

Comparative analysis of bankruptcy risk using Altman, Taffler, and Zmijewski models of a selected Zimbabwe Stock Exchange listed extractive sector firm

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Abstract: The research compared the predictive accuracy of Altman Z Score, Taffler Z Score and Zmijewski X Score bankruptcy analysis models in relation to a listed Zimbabwe Stock Exchange listed extractive sector firm from 2011 to 2022. The objective was to determine the most accurate models in predicting corporate distress within Zimbabwe's volatile economic environment. The study employs a quantitative methodology analysing secondary data from the published annual audited reports as well as independent external auditor reports for two periods: USD denominated reporting (2011 to 2018) and ZWL denominated reporting (2019 to 2022) following the introduction of statutory instrument 33 of 2019. The Zmijewski X Score achieved greater predictive accuracy of 91.67% thus correctly identifying 11 of 12 sample years with zero Type 1 error with 8.33% Type 11 errors. The Altman and Taffler models achieved 83.33% accuracy, correctly predicting 10 out of 12 sample with Type 11 error at 16.67%. Cross validation with External independent auditor report confirms the firm in financial distress from 2010 to 2018, and in 2021 to 2022. The firm was solvent in 2019 and 2020 of which only the Zmijewski X Score accurately predicted. The findings thus demonstrate superiority of the Zmijewski model which implies a credible tool for investors and creditors in making decisions in relation to monitoring and capital allocation. Therefore, there is need to adopt multiple models in the analysis to mitigate the limitations of using one model. In relation to the agency theory, the adoption of an accurate predictive model reduces information asymmetry thus enhancing oversight efficiency and curbing managerial optimism. This will provide a reliable indicator of the agent's financial stewardship.

Keywords: Bankruptcy prediction, Altman Z Score, Taffler Z Score, Zmijewski X Score, Agency theory.

1. INTRODUCTION

1.1 Overview of Zimbabwe's mining sector

Zimbabwe has 40 distinct minerals with a diverse mining industry. Chrome, gold, coal, and diamonds are the main minerals. The sector makes up about 12% of the nation's GDP, and according to the minister of mines, it has the potential to generate US\$12 billion annually by 2023 if the government addresses issues like ongoing power shortages, a lack of foreign currency, and policy uncertainty (International Trade Administration, 2022). According to Zwinoira (2018), the mining sector in Zimbabwe faced several economic and financial challenges encompassing the following:

- i. Electricity supply: The mining industry in Zimbabwe is facing challenges with electricity supply, which can affect production and operations.
- ii. Foreign currency shortages: Shortages of foreign currency can make it difficult for mining companies to import necessary equipment and materials.
- iii. Rising costs: The cost of inputs for the mining industry is rising, which can affect profitability.

- iv. Capital shortages: There is a shortage of capital available for investment in the mining sector.
- v. International market movements: Fluctuations in international markets can affect the profitability of the mining industry.
- vi. High risk perception: The perception of high risk in Zimbabwe can make it difficult to attract investment in the mining sector.
- vii. Infrastructure and energy deficits: Continuing deficits in infrastructure and energy can affect the operations of mining companies.
- viii. Access to foreign currency: Problems with access to foreign currency can make it difficult for mining companies to conduct business.
- ix. Increasing costs of capital and operations: The costs of capital and operations are increasing, which can affect the profitability of mining companies.

The International Trade Administration (2022) posits that the mining sector is negatively affected by policy uncertainties that affected operations and investment. The following paragraph informs of the extent of bankruptcy model usage in Zimbabwe.

1.2 Bankruptcy models used in research in Zimbabwe.

Moyo, Gumbo, Chikodza, and Jones (2020) adopted the panel multi-state Markov (MSM) chains to build a predictive model for financial distress of banks in Zimbabwe. Mavengere (2015) tested the Altman Z Score in an attempt to unearth bankruptcy of a selected manufacturing firm in Zimbabwe. Mugozhi and Ngirazi (2020) utilised the Altman Z Score to determine its corporate failure predictive value in Zimbabwe financial institutions. Gumbo and Zoromedza (2016) advance their bankruptcy model as superior in analysis when compared to the Altman Z score in financial institutions bankruptcy prediction in Zimbabwe between 2009 to 2013. Gumbo and Muparuri (2021) propose book value, book value per share, average debt to equity and equity per share as significant determinants of corporate distress using binary logistic regression. Ncube (2014) advances the Z Score model is assessing corporate failure in Zimbabwe financial institutions from the years 2011 to 2013 concluding that 83.33% of listed financial sector firms are under distress, 16.67% are under the grey area and no financial sector institution is in the safe zone.

