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EXTRAPOLATION USAGE FOR PREDICTING CRYPTOCURRENCY PRICING

ВИКОРИСТАННЯ ЕКРАПОЛЯЦІЇ ДЛЯ ПРОГНОЗУВАННЯ ЦІНОУТВОРЕННЯ БІТКОЇНА

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In this article, we delve into the challenging problem of forecasting cryptocurrency prices using mathematical extrapolation techniques. We highlight the scarcity of research in this domain, underlining the necessity for in-depth investigation. The article outlines the unresolved issues related to extrapolation-based cryptocurrency price prediction, such as market volatility and non-linearity. It primarily aims to showcase the potential of extrapolation for predicting bitcoin prices. The analysis involves a year-long bitcoin price trend, with the application of linear and polynomial extrapolation methods. While some correlation exists, notable discrepancies, especially during abrupt price changes, are evident. The conclusion emphasizes the limitations of extrapolation and advises a diversified approach to cryptocurrency investment decisions, considering various factors beyond mathematical data. In this article, we delve into the challenging problem of forecasting cryptocurrency prices using mathematical extrapolation techniques. We highlight the scarcity of research in this domain, underlining the necessity for in-depth investigation. The article outlines the unresolved issues related to extrapolation-based cryptocurrency price prediction, such as market volatility and non-linearity. It primarily aims to showcase the potential of extrapolation for predicting bitcoin prices. The analysis involves a year-long bitcoin price trend, with the application of linear and polynomial extrapolation methods. While some correlation exists, notable discrepancies, especially during abrupt price changes, are evident. The conclusion emphasizes the limitations of extrapolation and advises a diversified approach to cryptocurrency investment decisions, considering various factors beyond mathematical data.

Keywords: economy, crypto, cryptocurrencies, BTC, extrapolation, approximation.

У цій статті досліджується актуальне завдання прогнозування цін на криптовалюту, зокрема біткоїн, використовуючи математичні методи екстраполяції. Стаття розпочинається зі сформульовання загальної проблеми, яка полягає в розробці прогнозних моделей для точного передбачення майбутніх цін на криптовалюту в різні періоди часу, від короткострокових (години до днів) до довгострокових (тижні, місяці або навіть роки). В стислому, задача передбачення цін на криптовалюту включає збір та попередню обробку даних, вибір та навчання прогностичних моделей, оцінку їхньої ефективності та впровадження їх у практику, при цьому враховуючи аспекти управління ризиками та етичні вимоги. Ця задача є багатодисциплінарною і вимагає спеціалістів у галузі науки про дані, фінансів та знань у сфері криптовалютних ринків. Стаття наголошує на обмеженому обсязі наукових робіт, присвячених вивченню криптовалют та математичних моделей у цьому контексті. Один із згаданих дослідників – Раліца Петкова, разом з іншими співавторами – Джетіном Абрахамом, Деніелом Хігдоном, Джеком Нельсоном та Хуаном Ібарра – вказує на актуальність цієї теми. У статті наголошується, що, незважаючи на можливість використання екстраполяції для прогнозування цін на криптовалюту, існують кілька невирішених викликів та обмежень, пов'язаних з цим підходом. Зокрема, висвічуються особливості криптовалютних ринків, такі як їхня нелинійність, волатильність, чутливість до сентименту та новин, а також постійно змінюючийся характер. Дослідники і практики продовжують працювати над вдосконаленням моделей передбачення та вирішенням цих викликів за допомогою поєднання методів, таких як машинне навчання, аналіз сентименту та фундаментальний аналіз. Головна мета статті – продемонструвати можливість використання математичних методів, зокрема екстраполяції, для прогнозування цін на біткоїн. Для підтвердження правильності вибраних методів, проводиться аналіз річного тренду цін на біткоїн та застосування лінійних і поліноміальних методів екстраполяції. Результати представлені у вигляді графічних відображень, що виявляють певну кореляцію з реальними цінами, але також помітні відхилення, особливо під час несподіваних коливань цін.

Ключові слова: економіка, крипто, криптовалюти, BTC, екстраполяція, апроксимація.

Formulation of the problem in general. Given a historical dataset of cryptocurrency price movements and relevant market data, the objective is to develop a predictive model that can estimate future cryptocurrency prices accurately. This predictive model aims to provide forecasts for various time horizons, ranging from short-term (hours to days) to long-term (weeks, months, or even years) predictions. In summary, the problem of predicting cryptocurrency pricing involves collecting and preprocessing data, selecting and training predictive models, evaluating their performance, and deploying them for practical use while considering risk management and ethical considerations. It is a multidisciplinary challenge that requires expertise in data science, finance, and domain knowledge of cryptocurrency markets. In summary, the problem of predicting cryptocurrency pricing involves collecting and preprocessing data, selecting and training predictive models, evaluating their performance, and deploying them for practical use while considering risk management and ethical considerations. It is a multidisciplinary challenge that requires expertise in data science, finance, and domain knowledge of cryptocurrency markets.

