Pricing Bermudan Swaptions In The Libor Market Model

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Bermudan Swaptions in the Libor Market Model

LUIS LILIAN

two approaches to pricing Princeton University Press
This book presents a major innovation in the interest rate space. It explains a financially motivated extension of the LIBOR Market model which accurately reproduces the prices for plain vanilla hedging instruments (swaptions and caplets) of all strikes and maturities produced by the SABR model. The authors show how to accurately recover the whole of the SABR smile surface using their extension of the LIBOR market model. This is not just a new model, this is a new way of option pricing that takes into account the need to calibrate as accurately as possible to the plain vanilla reference hedging instruments and the need to obtain prices and hedges in reasonable time whilst reproducing a realistic future evolution of the smile surface. It removes the hard choice between accuracy and time because the framework that the authors provide reproduces today's market prices of plain vanilla options almost exactly and simultaneously gives a reasonable future evolution for the smile surface. The authors take the SABR model as the starting point for their extension of the LMM because it is a good model for European options. The problem, however with SABR is that it treats each European option in isolation and the processes for the various underlyings (forward and swap rates) do not talk to each other so it isn't obvious how to relate these processes into the dynamics of the whole yield curve. With this new model, the authors bring the dynamics of the various forward rates and stochastic volatilities under a single umbrella. To ensure the absence of arbitrage they derive drift adjustments to be applied to both the forward rates and their volatilities. When this is completed, complex derivatives that depend on the joint realisation of all relevant forward rates can now be priced. Contents THE THEORETICAL SET-UP The Libor Market model The SABR Model The LMM-SABR Model IMPLEMENTATION AND CALIBRATION Calibrating the LMM-SABR model to Market Caplet prices Calibrating the LMM/SABR model to Market Swaption Prices Calibrating the Correlation Structure EMPIRICAL EVIDENCE The Empirical problem Estimating the volatility of the forward rates Estimating the correlation structure Estimating the volatility of the volatility HEDGING Hedging the Volatility Structure Hedging the Correlation Structure Hedging in conditions of market stress
Modeling Derivatives in C++ John Wiley & Sons
The quantitative nature of complex financial transactions makes them a fascinating subject area for mathematicians of all types. This book gives an insight into financial engineering while building on introductory probability courses by detailing one of the most fascinating applications of the subject.
Valuation of Exotic Interest Rate Derivatives - Bermudans and Range Accruals Springer
Manufacturing and Managing Customer-Driven Derivatives Manufacturing and Managing Customer-Driven Derivatives sheds light on customer-driven derivative products and their manufacturing process, which can prove a complicated topic for even experienced financial practitioners. This authoritative text offers up-to-date knowledge and practices across a broad range of topics that address the entire manufacturing, pricing and risk

management process, including practical knowledge and industrial best practices. This resource blends quantitative and business perspectives to provide an in-depth understanding of the derivative risk management skills that are necessary to adopt in the competitive financial industry. Manufacturing and managing customer-driven derivative products have become more complex due to macro factors such as the multi-curve environments triggered by the recent financial crises, stricter regulatory requirements of consistent modelling and managing frameworks, and the need for risk/reward optimisation. Explore the fundamental components of the derivatives business, including equity derivatives, interest rates derivatives, real estate derivatives, and real life derivatives, etc. Examine the life cycle of manufacturing derivative products and practical pricing models Deep dive into a wide range of customer-driven structured derivative products, their investment or hedging payoff features and associated risk exposures Examine the implications of changing regulatory standards, which can increase costs in the banking sector Discover practical yet sophisticated product analysis, quantitative modeling, infrastructure integration, risk analysis, and hedging analysis Gain insight on how banks should handle complex derivatives products Manufacturing and Managing Customer-Driven Derivatives is an essential guide for quants, structurers, derivatives traders, risk managers, business executives, insurance industry professionals, hedge fund managers, academic lecturers, and financial math students who are interested in looking at the bigger picture of the manufacturing, pricing and risk management process of customer-driven derivative transactions.