Research objectives

- i. To analyse the financial health of the extractive sector firm using Altman, Taffler, and Zmijewski models.
- ii. To compare the predictive accuracy of the Altman, Taffler, and Zmijewski models in assessing bankruptcy of the ZSE listed extractive sector firm.

2. LITERATURE REVIEW

2.1 Agency theory

The theory was advocated by Jensen and Meckling in 1976 examining principal and agent relationships impacted by information asymmetry. Due to financial and non-financial information at the disposal of management, they may delay bankruptcy filing as they gamble the company's resources with the hope of resurrection from insolvency to solvency. Managers (agents) may "window dress" financial statements in an attempt to conceal poor performance by selective disclosure that highlight favourable financial information and by manipulating financial data. Agents (managers) may prioritise personal gain, for example, bonuses, at the expense of shareholder value. Therefore, they undertake unwarranted risk fully aware the principals will bear the consequences of their risky as well as opportunistic behaviour. Weak governance that primarily rests on lack of board oversight increases the likelihood of bankruptcy. CEOs may engage in value destroying acquisition to expand control in their attempt to empire building that will result in agency conflicts translating into financial distress for the firm.

2.2 International Standard on Auditing (ISA) 570 Going Concern

There are events or conditions that may cast doubt on the entity's status as a going concern either when considered individually or collectively. Examples of these are as per table 1 below.

Table 1- ISA 570 extract

Financial	Operating	Other factors
Net current liability or net liability position.	Management intentions to liquidate the entity or to cease operations.	Substantial decrease in share price.
Excessive reliance on short term borrowings to finance long term assets.	Loss of key personnel and management without replacement.	Non-compliance or marginal ability to meet capital or other statutory or regulatory requirements.
Adverse key financial ratios.	Significant decline in customer demand.	Change in government policy expected to adversely affect the entity.
Substantial operating losses or significant deterioration in the value of assets used to generate cash flows.	Labour difficulties.	Significant exposure to volatile markets, for example, exchange rates, equities and interest rates.
Change from credit to cash on delivery terms with suppliers.	Emergence of a highly successful competitor.	Uninsured or underinsured catastrophes or business interruption losses when they occur.
Exposure to liquidity risk as a result of the maturity mismatch of financial assets and liabilities.	Loss of major market share, franchise, principal supplier, and significant customers.	Changes in the environment such as outbreaks of disease, civil unrest, war that adversely affect the entity or physical risks related to climate change.
Inability to pay creditors on due dates.	Shortages of important supplies.	Significant business interruption due to a cyber-attack, for example, denial of access to information or inability to provide service).

Source: ISA 570 redrafted (2024:20-21)

2.3 Bankruptcy Models

2.3.1 Zmijewski X score

The Zmijewski X score was introduced in 1984 with the model stated as follows:

$$X \text{ Score} = -4.3 - 4.5X_1 + 5.7 X_2 - 0.004X_3$$

Balcaen and Ooghe (2012) postulate the Zmijewski X score as having lower type 1 errors in comparison with Altman Z score. Agarwal and Taffler (2013) advance the X score as outperforming market based models. Altman, Iwanicz-Dzozdowska, and Laitinen (2014) articulate the X score as having lower accuracy in Europe and Asia markets when compared with the Altman Z score. In relation to SMEs, the X score was deemed less effective in determining bankruptcy (Ciampi and Gordini, 2015). Kumar and Rao (2016) attest to the combination of the X score with macroeconomic variables to improve its accuracy in the region of 12%. According to Wang, Campbell and Johnson (2017), the X score attained 75% accuracy when tested against retail companies' bankruptcy which didn't compare favourably with logit model's accuracy of 82%. Gupta, Gregoriou and Healy (2020) state the X score as superior and outperforms the Altman Z score in Brazil as well as India. Altman, Esentato and Sabato (2021) posit the X score as a model that lags behind dynamic models in capturing covid-19 induced bankruptcy. Zhou and Li (2023) suggest the X score accuracy as 73% as compared to 88% for XGBoost models in China. The above literature attests to the adoption and utilisation of the Zmijewski X score as a bankruptcy prediction model.