Analysis of recent research and publications. There is not a large number of published works devoted to the study of crypto currency and mathematical models. Lienard A., Davies, T. V., and James, E. M., Goursat, E. V., Hedrik, E. R., and Dunkel, O. That's why this topic has to be researched in detail.

Unresolved parts of the common problem. While extrapolation can be used for predicting cryptocurrency pricing, there are several unresolved challenges and limitations associated with this approach. In summary, while extrapolation can be a valuable tool for cryptocurrency price prediction, it is far from a complete solution. Many challenges and unresolved issues stem from the unique characteristics of cryptocurrency markets, including their non-linearity, volatility, sensitivity to sentiment and news, and evolving nature. Researchers and practitioners continue to work on improving prediction models and addressing these challenges through a combination of techniques, including machine learning, sentiment analysis, and fundamental analysis.

The purpose of the article. This article highlights mathematical approaches for bitcoin price predicting. This article shows the expediency of such an application of extrapolation

Presenting main material. By approximate methods we shall mean analytical procedures for developing solutions in the form of functions which are close, in some sense, to the exact, but usually unknown, solution of the nonlinear problem. Therefore numerical methods fall into a separate category (see Chapter 5) since they result in tables of values rather than functional forms. Approximate methods may be divided into three broad interrelated categories; "iterative," "asymptotic," and "weighted residual." The iterative methods include the development of series, methods of successive approximation, rational approximations, and the like. Some form of repetitive calculation via some operation F whose character is $u_{n+1} = [u_n, u_{n-1}, ...]$ successively improves the approximation. Transformation of the equation to an integral equation leads to a natural iterative method. Asymptotic procedures have at their foundation a desire to develop solutions that are approximately valid when a physical parameter (or variable) of the problem is very small, very large or in close proximity to some characteristic value. Typical of these methods are the perturbation procedures both regular and singular [1].

Asymptotic procedures are fundamentally aimed at developing solutions that maintain approximate validity when dealing with a physical parameter (or variable) in a problem, which is either very small, very large, or closely aligned with some characteristic value. These methods commonly include perturbation procedures, both regular and singular, as well as weighted residual methods, possibly originating from the calculus of variations. The latter demands that the approximate solution closely approximates the exact solution, such that the difference between them (the residual) is minimized. Collocation, on the other hand, mandates that the residual becomes zero at predefined points, while Galerkin's method is formulated to ensure that weighted integrals of the residual equal zero. These error distribution techniques are at times referred to as direct methods of the calculus of variations, even though they might not necessarily be associated with a variational problem. Given the inherently approximate nature of these procedures, a critical question arises concerning the accuracy of the approximation. In many instances, convergence theorems exist, suggesting that if an iteration continues indefinitely or if the interval size shrinks without bound, the process will eventually converge to the true solution. While these theorems certainly boost the analyst's confidence, they may not be as practically valuable as a realistic error bound applicable at any stage of computation. Realistic error bounds or estimates are available for certain approximate processes, with perhaps the most well-known being those for the Taylor series and the method of successive approximations for integral equations. In cases where these bounds are unavailable, a common approach to demonstrate the utility of an approximation method is to apply it to a problem with a known exact solution. This allows for the calculation of the error, with the presumption that the method will produce errors of a similar magnitude when applied to similar problems. While this procedure is not ideal, it is sometimes necessary [1].

Some mathematical properties. Equations of order n, n > 1 are reducible to n simultaneous first order equations. This reduction is not unique as will be demonstrated for the third order Blasius equation:

$$w''' + ww'' = 0. \quad (1)$$

One obvious substitution is u = w', v = u' (= w") so that Eq. (1) is equivalent to the three equations:

$$\frac{\partial w}{\partial \eta} = u$$
$$\frac{\partial u}{\partial \eta} = \nu , \quad (2)$$
$$\frac{\partial \nu}{\partial \eta} = -w\nu$$

An alternative to this procedure is to set (say) u = w' + w, v = u' whereupon. Eq. (1) is equivalent to the three equations:

$$\frac{\partial w}{\partial \eta} = u - w$$
$$\frac{\partial u}{\partial \eta} = \nu \quad (3)$$
$$\frac{\partial u}{\partial \eta} = \nu - u + w\left[1 - \nu + u - w\right].$$