Simulations and Case Studies A Simple Approach to the Pricing of Bermudan Swaptions in the Multi-Factor Libor Market ModelThis paper considers the pricing of Bermuda-style swaptions in the Libor market model (Brace et al (1997), Jamshidian (1997), Miltersen et al (1997)) and its extensions (Andersen and Andreasen (1998)). Due to its large number of state variables, application of lattice methods to this model class is generally not feasible, and we instead focus on a simple technique to incorporate early exercise features into the Monte Carlo method. Our approach involves a direct search for an early exercise boundary parametrized in intrinsic value and the values of still-alive swaptions. We compare results of the proposed algorithm against prices obtained from Markov Chain approximations and finite difference methods. The proposed algorithm is fast and robust, and produces a lower bound on Bermuda swaption prices that appears to be very tight for many realistic structures. The paper contains several numerical results against which other methods can be tested.Pricing Bermudan Swaptions in the LIBOR Market ModelBermudan Swaptions in the Libor Market ModelBermudan swaptions have until recently been valued using only one-factor models such as the Black-Derman-Toy (BDT) or Black-Karasinski (BK) models. The LIBOR Market (LM) model which is a more general multi-factor model is becoming increasingly popular as a benchmark model. Whereas the BDT and BK models can be approximated using a lattice facilitating easy valuation of Bermudan swaption, the LM model doesn't conform to the lattice framework and as such the valuation seems very difficult. Monte-Carlo simulation is a popular alternative to the lattice framework for derivatives valution. In order to facilitate valuation of Bermudan swaptions the Monte-Carlo simulation technique must be extended. A few methods doing this are presently available, eg [And98]. A common feature of these methods is that the estimated option premia are only lower bounds on the true premia. The Stochastic Mesh method proposed by [BG97b] for valuation of Bermudan (equity) options with applications to equity options provides a lower and an upper bound. We have applied this method to the LM model and use this to verify the premia found by Andersen. We will also apply the approach suggested in [LS98] to the LM model and verify the premia found using that approach. As it turns out this approach is a special case of the [And98] approach.Furthermore we also examine the impact on the Bermudan swaption premia when moving from a LM model with only one factor to a LM model with multiple factors and do indeed find a significant--but not dramatic--impact. We find the [And98] and [LS98] approaches to be mutually consistent and in line with results obtained from low-biased Stochastic Mesh estimates.Pricing of Bermudan Swaptions Under OIS DiscountingFactor Dependence of Bermudan Swaption PricesFact or Fiction?This paper investigates the effect of interest rate correlation in the pricing of Bermudan swaptions. Investigating both Gaussian Markov models and Libor Market models, we find that Bermudan swaption prices depend only weakly on the number of factors in the underlying interest rate model. Moreover, we find that prices of standard Bermudan swaptions typically decrease slightly in the number of factors, primarily a consequence of effects on the time evolution of volatility induced by calibration of the model dynamics. Our findings are markedly different from those of Longstaff, Schwarz, and Santa-Clara (1999) who conclude that single-factor interest rate models significantly undervalue Bermudan swaptions. We argue that the conclusions of Longstaff, Schwarz, and Santa-Clara are due to non-standard choices of model dynamics and calibration methodology. Our study highlights the importance of using a reasonable set of calibration instruments when applying and comparing interest rate models.Monte Carlo Methods for Pricing and HedgingApplications to Bermudan Swaptions and Convertible BondsBermudan swaptionstwo approaches to pricingPricing of Bermudan Swaptions Using Calibrated LIBOR Market ModelsPricing Models for Bermudan-style Interest Rate DerivativesChoice of One Factor Interest Rate Term Structure Models for Pricing and Hedging Bermudan SwaptionsModeling Derivatives in C++

An authoritative handbook on risk management techniques and simulations as applied to financial engineering topics, theories, and statistical methodologies The Handbook of Financial Risk Management: Simulations and Case Studies illustrates the practical implementation of simulation techniques in the banking and financial industries through the use of real-world applications. Striking a balance between theory and practice, the Handbook of Financial Risk Management: Simulations and Case Studies demonstrates how simulation algorithms can be used to solve practical problems and showcases how accuracy and efficiency in implementing various simulation methods are indispensable tools in risk management. The book provides the reader with an intuitive understanding of financial risk management and deepens insight into those financial products that cannot be priced traditionally. The Handbook of Financial Risk Management also features: Examples in each chapter derived from consulting projects, current research, and course instruction Topics such as volatility, fixed-income derivatives, LIBOR Market Models, and risk measures Over twenty-four recognized simulation models Commentary, data sets, and computer subroutines available on a chapter-by-chapter basis As a complete reference for practitioners, the book is useful in the fields of finance, business, applied statistics, econometrics, and engineering. The Handbook of Financial Risk Management is also an excellent text or supplement for graduate and MBA-level students in courses on financial risk management and simulation.

