# Hedging Alternatives for the Mortgage Stabilization Fund (FRECH): European Cap Options for the Real Interest Rate

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**Abstract**

The World Bank has proposed an alternative hedging instrument to be offered by the FRECH, instead of the collar-swap currently available. The suggested derivative corresponds to a European Cap option for the real interest rate, which could give greater flexibility to the hedging mechanism, allowing it to be tailored for the specific needs of each Colombian Mortgage Bank (BECH). This paper finds the value of this derivative and analyses the critiques that have been made about the pricing of the collar-swap.

## 1 Introduction

The recent episode of low real interest rates in Colombia has undermined the interest of the BECH to purchase the hedging instrument (a collar-swap) currently offered by the FRECH[1]. In the last four years, the data for this indicator has been characterized by a significantly lower mean *vis à vis* that of the period 1984-2001, with a lower volatility as well[2].

Setting aside possible explanations to this phenomenon it is indisputable that, had the BECH purchased the collar swap in 2001, they would have had incurred in significant net contributions to the FRECH, up to the present. Despite providing the BECH with insurance against real interest rate "catastrophes", this would have had implied lesser cash flows than those they have enjoyed due to the ongoing low real rates, which has helped them heal their sick balances.

*The views expressed herein correspond to the authors and may not coincide with those of the Banco de la República or its Board of Governors. We gratefully acknowledge the comments by Britt Gwinner, Leonardo Villar and Juan Pablo Zárate. The usual caveat applies.

[1] For a complete description of the FRECH, see Vásquez (2003).

[2] The average real interest rate for the past four years is 3.18% and the standard deviation 2.13%. The historic mean of the indicator (1984-2001) is 6.32% and the standard deviation 3.18%.

In the light of this, several market analysts, including World Bank officials among others, have expressed worries about the fact that the reticence of the BECH to enter the contracts might be explained by i) an overpricing of the collar swap, as the former claim, ii) The fact that the cost of the swap, even if fairly priced, might be too high for the BECH to purchase it, as the World Bank perceives or iii) The current hedging needs of the BECHs differ, hence the collar-swap seems inflexible to meet such specific needs, as the recent data from the Superintendencia Bancaria suggests.

Our paper, thus, has two main objectives: 1) We offer an alternative explanation for the unwillingness of the BECH to demand the collar-swap offered by the FRECH, stressing it is fairly priced, and 2) Attending reasonings i) and ii) above, we explore an alternative derivative to be offered by the FRECH, which could make its hedging nature more flexible and tailor-made for each BECH. This derivative corresponds to a European Cap option for the real interest rate, over a notional of $4 trillion pesos (about $1.3 billion dollars)[3] and 4 years of duration. As we will show, this length for the contract matches the actual average duration (measured as the McCaulay duration) of the mortgage assets of the BECHs. We illustrate examples of such caps ranging from 4% to 8%. These new contracts would allow each BECH to choose a different cap level or even hedge different mortgage pools with different caps. Moreover, the BECHs could choose shorter maturity contracts or mix different caplets at different maturities.

The rest of the paper is structured as follows: In the second part we analyze the discussion around the hedging mechanism currently offered by the FRECH. In the third we provide an alternative explanation to its apparent underperformance. In the fourth part we illustrate the design of the cap options and in the fifth, we extract relevant conclusions and policy recommendations.

## 2 Critiques to the Hedging Mechanism Offered by the FRECH

A significant share of the critiques directed to the hedging instrument offered by the FRECH stems from a misunderstanding of the true nature of the mechanism, by incorrectly assuming that it is a short-run derivative. Since its creation, the collar-swap was intended to be of a long-run duration, for it was supposed to cover the long-run interest rate mismatch faced by the BECH.

Based on this misinterpretation, the hypothesis pointing to an over-pricing of the collar-swap gained support, arguably explaining why these banks had been reluctant to purchase it. Unfortunately for the FRECH, back in 2001 when the derivative was designed, market information about future interest rates was inexistent, leading the discussion to purely statistical grounds, where each side argued in favor of one model or other to calculate the swap rate. The debate

[3] This corresponds to the approximate amount of mortgages that remain unhedged by the mortgage banks.

turned highly argumentative, leaving no room for agreement.