Occasionally transformations other than the immediately obvious one that leads to Eqs. (2) may be more convenient. Such a situation occurred in the work of Lienard [2] in his investigation of limit cycles for the general second order equation

$$x'' + f(x)x' + x = 0. \quad (4)$$

Equation (4) may be written as

$$\frac{\partial}{\partial t}\left[\frac{\partial x}{\partial t} + F(x)\right] + x = 0 ,$$

where F'(x) =f(x) and instead of the previous substitutions Lihard writes y = $\frac{\partial x}{\partial t} + F(x)$ whereupon Eq. (4) is equivalent to the two first order equations

$$\frac{\partial x}{\partial t} = y - F(x), \frac{\partial y}{\partial t} = -x. \quad (5)$$

Differential equations are used to model physical phenomena, and they typically fall into two categories: propagation or initial value problems, and equilibrium or boundary value problems.

In an initial value problem, the analyst's task is to predict the system's future behavior based on the initial data and the equation governing the system. On the other hand, in an equilibrium problem, the objective is to find a configuration that satisfies the equation while adhering to specific boundary conditions. These questions often lead to eigenvalue problems, which involve an additional challenge.

In an equilibrium problem, the primary concern is determining the configuration itself. However, in an eigenvalue problem, the analyst must not only find the configuration but also ascertain the value or values of a scalar parameter known as eigenvalues. Some guiding principles in the form of existence and uniqueness theorems are available. These will be stated in the sequel without proof. The interested reader may find various proofs in the work of Davies and James [3], Goursat et al. [4], and Ince [5].

Our general propagation problem may be expressed as a set of governing differential equations.

$$\frac{\partial y_j}{\partial t} = f_j\left(y_1,\ldots y_n,t\right), \quad j = 1,\ldots,n. \quad (6)$$

Subject to the initial conditions $y_j(t_0) = y_{j0}$, for the variables y_j(t). The course of a typical propagating variable in a "well behaved" system might be as shown in Fig. 1. a.

As integration inherently involves a 'smoothing' operation, it is reasonable to anticipate that the functions y_j(t) will typically exhibit a higher degree of smoothness compared to the & functions. However, it's important to note that the solution might not always exist or could lack uniqueness. Certain challenges and complications are illustrated in Figure 1. b-d. The presence of these singularities is not always readily apparent, but it is advisable to remain vigilant for their potential occurrence.

Having such information, let's apply this knowledge to predict bitcoin pricing. To validate the correctness of chosen methods, let's analyze already known data, in our case it's the bitcoin price trend during 1 year (graph 1).

Let's choose 2 different extrapolation methods: linear [6] and polynomials [7].

We performed an analysis by utilizing the three most recent data points, consisting of both date and price, to predict the next point using extrapolation methods. Subsequently, we compared these predicted points with the already known data, repeating the same procedure for all known data points. As a result, 2 charts which represent the "predicted" chart. (Graph 2, Graph 3).

Let's examine how the actual price trend and the predicted price are displayed together on the same graph (Graph 4).

Here we can see some correlation with real price, but let's take a closer look at these graphs and estimate the errors of each of the approximation methods. Here we see a significant deviation from the real price (especially polynomial method) (Graph 5, Graph 6). Especially we can see it when price unexpectedly extremely decrease.

Conclusions. Let's summarize, extrapolation it's mathematical method which takes into account only mathematical data (data points) and analyze it and don't count other important reason which can effect on price, such:

– Data Quality and Reliability: Extrapolation assumes that past price trends will continue, which depends on the quality and reliability of the historical data. Cryptocurrency markets are known for their volatility and susceptibility to