Irregular Grid Methods for Pricing High-dimensional Amercian Options Columbia University Press

The first swap was executed over thirty years ago. Since then, the interest rate swaps and other derivative markets have grown and diversified in phenomenal directions. Derivatives are used today by a myriad of institutional investors for the purposes of risk management, expressing a view on the market, and pursuing market opportunities that are otherwise unavailable using more traditional financial instruments. In this volume, Howard Corb explores the concepts behind interest rate swaps and the many derivatives that evolved from them. Corb's book uniquely marries academic rigor and real-world trading experience in a compelling, readable style. While it is filled with sophisticated formulas and analysis, the volume is geared toward a wide range of readers searching for an in-depth understanding of these markets. It serves as both a textbook for students and a must-have reference book for practitioners. Corb helps readers develop an intuitive feel for these products and their use in the market, providing a detailed introduction to more complicated trades and structures. Through examples of financial structuring, readers will come away with an understanding of how derivatives products are created and how they can be deconstructed and analyzed effectively.

In the Presence of Counterparty Credit Risk for the Fixed-Income Market John Wiley & Sons

This article presents a novel approach for calculating swap vega per bucket in the Libor BGM model. We show that for some forms of the volatility an approach based on re-calibration may lead to a large uncertainty in estimated swap vega, as the instantaneous volatility structure may be distorted by re-calibration. This does not happen in the case of constant swap rate volatility. We then derive an alternative approach, not based on re-calibration, by comparison with the swap market model. The strength of the method is that it accurately estimates vegas for any volatility function and at a low number of simulation paths. The key to the method is that the perturbation in the Libor volatility is distributed in a clear, stable and well understood fashion, whereas in the re-calibration method the change in volatility is hidden and potentially unstable.

On the Suboptimality of Single-Factor Exercise Strategies for Bermudan Swaptions Springer Science & Business Media

The class of interest rate models introduced by O. Cheyette in 1994 is a subclass of the general HJM framework with a time dependent volatility parameterization. This book addresses the above mentioned class of interest rate models and concentrates on the calibration, valuation and sensitivity analysis in multifactor models. It derives analytical pricing formulas for bonds and caplets and applies several numerical valuation techniques in the class of Cheyette model, i.e. Monte Carlo simulation, characteristic functions and PDE valuation based on sparse grids. Finally it focuses on the sensitivity analysis of Cheyette models and derives Model- and Market Greeks. To the best of our knowledge, this sensitivity analysis of interest rate derivatives in the class of Cheyette models is unique in the literature. Up to now the valuation of interest rate derivatives using PDEs has been restricted to 3 dimensions only, since the computational effort was too great. The author picks up the sparse grid technique, adjusts it slightly and can solve high-dimensional PDEs (four dimensions plus time) accurately in reasonable time. Many topics investigated in this book are new areas of research and make a significant contribution to the scientific community of financial engineers. They also represent a valuable development for practitioners.

Interest Rate Swaps and Other Derivatives World Scientific

This paper studies the effect of forward rate correlations on caplet and swaption prices. A two-factor HJM lognormal model of forward rates that implies a realistic covariance matrix of forward rates is constructed. A one-factor lognormal model, with the same forward rate volatilities as the two-factor one, is employed for comparison purposes. The one- and two-factor models price European caplets identically. The one-factor model overprices European swaptions as expected. But the magnitude of overpricing is surprisingly small, less than three percent for at-the-money swaptions on five-year semi-annual swaps. The overpricing is less for shorter swap lengths. The surprising result is that the one-factor model underprices both American caplets and American-type swaptions. Five-year at-the-money American caplets on six-month rates are underpriced by as much as twelve percent and three-year at-the-money constant maturity Bermudan swaptions on two-year semi-annual swaps by as much as ten percent. The underpricing is relatively low for six-month and one-year options but increases with option maturity and forward rate decorrelation. Unlike constant maturity Bermudan swaptions, regular Bermudan swaptions are overpriced by the one-factor model by more than four percent in the case of three-year maturity swaptions. An intuitive explanation for the underpricing of American options under the one-factor model is offered. This explanation implies that American options on any type of interest rate security would be underpriced if perfect correlation across the forward rate term structure is assumed.