Luckily enough, the recent adoption of a methodology for the calculation of spot curves for the interest rate of public debt issues[4] has been crucial to void the "over-pricing" argument, for the current long-run spot rate is astonishingly similar to that estimated for the collar-swap. Indeed, whilst the 4-year current spot rate is 6.6%[5], the long-run estimated value for the real interest rate of the collar-swap is 6.82%. To put it bluntly, markets have acknowledged our heuristic estimation for the swap rate. This has not only convinced many critics about the fair pricing of the collar-swap, but has also drawn attention about the expensiveness of the derivative, given the high levels of interest rate risk born by the BECHs.

Other criticisms to the FRECH's nature have been made, in terms of the inflexibility of the derivative it offers and the apparent counter-party risk embedded in the contracts, due to the clause of limited liability that favours the Fund.

On the first issue, we agree in that the hedge instrument offered by the FRECH is somewhat rigid, in the sense that although it allows each BECH to enter a contract with a different notional amount (corresponding to the desired coverage for a given stock of eligible mortgages), the swap rate is fixed and equal for every contract. The reason underlying this initial design relied on the fact that back in 2000, all BECH were thought to bear the same degree of interest rate risk. Nevertheless, this situation has changed dramatically over the past two years, to the extent that some BECH could survive[6] to shocks to the DTF rate of up to 400 basis points with a year of persistence, as it is the case of BECHs[7] A and B, and to a lesser extent C and D, which could bear each 300 b.p. shocks of equal persistence, whilst E and F, in contrast, could get seriously distressed if faced with shocks greater than 120 and 0 b.p., respectively (see Janna, 2003).

It is worth noting, however, that although the level of real interest rate risk born by several BECH may seem low, it is underestimated to some extent in Janna's calculations, who follows the methodology used by the Superintendencia Bancaria due to the fact that the sort of shocks considered are mere parallel shifts of the yield curve, without considering changes in convexity (i.e., on the slope of the yield curve). Likewise, the maximum duration considered for the mortgage portfolio of each BECH is of up to 12 months, which contrasts with the actual durations displayed by these intermediaries, closer on average to 4 years[8].

In any case, setting aside the discussion on the underestimation of the real interest rate exposure faced by the BECH, it is indeed true that we see today

[4] See, Arango, Melo and Vásquez (2002).

[5] Calculated as of August 18th 2003.

[6] That is, without incurring in negative profits.

[7] We ommit the names of the banks, following the secrecy regulations by Superintendencia Bancaria.

[8] We use here a McCaulay duration as an approximation.

marked differences in the risk born by each BECH[9]. This, *per se*, justifies a revision of the hedging instrument in order to make it more flexible and tailor-made for each institution.

On the other hand, the observation about the counter-party risk implied by the limited liability of the FRECH in case its payments exceed the available funds, denotes, again, a misunderstanding of the mechanism by those who claim it. The FRECH was born from the good will of the Government to offer a derivative to help the BECH deal with the interest rate risk embedded in their balance sheets, whilst they transform their funding schemes towards long-run capital markets-based strategies. In the light of this, the FRECH may be regarded as a subsidy with the precise objective to hedge the described risks and therefore, as any other subsidy, it is *finite* in nature. In fact, the collar-swap was designed to be non-neutral against the FRECH, i.e., the thresholds were structured such that, in present value, the fund would exhaust its funds in the BECH's favor.

Nevertheless, the Fund is *asymmetric* in the sense that in the event of an exhaustion of the funds given a sufficiently strong real interest rate hike, the limited liability clause would imply the liquidation of the FRECH, whereas there is no bound for the BECH's contributions in case of very low rate scenarios.