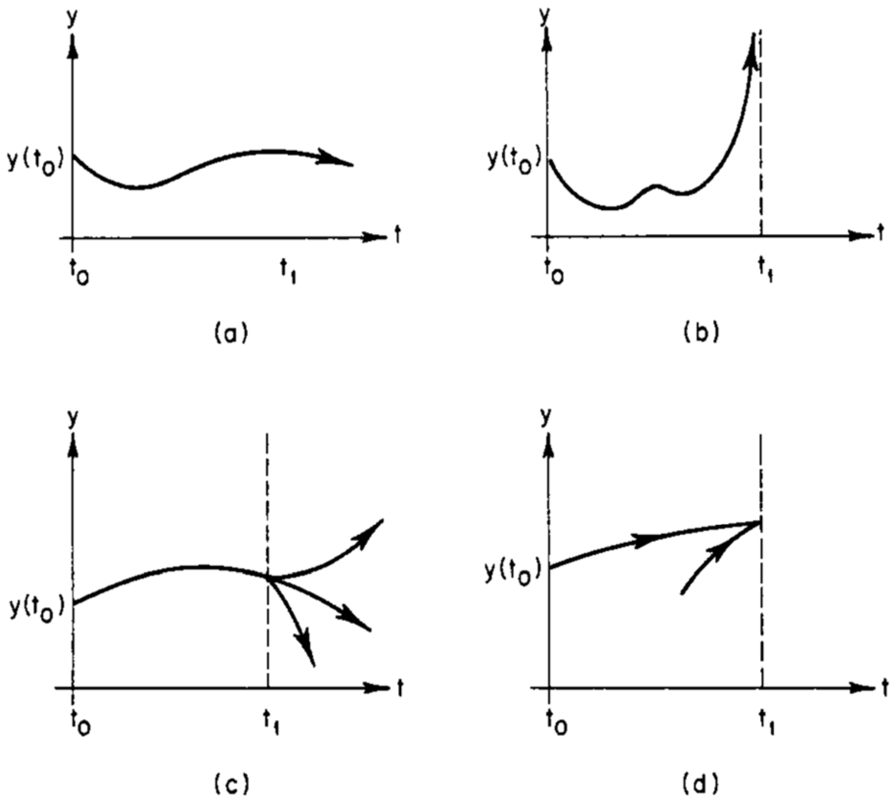
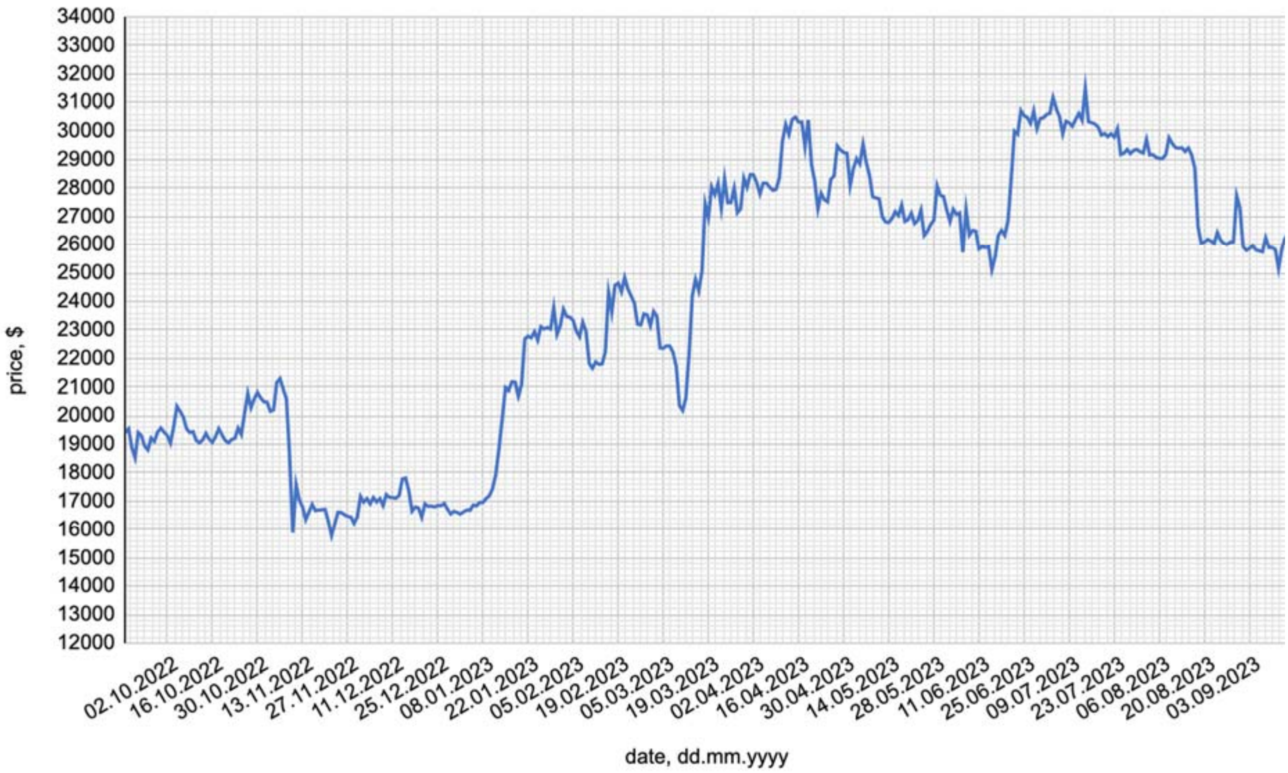
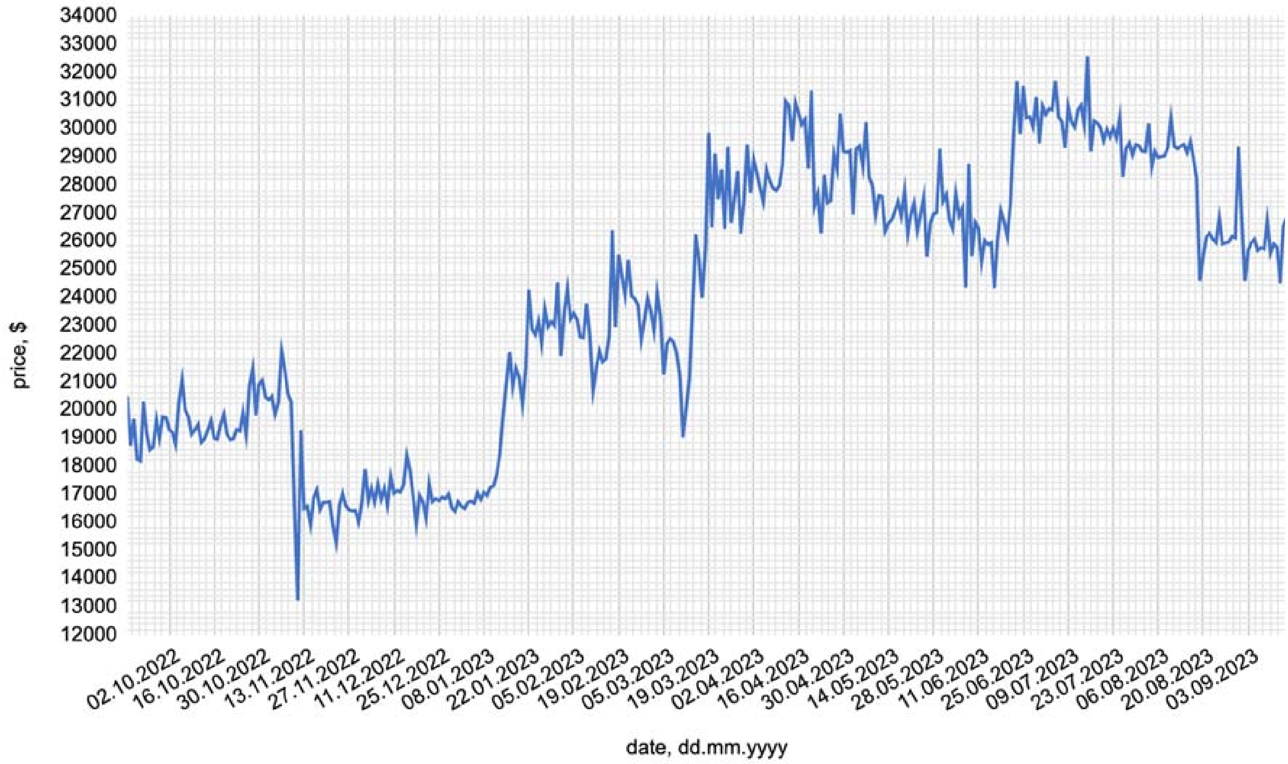