Risk Managing Bermudan Swaptions in the Libor BGM Model John Wiley & Sons

This paper investigates the effect of interest rate correlation in the pricing of Bermudan swaptions. Investigating both Gaussian Markov models and Libor Market models, we find that Bermudan swaption prices depend only weakly on the number of factors in the underlying interest rate model. Moreover, we find that prices of standard Bermudan swaptions typically decrease slightly in the number of factors, primarily a consequence of effects on the time evolution of volatility induced by calibration of the model dynamics. Our findings are markedly different from those of Longstaff, Schwarz, and Santa-Clara (1999) who conclude that single-factor interest rate models significantly undervalue Bermudan swaptions. We argue that the conclusions of Longstaff, Schwarz, and Santa-Clara are due to non-standard choices of model dynamics and calibration methodology. Our study highlights the importance of using a reasonable set of calibration instruments when applying and comparing interest rate models.

theory and empirical evidence World Scientific

"The three volumes of Interest rate modeling are aimed primarily at practitioners working in the area of interest rate derivatives, but much of the material is quite general and, we believe, will also hold significant appeal to researchers working in other asset classes. Students and academics interested in financial engineering and applied work will find the material particularly useful for its description of real-life model usage and for its expansive discussion of model calibration, approximation theory, and numerical methods."--Preface.

The SABR/LIBOR Market Model John Wiley & Sons

This paper compares the pricing and hedging performance of the LMM model against two spot-rate models, namely Hull-White and Black-Karasinski, and the more recent Swap Market Model from an Asset-Liability-Management (ALM) perspective. In contrast to previous studies in the literature, our emphasis here is on ALM and we use hedging performance on Bermudan swaptions to proxy risk management outcome of long-term mortgage loans. Our tests involve calibrating the four interest rate models to European swaption prices for EURO and USD over the period February 2005 to September 2007. The calibrated models are then used to price and hedge a constant 11-year Bermudan swaption portfolio using a series of interest rate swaps and a 1-year holding-revision period. Our empirical results show that, the calibrated parameters of all four models are stable and their

pricing errors are small and comparable. No single model dominates in the pricing exercise. The hedging performance of all four models is similar for the Euro market. For the USD market, the short rate models perform marginally better than SMM and LMM. The HW model is marginally better than BK model in terms of model parameter stability and smaller pricing and hedging errors.

Pricing, Calibration and Hedging for Complex Interest-Rate Derivatives John Wiley & Sons

In this paper we examine the cost of using recalibrated single-factor models to determine the exercise strategy for Bermudan swaptions in a multi-factor world. We demonstrate that single-factor exercise strategies applied in a multi-factor world only give rise to economically insignificant losses. Furthermore, we find that the conditional model risk as defined in Longstaff, Santa-Clara amp;amp; Schwartz (2001), is statistically insignificant given the number of observations. Additional tests using the Primal-Dual algorithm of Andersen amp;amp; Broadie (2001) indicate that losses found in Longstaff et al. (2001) cannot as claimed be ascribed to the number of factors. Finally we find that for valuation of Bermudan swaptions with long exercise periods, the simple approach proposed in Andersen (2000) is outperformed by the Least Square Monte Carlo method of Longstaff amp;amp; Schwartz (2001) and, surprisingly, also by the exercise strategies from the single-factor models.

Monte Carlo Methods for Pricing and Hedging World Scientific

Exotic interest rate derivatives are hard to value. Care must be taken to make sure that sources of volatility that impact the contingent claim are properly modeled, and that appropriate relationships are maintained between the underlying rates involved.In this presentation, we outline the issues involved in valuing exotics. We review valuation issues for interest rate derivatives in general, and for caps, floors and swaptions. We outline a pricing methodology and apply it to Bermudan swaptions, range accruals, callable range accruals, spread options and callable spread range accruals.Outline: - Review of interest rate modeling - Handling of vanilla options - - Forward Libor and swap rates - - Caps and Floors - - Swaptions - - Cap stripping - - Smile lifting - Bermudan valuation - - Hedging Bermudans - - LGM model specification of the HW model - - Pricing cashflows and options under the LGM model - - Model calibration - - Numerical methods - Digital options - - Pricing via vanillas. - Range accruals - - Pricing as a portfolio of digitals - - Convexity adjustment - Change of measure and approximation - Callable range accruals - - Pricing under the one factor LGM model - - - Model calibration. - - - Use of control variates (adjusters). - - Calibration and pricing under the two factor LGM model - - - Model calibration. - Spread range accruals - - Pricing under the two factor LGM model.

