Analytical Approximations. J. Decisions in Economics and Finance, 35(2):171-202.

[10] Fan, G.Z., Sing, T.F., Ong, S.E. (2012) Default Clustering Risks in Commercial Mortgage-Backed Securities. J. Journal of Real Estate Finance and Economics, 45(1):110-127.

[11] Fermanian, J.D. (2013) A Top-Down Approach for Asset-Backed-Securities: A Consistent Way of Managing Prepayment, Default and Interest Rate Risks. J. Finance and Economics, 46(3):480-515.

[12] Zhao, L., Yu, Y., Meng, Q. (2013) Research on Pricing of Credit Asset Securitization Products. J. Financial Theory and Practice, 03:41-46.

[13] Zhang, Y., Yang, Z.J., Luo, P.F. (2016) Selection of Credit Asset Securitization Model and Product Design. J. Journal of Chinese Management Science, 24(12):1-9.

[14] Cao, H.Y., Li, H., Zhang, X.Y. (2017) Research on G-Bass Stochastic Diffusion Forecast Model for Cultural Asset Securitization Pricing. J. Journal of Engineering Management, 31(01):192-200.

[15] Zhou, Z.K., Wang, N., Yang, H. (2008) Research and Empirical Analysis on Term Structure Model of Chinese National Debt Interest Rate. J. Financial Research, 03:131-150.

[16] Wen, Z.Q. (2013) Empirical Analysis on Term Structure of Interest Rate in China's Inter-bank Bond Market — Based on Nelson-Siegel Model. J. Finance and Trade Research, 24(03):124-129.

[17] He, Y., Pang, Y., Li, X. (2017) Dynamic subsidy model of photovoltaic distributed generation in China. J. Renewable Energy, 118:555-564.