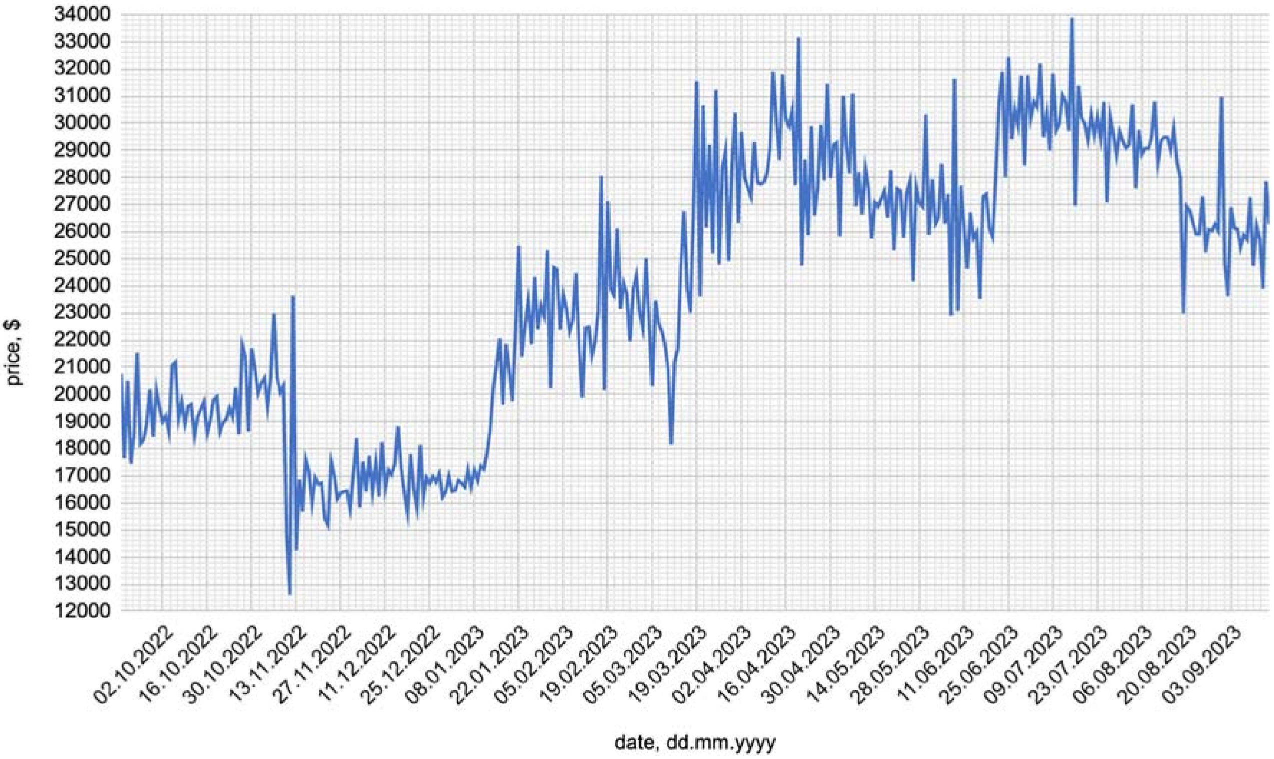
Fig. 1–4. Qualitative solution properties for ordinary differential equations. (a) Well behaved solution. (b) Solution does not exist at t_1. (c) Solution not unique at t_1. (d) Nonuniqueness at tl and no solution for $t > t_1$