In a nutshell, the FRECH was meant to be a *second best* solution to the BECHs' interest rate risk exposure, whilst they carried on the proper funding changes to put in motion *first best* solutions to the problem (i.e., long-run capital markets-based funding). Furthermore, markets have validated the collar-swap's pricing, given the close similarity of the swap's rate with the long-run real interest rate of UVR-indexed public debt.

In what follows, we build an argument to explain what we think are the true underlying reasons that account for the reticence of the BECH to demand the collar-swap.

# 3 Why has the Collar Swap Offered by the FRECH not been Demanded?

Amongst the sectors hit by the strong downturn of 1998-2002, the mortgage industry was first and in particular, mortgage banks, not only for the deceleration in the economic activity, but also for a series of rulings by the Constitutional Court that induced a huge deal of uncertainty in the mortgage business.

Due to this and to the strong lobbying power of the mortgage sector derived from decades of prosperity, the Colombian Government was acquiescent with their critical condition when the time came to design policies to face the crisis, spending no less than 6% of the GDP in the bailout.

Following the same logic, the Government, through the Supervisory bodies, was particularly lax in implementing capital requirements for market risks for

[9] In fact, not only the BECH's average mortgages as a share of total assets fell from 80.5% in August 1999 to 66.7% in August 2003, but also the standard deviation increased from 7.7% to 13.3%. This reinforces our argument on the heterogeneity of these intermediaries.

the BECH, in line with international standards. This has resulted in the persistence of the interest rate mismatch that these institutions bear, due to the moderate effort they have made to switch to long-run capital markets-based funding. A proof to this assertion is the vulnerability to adverse DTF shocks of several BECH, that we illustrate above.

In particular, the current capital requirements for market-risks have two deficiencies[10]: 1) Assume a maximum duration of a BECH's assets of 12 months (See Janna and Muñoz, 2003) and 2) Only contemplate parallel shifts of the term structure of interest rates, leaving aside convexity issues. As we stressed before, the actual duration of the assets of a representative BECH is close to 4 years, which implies, of course, that a strong shock to interest rates is expected to induce as well changes in the slope of the term structure, and thus hit the entire schedule of assets and liabilities (not just the 1-year maturity portion).

In the light of the aforementioned, our thesis points to the fact that, had the BECH been subject to more stringent capital requirements for market risks, in line with successful international regulatory practices, these institutions would have had entered in contracts with the FRECH to avoid capitalizations of the said mismatches. Clearly, it is more profitable for the BECH to keep interest rate risk within their balance sheets, in the absence of prudential regulations to limit it, than to incur in costs to hedge it, such as the implied by the FRECH derivative, especially in times in which rates are low, as the ones we have witnessed during the past 4 years.

In any case, as we mentioned in the previous part of this paper, the interest rate mismatch faced by the BECH is not homogeneous amongst them nowadays, which justifies a redesign of the hedging mechanism to make it more flexible and tailor-made for each institution. Moreover, as we show below, the design of the new derivative we are proposing takes into account the asymmetry described above, by means of a discount premium applied to the value of each option contract. In short, the use of the European Cap options for the real interest rate, as described herein, copes with two aspects of the collar-swap which the BECH have manifested to be unappealing: 1) inflexibility, and 2) asymmetry. In what follows, we describe the use of these derivatives, along the lines suggested recently by several World Bank's Officials.

# 4 European Cap Options for the Real Interest Rate

Before getting into the model's details, we define the real interest rate (in discrete time) as follows:

$$r_t = \left( \frac{1 + i_t}{1 + \Delta UVR_t} \right) - 1 \qquad (1)$$

[10]It is important to note that, broadly speaking, the banking supervision has improved dramatically in Colombia during the past 2-3 years. Nevertheless, certain aspects such as the one we are focusing on, deserve further analysis and changes.

where $i_t$ corresponds to the $t^{th}$ observation of the nominal interest rate (DTF) and $\Delta UVR_t$ constitutes the $t^{th}$ observation of the annual growth of the UVR, (which is calculated based on the lagged monthly inflation rate $\pi_{t-1}$[11]). The reason for the hedging instrument to be designed for the real interest rate rather than for the nominal DTF, is born in the fact that the BECH receive a flow of UVR-denominated income from their assets (mortgages, broadly speaking) and pay a DTF-denominated flow for their liabilities (mainly deposits). The difference between these two rates corresponds precisely to the real interest rate, which being low implies the funding of mortgages with deposits is relatively cheap and in the opposite case, this type of funding becomes pretty expensive. This interest rate risk mismatch that the BECHs face is what the FRECH is meant to hedge.