Pricing Models for Bermudan-style Interest Rate Derivatives CRC Press

We build a multi-factor, no-arbitrage model of the term structure of spot interest rates. The stochastic factors are the short-term interest rate and the premia of the futures rates over the short-term interest rates. In the three-factor version of the model, for example, the first factor is the three-month LIBOR, the second factor is the premium of the first futures LIBOR over spot LIBOR, and the third factor is the incremental premium of the second futures over the first. The model provides an extension of the lognormal interest rate model of Black and Karasinski (1991) to multiple factors, each of which can exhibit mean-reversion.This method is computationally efficient for several reasons. First, we suggest calibrating the model to LIBOR futures prices, which enables us to satisfy the no-arbitrage condition without resorting to iterative methods. Second, we modify and implement the binomial approximation methodology of Nelson and Ramaswamy (1990) and Ho, Stapleton and Subrahmanyam (1995) to compute a multi-period tree of rates with the no-arbitrage property. The method uses a recombining two or three-dimensional binomial lattice of interest rates that minimizes the number of states and term structures over time. In addition to these computational advantages, a key feature of the model is that it is consistent with the observed term structure of futures rates as well as the term structure of volatilities implied by the prices of interest rate caps and floors. We use the model to price European-style and Bermuda-style swaptions and yield-spread options.To implement the methodology, we first calibrate the model to the caplet implied-volatility curve on a given day, and then use the model to price European-style swaptions. We find that the two-factor model, where the LIBOR mean reverts rapidly to a slowly mean-reverting second factor, overprices the swaptions relative to market quotations. However, introducing a third factor significantly reduces the overpricing. The calibrated model is used to price Bermudan-style swaptions and yield-spread options. Then, we re-calibrated the two-factor model simultaneously to caplet and swaption prices and use the model output to price Bermudan-style swaptions.

Explicit European Swaption Formula in a Separable One-Factor Libor Market Model; Extension to Bond Futures and 2-Bermudan Swaptions CRC Press

This book contains lectures delivered at the celebrated Seminar in Mathematical Finance at the Courant Institute. The lecturers and presenters of papers are prominent researchers and practitioners in the field of quantitative financial modeling. Most are faculty members at leading universities or Wall Street practitioners. The lectures deal with the emerging science of pricing and hedging derivative securities and, more generally, managing financial risk. Specific articles concern topics such as option theory, dynamic hedging, interest-rate modeling, portfolio theory, price forecasting using statistical methods, etc. Contents:Estimation and Data-Driven Models:Transition Densities for Interest Rate and Other Nonlinear Diffusions (Y Aït-Sahalia)Hidden Markov Experts (A Weigend & S-M Shi)When is Time Continuous? (A Lo et al.)Asset Prices are Brownian Motion: Only in Business Time (H Geman et al.)Hedging Under Stochastic Volatility (K Ronnie Sircar)Model Calibration and Volatility Smile:Determining Volatility Surfaces and Option Values from an Implied Volatility Smile (P Carr & D Madan)Reconstructing the Unknown Local Volatility Function (T Coleman et al.)Building a Consistent Pricing Model from Observed Option Prices (J-P Laurent & D Leisen)Weighted Monte Carlo: A New Technique for Calibrating Asset-Pricing Models (M Avellaneda et al.)Pricing and Risk Management:One- and Multi-Factor Valuation of Mortgages: Computational Problems and Shortcuts (A Levin)Simulating Bermudan Interest-Rate Derivatives (P Carr & G Yang)How to Use Self-Similarities to Discover Similarities of Path-Dependent Options (A Lipton)Monte Carlo Within a Day (J Cárdenas et al.)Decomposition and Search Techniques in Disjunctive Programs for Portfolio Selection (K Wyatt) Readership: Students and researchers in economics, finance and applied mathematics. Keywords:

Pricing of Bermudan Swaptions Under OIS Discounting Springer Science & Business Media

This paper considers the pricing of Bermuda-style swaptions in the Libor market model (Brace et al (1997), Jamshidian (1997), Miltersen et al (1997)) and its extensions (Andersen and Andreasen (1998)). Due to its large number of state variables, application of lattice methods to this model class is generally not feasible, and we instead focus on a simple technique to incorporate early exercise features into the Monte Carlo method. Our approach involves a direct search for an early exercise boundary parametrized in intrinsic value and the values of still-alive swaptions. We compare results of the proposed algorithm against prices obtained from Markov Chain approximations and finite difference methods. The proposed algorithm is fast and robust, and produces a lower bound on Bermuda swaption prices that appears to be very tight for many realistic structures. The paper contains several numerical results against which other methods can be tested.

A Simple Approach to the Pricing of Bermudan Swaptions in the Multi-Factor Libor Market Model Oxford University Press

This book introduces the mathematics of stochastic interest rate modeling and the pricing of related derivatives, based on a step-by-step presentation of concepts with a focus on explicit calculations. The types of interest rates considered range from short rates to forward rates such as LIBOR and swap rates, which are presented in the HJM and BGM frameworks. The pricing and hedging of interest rate and fixed income derivatives such as bond options, caps, and swaptions, are treated using forward measure techniques. An introduction to default bond pricing and an outlook on model calibration are also included as additional topics.This third edition represents a significant update on the second edition published by World Scientific in 2012. Most chapters have been reorganized and largely rewritten with additional details and supplementary solved exercises. New graphs and simulations based on market data have been included, together with the corresponding R codes.This new edition also contains 75 exercises and 4 problems with detailed solutions, making it suitable for advanced undergraduate and graduate level students.

Interest Rate Derivatives

This book discusses the state-of-the-art and open problems in computational finance. It presents a collection of research outcomes and reviews of the work from the STRIKE project, an FP7 Marie Curie Initial Training Network (ITN) project in which academic partners trained early-stage researchers in close cooperation with a broader range of associated partners, including from the private sector. The aim of the project was to arrive at a deeper understanding of complex (mostly nonlinear) financial models and to develop effective and robust numerical schemes for solving linear and nonlinear problems arising from the mathematical theory of pricing financial derivatives and related financial products. This was accomplished by means of financial modelling, mathematical analysis and numerical simulations, optimal control techniques and validation of models. In recent years the computational complexity of mathematical models employed in financial mathematics has witnessed tremendous growth. Advanced numerical techniques are now essential to the majority of present-day applications in the financial industry. Special attention is devoted to a uniform methodology for both testing the latest achievements and simultaneously educating young PhD students. Most of the mathematical codes are linked into a novel computational finance toolbox, which is provided in MATLAB and PYTHON with an open access license. The book offers a valuable guide for researchers in computational finance and related areas, e.g. energy markets, with an interest in industrial mathematics.

Generic Market Models

In the framework of the Libor Market Model (LMM) an explicit pricing formula is obtained for European swaptions. The LLM used is a displaced diffusion also called Bond Market Model (BMM). The results are similar to the one obtained for the Gaussian HJM. The extension to bond futures and 2-Bermuda swaptions is also provided.

With Smile, Inflation and Credit

This book addresses selected practical applications and recent developments in the areas of quantitative financial modeling in derivatives instruments, some of which are from the authorsOCO own research and practice. While the primary scope of this book is the fixed-income market (with further focus on the interest rate market), many of the methodologies presented also apply to other financial markets, such as the credit, equity, and foreign exchange markets. This book, which assumes that the reader is familiar with the basics of stochastic calculus and derivatives modeling, is written from the point of view of financial engineers or practitioners, and, as such, it puts more emphasis on the practical applications of financial mathematics in the real market than the mathematics itself with precise (and tedious) technical conditions. It attempts to combine economic insights with mathematics and modeling so as to help the reader develop intuitions. In addition, the book addresses the counterparty credit risk modeling, pricing, and arbitraging strategies, which are relatively recent developments and are of increasing importance. It also discusses various trading structuring strategies and touches upon some popular credit/IR/FX hybrid products, such as PRDC, TARN, Snowballs, Snowbears, CCDS, credit extinguishers."