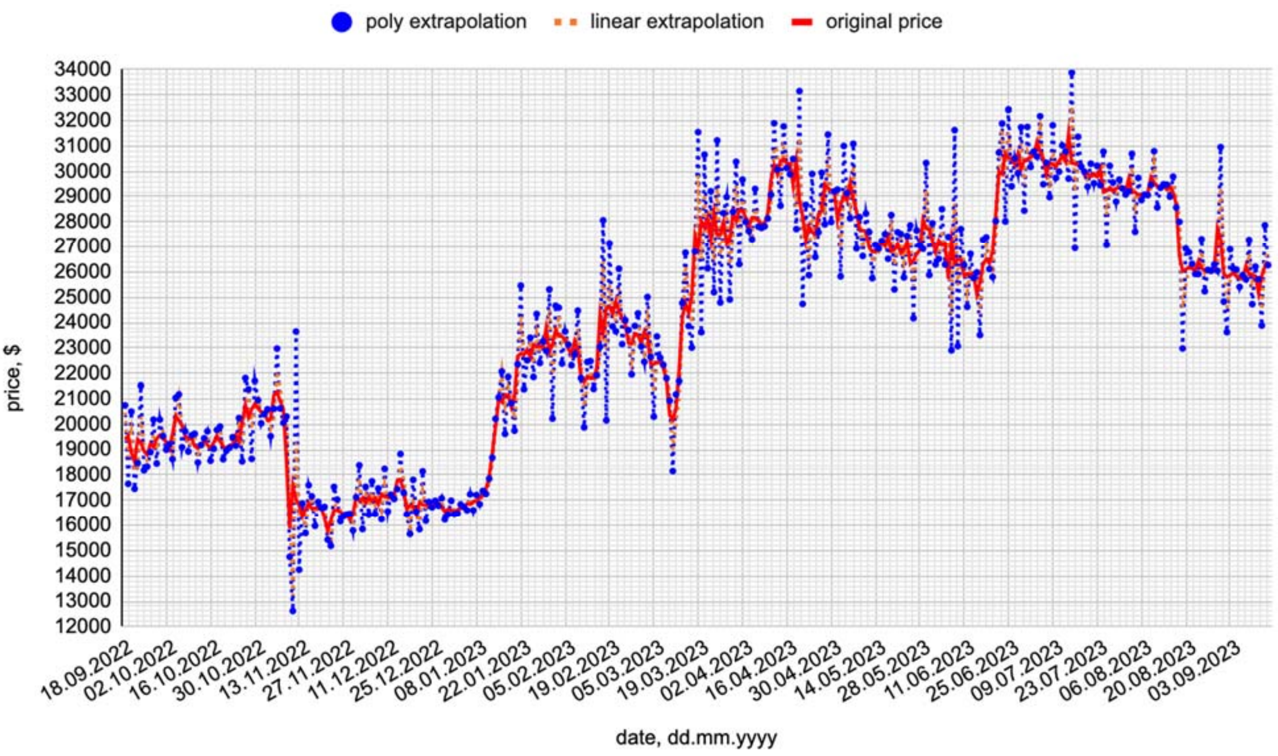
Graph 1. Bitcoin pricing trend during 1 year