2.3.2 Taffler Z score

The Z score was introduced by Taffler in 1983 and the prediction model is as follows:

$$Z \text{ score} = 0.53X_1 + 0.13X_2 + 0.18X_3 + 0.16X_4$$

According to Taffler (1983), the Z score attained 85%-90% accuracy when utilised for bankruptcy prediction in the United Kingdom. Agarwal and Taffler (2012) posit the Z score as superior and outperforming the Altman Z score 1 year to bankruptcy with an accuracy of 88%. The Taffler Z score has been effective in predicting bankruptcy in the United Kingdom but limited accuracy outside the United Kingdom (Balcaen and Ooghe, 2012; Altman et al., 2014). Ciampi and Gordini

(2015) and Mselmi et al (2017) postulate limited effectiveness of the Taffler Z Core when assessing bankruptcy for SMEs. Alaka et al (2018) state the Taffler Z score as among the top five bankruptcy models utilised for bankruptcy prediction studies in relation to accounting based models. In Tunisia, the Taffler model attained 62% accuracy in financial distress prediction. In relation to emerging economies and markets, the Taffler Z score outperformed the Altman Z score (Gupta et al: 2020). Within the Brazilian economy, the Taffler Z Score attained 72% accuracy in bankruptcy prediction research (Alencar et al, 2022). Zhou and Li (2023) advance XGBoost as having 87% accuracy with Taffler Z score attaining 75% in bankruptcy prediction in China.

2.3.3 Altman Z Score

The Z Score for non-manufacturing firms is as follows:

$$\text{Z-Score} = 6.56 X_1 + 3.26 X_2 + 6.72 X_3 + 1.05 X_4$$

Bellovary, Giacomino and Akers (2010) posit the Altman Z score as widely adopted and validated by many researchers in bankruptcy prediction studies. Ciampi (2015) states Altman Z score as having limited accuracy in relation to Italian SMEs. Mselmi, Lahiani and Hamza (2017) articulate the Z score has having limited effectiveness in the Tunisian economy. Wang and Campbell (2020) state machine learning based models as having greater accuracy than the Z score in relation to United States of America retail sector. Gupta, Gregoriou, and Healy (2015) hypothesize that the Z score as moderately effective in predicting bankruptcy in India. According to Altman, Esentato, and Sabato (2021), the Z score effectively identified bankrupt firms during the Covid-19 pandemic.

2.4 Empirical review

According to Agarwal and Taffler (2012) discover the Taffler model accuracy as 88% which outperformed Altman Z score (82%) and Zmijewski X score (76%) for United Kingdom companies. Balcaen and Ooghe (2012) state Altman Z score has been globally validated for bankruptcy studies with the Taffler Z score as superior in the United Kingdom and the Zmijewski X score being cited as prone to Type II errors. Tinoco and Wilson (2013) posit Altman Z score accuracy of 83%, Taffler Z score 85% with Zmijewski X score revealing 78% accuracy in financial distress prediction. Ciampi and Gordini (2015) attest to Altman Z score accuracy of 80%, Taffler 72% with Zmijewski 68% in relation to SME default prediction. In relation to French SMEs, Altman Z score exhibited 77% accuracy, Taffler Z score 67% accuracy with Zmijewski X score 70%. Jabeur and Fahmi (2019) postulate Altman Z score accuracy of 82%, Zmijewski X score 71% and Taffler Z score at 62% accuracy emanating from bankruptcy prediction study undertaken in Tunisia. Gupta et al. (2020) advance Altman Z score accuracy of 85%, Zmijewski X score 73%, and Taffler Z score 69% from bankruptcy prediction study undertaken in India and Brazil. u articulate the Altman Z score as attaining 85% average accuracy, Taffler Z score 87% in United Kingdom (70% elsewhere), and Zmijewski X score 68%-79% being the least consistent. According to Viciwati (2020), Zmijewski model (X-Score) is the most accurate bankruptcy prediction model compared to Altman model (Z-Score). The accuracy value of the Zmijewski model (X-Score) is 90% with a type 1 error of 0%, while a type 11 error is 10%.

