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Research Booklet

# Research questions:

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## Context article:

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| Source number | 1 |
| Source | **Notes** |
|  | The **Black–Scholes** [/ˌblæk ˈʃoʊlz/](https://en.wikipedia.org/wiki/Help:IPA/English)[[1]](https://en.wikipedia.org/wiki/Black%E2%80%93Scholes_model#cite_note-1) or **Black–Scholes–Merton model** is a [mathematical model](https://en.wikipedia.org/wiki/Mathematical_model) for the dynamics of a [financial market](https://en.wikipedia.org/wiki/Financial_market) containing [derivative](https://en.wikipedia.org/wiki/Derivative_(finance)) investment instruments. From the [partial differential equation](https://en.wikipedia.org/wiki/Partial_differential_equation) in the model, known as the [Black–Scholes equation](https://en.wikipedia.org/wiki/Black%E2%80%93Scholes_equation), one can deduce the **Black–Scholes formula**, which gives a theoretical estimate of the price of [European-style](https://en.wikipedia.org/wiki/Option_style) [options](https://en.wikipedia.org/wiki/Option_(finance)) and shows that the option has a *unique* price regardless of the risk of the security and its expected return (instead replacing the security's expected return with the [risk-neutral](https://en.wikipedia.org/wiki/Risk-neutral) rate). The formula led to a boom in options trading and provided mathematical legitimacy to the activities of the [Chicago Board Options Exchange](https://en.wikipedia.org/wiki/Chicago_Board_Options_Exchange) and other options markets around the world.[[2]](https://en.wikipedia.org/wiki/Black%E2%80%93Scholes_model#cite_note-mackenzie-2) It is widely used, although often with some adjustments, by options market participants.[[3]](https://en.wikipedia.org/wiki/Black%E2%80%93Scholes_model#cite_note-bodie-kane-marcus-3):751  Based on works previously developed by market researchers and practitioners, such as [Louis Bachelier](https://en.wikipedia.org/wiki/Louis_Bachelier), [Sheen Kassouf](https://en.wikipedia.org/wiki/Sheen_Kassouf) and [Ed Thorp](https://en.wikipedia.org/wiki/Edward_Thorp) among others, [Fischer Black](https://en.wikipedia.org/wiki/Fischer_Black) and [Myron Scholes](https://en.wikipedia.org/wiki/Myron_Scholes) demonstrated in the late 1960s that a dynamic revision of a portfolio removes the expected return of the security, thus inventing the *risk neutral argument*.[[4]](https://en.wikipedia.org/wiki/Black%E2%80%93Scholes_model#cite_note-4)[[5]](https://en.wikipedia.org/wiki/Black%E2%80%93Scholes_model#cite_note-5) In 1970, after they attempted to apply the formula to the markets and incurred financial losses due to lack of [risk management](https://en.wikipedia.org/wiki/Risk_management) in their trades, they decided to focus in their domain area, the academic environment.[[6]](https://en.wikipedia.org/wiki/Black%E2%80%93Scholes_model#cite_note-6) After three years of efforts, the formula named in honor of them for making it public, was finally published in 1973 in an article entitled "The Pricing of Options and Corporate Liabilities", in the [*Journal of Political Economy*](https://en.wikipedia.org/wiki/Journal_of_Political_Economy).[[7]](https://en.wikipedia.org/wiki/Black%E2%80%93Scholes_model#cite_note-7)[[8]](https://en.wikipedia.org/wiki/Black%E2%80%93Scholes_model#cite_note-8)[[9]](https://en.wikipedia.org/wiki/Black%E2%80%93Scholes_model#cite_note-9) [Robert C. Merton](https://en.wikipedia.org/wiki/Robert_C._Merton) was the first to publish a paper expanding the mathematical understanding of the options pricing model, and coined the term "Black–Scholes [options pricing](https://en.wikipedia.org/wiki/Options_pricing) model". Merton and Scholes received the 1997 [Nobel Memorial Prize in Economic Sciences](https://en.wikipedia.org/wiki/Nobel_Memorial_Prize_in_Economic_Sciences) for their work, the committee citing their discovery of the risk neutral dynamic revision as a breakthrough that separates the option from the risk of the underlying security.[[10]](https://en.wikipedia.org/wiki/Black%E2%80%93Scholes_model#cite_note-10) Although ineligible for the prize because of his death in 1995, Black was mentioned as a contributor by the Swedish Academy.[[11]](https://en.wikipedia.org/wiki/Black%E2%80%93Scholes_model#cite_note-11)  The key idea behind the model is to [hedge](https://en.wikipedia.org/wiki/Hedge_(finance)) the option by buying and selling the underlying asset in just the right way and, as a consequence, to eliminate risk. This type of hedging is called "continuously revised [delta hedging](https://en.wikipedia.org/wiki/Delta_hedging)" and is the basis of more complicated hedging strategies such as those engaged in by [investment banks](https://en.wikipedia.org/wiki/Investment_bank) and [hedge funds](https://en.wikipedia.org/wiki/Hedge_fund).  The model's assumptions have been relaxed and generalized in many directions, leading to a plethora of models that are currently used in derivative pricing and risk management. It is the insights of the model, as exemplified in the [Black–Scholes formula](file:////wiki/Black%25E2%2580%2593Scholes_formula%23Black–Scholes_formula), that are frequently used by market participants, as distinguished from the actual prices. These insights include [no-arbitrage bounds](https://en.wikipedia.org/wiki/No-arbitrage_bounds) and [risk-neutral pricing](https://en.wikipedia.org/wiki/Risk-neutral_measure) (thanks to continuous revision). Further, the [Black–Scholes equation](https://en.wikipedia.org/wiki/Black%E2%80%93Scholes_equation), a partial differential equation that governs the price of the option, enables pricing using [numerical methods](https://en.wikipedia.org/wiki/Numerical_methods) when an explicit formula is not possible.  The Black–Scholes formula has only one parameter that cannot be directly observed in the market: the average future volatility of the underlying asset, though it can be found from the price of other options. Since the option value (whether put or call) is increasing in this parameter, it can be inverted to produce a "[volatility surface](https://en.wikipedia.org/wiki/Volatility_surface)" that is then used to calibrate other models, e.g. for [OTC derivatives](https://en.wikipedia.org/wiki/Derivative_(finance)#OTC_and_exchange-traded). |
| Key points/summary | |
| * Black-Scholes-Merton model gives the theoretical estimate of the price of European-style options and shows that the option has a unique price regardless of the risk of the security and its respected return * Late 1960s, Fischer Black and Myron Scholes demonstrated dynamic update of a portfolio removes the expected return of the security 🡪 risk neutral argument * Published in 1973 in an article entitled “The Pricing of Options and Corporate Liabilities” * This was a discovery of the risk neutral dynamic revision as a breakthrough that separates the option from the risk of the underlying security * The Black-Scholes equation, a partial differential equation that governs the price of the option, enables pricing using numerical methods when an explicit formula is not possible * European call/put options you can only exercise it on the exercise date | |