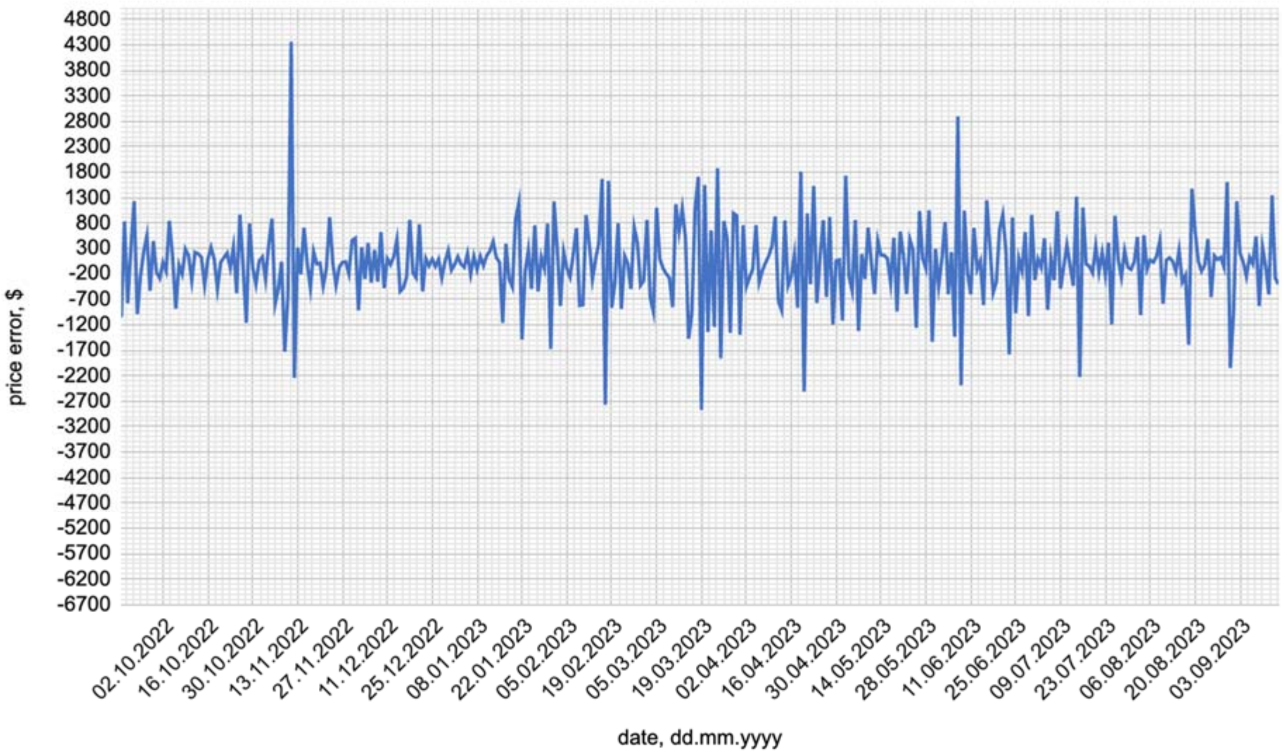
Graph 2. "Predicted" Bitcoin pricing trend during 1 year (using linear extrapolation method)