3. METHODOLOGY

The study adopts a quantitative research approach using secondary data was obtained from the mining firm's website with analysis from 2011 to 2018 when the United States dollar was in use and from 2019 to 2022 when the Zimbabwe dollar was introduced as a result of Statutory Instrument 33 of 2019 that resulted in the change of the functional currency to ZWL. Independent External Auditor reports (IEAR) were utilised as a means to correlate findings in relation to going concern status of the mining entity.

3.1 Analysis models

The study adopts the following models.

3.1.1 Zmijewski X Score

$$\text{X Score} = -4,3 - 4,5X_1 + 5,7 X_2 - 0,004X_3$$

Where:

X1 is Net Income / Total Assets.

X2 is Total liabilities / Total Assets

X3 is Current Assets / Current Liabilities

Interpretation of the X Score

$X > 0$, Bankrupt

$X < 0$, Not Bankruptcy

3.1.2 Taffler Z Score

$$Z \text{ score} = 0.53X_1 + 0.13X_2 + 0.18X_3 + 0.16X_4$$

Where:

X_1 = Profit before tax / Current Liabilities.

X_2 = Current Assets / Total Liabilities

X_3 = Current Liabilities / Total Assets

X_4 = (Quick Assets- Current Liabilities) / Daily operating expenses

Interpretation of the T score

$T < 0.2$ Firm is in the bankruptcy category

$0.2 \leq T \leq 0.3$ Grey area

$T > 0.3$ Firm not bankrupt

3.1.3 Altman Z Score

$$Z \text{ Score} = 6.56X_1 + 3.26X_2 + 6.72X_3 + 1.05X_4$$

Where:

X_1 = Working Capital to Total Asset.

X_2 = Retained Earnings to Total Assets.

X_3 = Earnings Before Interest & Taxes to Total Assets.

X_4 = Book Value of Equity to Book Value of Debt

3.4 Accuracy
3.4.1 Type 1 error

The error occurs when the bankruptcy prediction model reveals an entity as not bankrupt when it is actually bankrupt with the error rate computed as follows:

$$\text{Type 1} = \frac{\text{Number of corrects type 1}}{\text{Number of Sample}} \times 100\%$$

3.4.2 Type 11 error

The error occurs when the prediction model reveals an entity to be bankrupt when it actually is not bankrupt with the error computed as follows:

$$\text{Type 11} = \frac{\text{Number of correct type 11}}{\text{Number of sample}} \times 100\%$$

4. RESULTS AND DISCUSSION

The following are results of the comparative analysis of bankruptcy models that were adopted for the study.

4.1 Zmijewski X Score

Table 2: Zmijewski Findings (USD)

Zmijewski	X Score					
		X1	X2	X3		
USD	-4.3	4.5	5.7	0.004	X Score	Decision
2011	-4.3	-0.536	4.577	0.002	0.810	Bankrupt
2012	-4.3	-0.023	4.589	0.003	0.308	Bankrupt
2013	-4.3	-0.176	4.754	0.003	0.626	Bankrupt
2014	-4.3	-0.711	5.643	0.002	2.052	Bankrupt
2015	-4.3	-0.351	5.615	0.003	1.663	Bankrupt
2016	-4.3	0.095	5.518	0.002	1.121	Bankrupt
2017	-4.3	0.239	5.227	0.003	0.686	Bankrupt
2018	-4.3	-0.063	5.341	0.002	1.101	Bankrupt

The results reveal that from 2011 to 2018, the mining entity was facing bankruptcy with current liabilities were in excess of current assets with significant operating losses summarised as per Table 8.

Table 3: Zmijewski Findings (ZWL)

ZWL	-4.3	4.5	5.7	0.004	X Score	
2019	-4.3	-1.427	3.226	0.005	0.348	Bankrupt
2020	-4.3	0.419	3.141	0.005	-1.583	Not Bankrupt
2021	-4.3	-6.458	4.241	0.002	6.396	Bankrupt
2022	-4.3	-1.004	5.472	0.001	2.174	Bankrupt

The mining firm as per the Zmijewski X Score results above reveals the years 2019,2021, and 2022 as bankrupt. 2020, the entity is not facing bankruptcy.