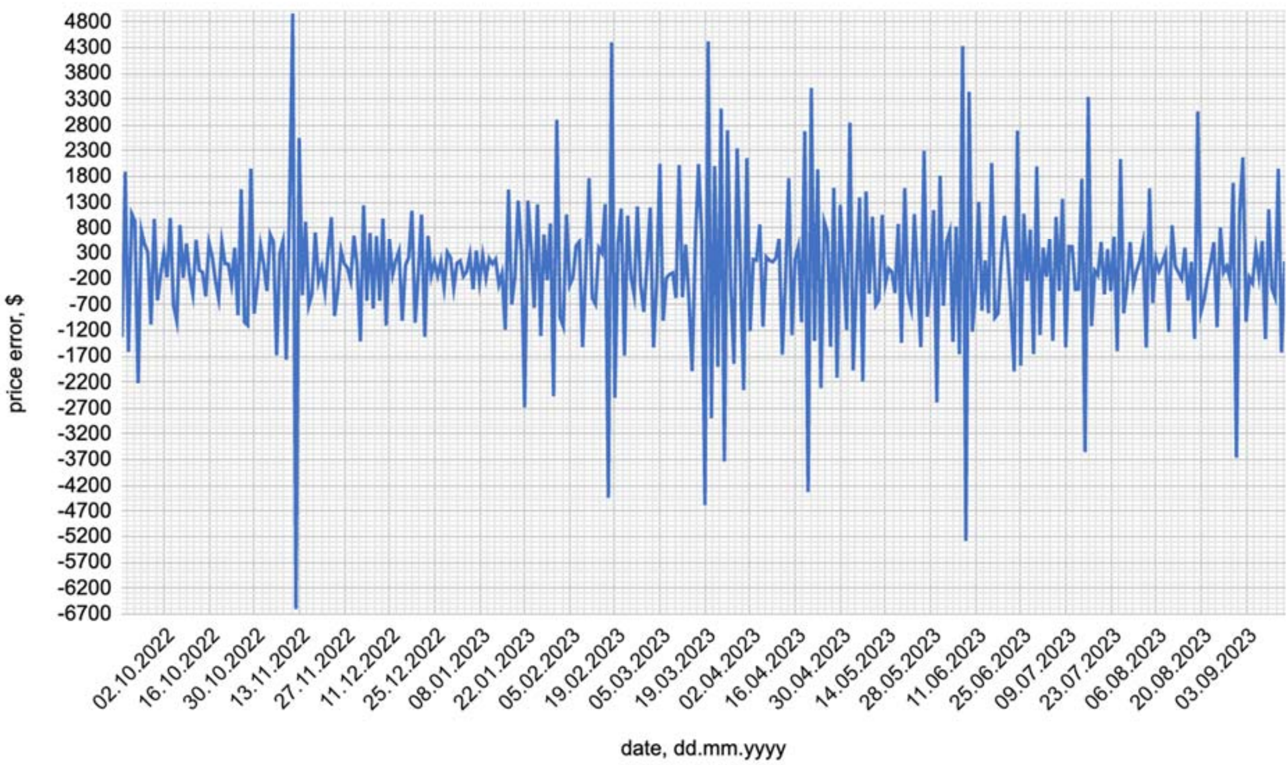
Graph 3. "Predicted" Bitcoin pricing trend during 1 year (using polynomial extrapolation method)



Graph 4. "Predicted" and real Bitcoin pricing trend during 1 year (using linear and polynomial extrapolation method)



Graph 5. "Predicted" and real Bitcoin price errors trend during 1 year (using linear extrapolation method)



Graph 6. "Predicted" and real Bitcoin price errors trend during 1 year (using polynomial extrapolation method)

manipulation, so historical data may not always accurately reflect future conditions.

– Market Factors: Cryptocurrency prices are influenced by a wide range of factors, including market sentiment, news events, regulatory changes, and technological developments. Extrapolation typically doesn't take these factors into account, making it less effective for capturing sudden and unexpected price movements.

– Short-Term vs. Long-Term Predictions: Extrapolation is often more accurate for short-term predictions when market conditions are relatively stable. For longer-term predictions, it becomes less reliable, as it doesn't account for fundamental changes in the cryptocurrency landscape.

– Volatility: Cryptocurrencies are known for their extreme price volatility. Extrapolation assumes a linear or simple mathematical relationship between past and future prices, which may not hold in highly volatile markets.

– Overfitting: Extrapolation methods can sometimes overfit to historical data, meaning they fit too closely to past price movements but fail to generalize well to new data. This can result in inaccurate predictions.

– Diversification: Relying solely on extrapolation for cryptocurrency investment decisions is risky. It's important to diversify your investment portfolio and consider other factors, such as fundamental analysis and market sentiment, when making investment decisions.

– Use of Multiple Models: To improve prediction accuracy, consider using multiple forecasting models, including fundamental analysis, technical analysis, sentiment analysis, and machine learning models. Combining these approaches can provide a more comprehensive view of the market.

– Regular Updates: Cryptocurrency markets can change rapidly. If you are using extrapolation, make sure to regularly update your models and adjust your predictions based on new data and market developments.

It can’t be used for such a kind of prediction, because as shown on the graphs, the predicted price does not coincide with the real price.

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