4.2 Taffler Z Score

Table 4: Taffler Findings (USD)

Taffler	Z Score					
		X1	X2	X3	X4	Z Score
USD	0.53	0.13	0.18	0.16	1	Decision
2011	-0.095	0.074	0.141	-0.171	-0.052	Bankrupt
2012	-0.051	0.082	0.118	-0.444	-0.295	Bankrupt
2013	-0.048	0.077	0.114	-0.520	-0.377	Bankrupt
2014	-0.100	0.063	0.164	-0.806	-0.678	Bankrupt
2015	-0.066	0.062	0.116	-0.395	-0.283	Bankrupt
2016	0.012	0.054	0.117	-0.648	-0.465	Bankrupt
2017	0.048	0.052	0.104	-0.484	-0.279	Bankrupt
2018	-0.017	0.052	0.109	-0.493	-0.348	Bankrupt

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The results reveal that from 2011 to 2018, the mining entity was facing bankruptcy with current liabilities were in excess of current assets with significant operating losses summarised as per Table 8.

Table 5: Taffler Findings (ZWL)

	X1	X2	X3	X4	Z Score	
ZWL	0.53	0.13	0.18	0.16	1	Decision
2019	-0.822	0.063	0.040	-0.042	-0.760	Bankrupt
2020	0.222	0.033	0.040	-0.209	0.085	Bankrupt
2021	-0.105	0.033	0.066	-0.399	-0.406	Bankrupt
2022	-0.110	0.022	0.101	-0.681	-0.668	Bankrupt

The mining firm as per the Taffler Z Score results above reveals the entity as bankrupt for the years 2019,2020,2021, and 2022.

4.3 Altman Z Score
Table 6: Altman Findings (USD)

Altman Z Score						
	X1	X2	X3	X4	Z Score	
USD	6.56	3.26	6.72	1.05		Decision
2011	-2.145	0.613	-0.094	0.257	-1.369	Bankrupt
2012	-0.977	0.300	0.262	0.257	-0.158	Bankrupt
2013	-0.938	0.212	0.121	0.213	-0.392	Bankrupt
2014	-2.854	0.310	0.632	0.013	-1.900	Bankrupt
2015	-1.135	-0.580	-0.007	0.022	-1.700	Bankrupt
2016	-1.633	0.463	0.410	0.041	-0.720	Bankrupt
2017	-1.391	0.189	0.356	0.101	-0.745	Bankrupt
2018	-1.542	0.228	0.101	0.076	-1.137	Bankrupt

The results reveal that from 2011 to 2018, the mining entity was facing bankruptcy with current liabilities were in excess of current assets with significant operating losses summarised as per Table 8.

Table 7: Altman Findings (ZWL)

	X1	X2	X3	X4	Z Score	
ZWL	6.56	3.26	6.72	1.05		Decision
2019	0.328	-1.060	-2.392	0.800	-2.324	Distress
2020	0.295	0.010	0.323	0.856	1.483	Distress
2021	-1.174	0.437	0.679	0.364	0.306	Distress
2022	-2.611	-0.805	-0.685	0.047	-4.054	Distress

The mining firm as per the Altman Z Score results above reveals the entity as bankrupt for the years 2019,2020,2021, and 2022.

4.4 Independent External Auditor Report.

The Audited published financial statement extract in relation to going concern status of the mining entity from 2011 to 2022 are as summarised in table 8 below.

Table 8: Independent External Auditor Report (extract)

Year	Going concern challenges
2011	Current liabilities exceed current assets by USD\$37 million and significant operating loss of USD\$12 million.
2012	Emphasis of matter in relation to going concern due to significant losses USD\$6 million (2011: USD\$12 million) with current liabilities exceeding current assets USD \$18 million (2011 :USD \$37 million)
2013	Emphasis of matter in relation to going concern due to significant losses USD \$4 million (2012: USD \$6 million) with current liabilities exceeding current assets by USD \$17 million (2012 :USD \$18 million)
2014	Emphasis of matter in relation to going concern due to significant losses USD \$19 million with current liabilities exceeding current assets by USD \$51 million.
2015	Emphasis of matter in relation to going concern due to significant losses USD \$9 million with current liabilities exceeding current assets by USD \$19 million.
2016	Emphasis of matter in relation to going concern due to current liabilities exceeding current assets by USD \$31 million.
2017	Emphasis of matter in relation to going concern due to current liabilities exceeding current assets by USD \$32 million.
2018	Temporary closure of the mines due to foreign currency shortages
2019	Current assets exceeded current liabilities by ZWL\$96 million.
2020	Current assets exceeded current liabilities by ZWL\$635 million.
2021	The group incurred a net loss of ZWL'000 (2 million) and ZWL'000 (2 million) respectively during the year ended 31 December 2021 indicating that a material uncertainty exists that may cast significant doubt on the Group's ability to continue as going concern. Current liabilities exceed the current assets by ZW\$3 billion.
2022	The current liabilities exceed the current assets by ZW\$36 billion (December 2021 ZW\$3 billion)

Source: Published financial statements

4.5 DISCUSSION

The Zmijewski X score, Taffler Z score, and Altman Z score computations for the years 2011 to 2018 are the same with the entity indeed facing bankruptcy. For the years 2019 to 2022, Altman Z Score and Taffler Z Score reveal bankruptcy in 2019 and 2020 which is incorrect. The Zmijewski X score reveals bankruptcy in 2019, 2021 and 2022 with the mining firm not facing bankruptcy in 2020 which is in accordance with audited published financial statements as per table 8 above. In the year 2019, the mining firm's current assets (ZWL\$ 506 million) exceeded current liabilities (ZWL\$ 411 million) by ZWL\$96 million. To this effect, the Zmijewski X score, Taffler Z score, and Altman Z score computations are incorrect as they detect bankruptcy for the particular year. In the year 2020, current assets (ZWL\$ 3 billion) exceeded current liabilities (ZWL\$2 billion) by ZWL\$ 435 million. Therefore, only the Zmijewski X score has an accurate result with Altman Z score and Taffler Z score producing incorrect results of bankruptcy while the entity isn't facing bankruptcy in the current year.

Table 9: Accuracy prediction

	Zmijewski X Score	Taffler Z Score	Altman Z Score
Sample	12	12	12
Correct Prediction	$11/12 * 100 = 91.67\%$	$10/12 * 100 = 83.33\%$	$10/12 * 100 = 83.33\%$
Type 1 error	0	0	0
Type 11 error	$1/12 * 100 = 8.33\%$	$2/12 * 100 = 16.67\%$	$2/12 * 100 = 16.67\%$

Therefore, the Zmijewski X score is the most accurate bankruptcy prediction model in the study with 91.67% accuracy, Type 1 error is 0 and Type 11 error is 8.33%. The X score 0% Type 1 error signifies reduction in false bankruptcy signals thereby reducing costly false alarms in relation to operational modalities. Z score and Altman Z score have the same level

of accuracy at 83.33% and Type 11 error 16.67%. The results are in agreement with Viciwati (2020) who state the Zmijewski X score outperforms the Altman Z score with less Type 11 errors. Thus creditors and investors can adopt the X score for analysis of bankruptcy risk as well as risk based capital computations. Agency theory implications are the mitigation of information asymmetry. The low Type 11 error reduces the risk of principals being unaware of potential bankruptcy due to incompetence or managerial opportunism. The reliability of a bankruptcy prediction models lowers monitoring costs in terms of solvency making oversight efficient.

5. CONCLUSION

Zmijewski X score outperforms the Altman Z score and Taffler Z score with 91.67% accuracy compared to Altman Z score and Taffler Z score at 83.33%. The X score attains zero Type 1 errors and 8.33% Type 11 errors compared to the Z score (Altman and Taffler) at 16.67% for this particular study. Type 1 errors did not exist for all models tested in this study. The X score superiority suggests that it may be superior in certain contexts and challenges the validation of the Altman Z score in certain economies and sectors. The study also highlights the significance of adopting multiple bankruptcy models for financial distress prediction. From an agency theory perspective, the adoption and use of multiple models can deter financial statement manipulation as the models capture varying aspects of the firm's financial health or distress. This will reduce the risk of potential loss on investment through informed decision making utilizing the output of the varying bankruptcy models, in this instance, Zmijewski X score proving superior. Thus there is alignment from an agency theory perspective of the interests of shareholders and managers by furnishing accurate measures of financial health in relation to the firm.

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