To value the options in the absence of swap markets, one must: 1) Estimate a model for the real interest rate and 2) Perform Montecarlo experiments using the estimated model, in order to simulate possible interest rate scenarios and hence, price the derivative. In what follows, we describe these two steps in detail.

## 4.1 Estimation of an Ornstein-Uhlenbeck Model for the Real Interest Rate[12]

The point of departure for our strategy is to assume that the real interest rate follows a stationary diffusion process given by[13]:

$$dr(t) = -\lambda(r(t) - \overline{r})dt + \sigma dB \tag{2}$$

with $r(0) = r_0$, $\lambda \geq 0$ and $t \in [0, \infty)$, and where $dr$ is the infinitesimal real interest rate growth, $\lambda$ is the convergence speed or mean reversion of the process, $\sigma$ corresponds to the volatility in the infinitesimal growth of $r$, $dB$ is a stochastic process $iid \sim N(0,1)$ and $\overline{r}$ represents the parameter corresponding to the long-run average real interest rate. The stochastic differential equation (2), which corresponds to a continuous-time version of an AR(1)[14] Gaussian process, describes the growth of the real interest rate as a stationary stochastic process with zero mean. Equation (2) corresponds to expression (17) of the general equilibrium dynamic model by Cox, Ingersoll and Ross (1985), who describe the dynamics of the real interest rate as a diffusion process with drift $-\lambda(r(t) - \overline{r})$ and variance $\sigma^2$.

[11] That is, the 12-order difference of the monthly inflation rate.

[12] The versed reader can skip this section without loss of generality and continue with Chart 1 below, where the results of the estimation are shown.

[13] This is the conventional "continous-time" format. However, we estimate the corresponding "discrete-time" version:

$$r_{t+1} - r_t = -\lambda(r_t - \bar{r}) + \sigma B_t$$

where $B_t \sim iid\ N(0,1)$, and $t$ is taken to be sufficiently small.

[14] Campbell, Lo and McKinlay (1997) claim that such a stochastic process is analogous to an Ornstein-Uhlenbeck model, which in turn belongs to a subset of Brownian motion processes.

In order to estimate the parameters in (2), we use the Simulated Method of Moments by Lee and Ingram (1991), which is a special case of the GMM methodology proposed by Hansen (1982).

This method seeks to find the parameters that guarantee the least "distance" between those of the observed series $(x_t)$ and the ones in the simulated $(y_j)_j$, for which we define a vector $(s \times 1)$ of statistics or moments, calculated as the time average of a function of observed data $H_T(x) = \frac{1}{T}\sum_{t=1}^{T} h(x_t)$ and a vector $(s \times 1)$ of calculated statistics for the simulated series $H_N(y_j(\beta)) = \frac{1}{N}\sum_{j=1}^{N} h(y_j(\beta))$, where $\beta$ is the vector of parameters that characterize the process described in (2), i.e. $(\lambda, \bar{r}$ and $\sigma)$. We assume ergodicity of the processes $x_t$ and $y_j(\beta)$, which allows us to define a consistent and asymptotically normal estimator $\widehat{\beta}_{TN}$, such that it minimizes the weighted sum of the quadratic difference between $H_T(x)$ and $H_N(y_j(\beta))$. Hence, given a symmetric random matrix $(s \times s)$ of weights $W_T$, the estimator $\widehat{\beta}_{TN}$ is defined as:

$$\arg\min_{\beta} \left[H_T(x) - H_N(y_j(\beta))\right]' W_T \left[H_T(x) - H_N(y_j(\beta))\right] \tag{3}$$

We define as well an integer $n = N/T > 1$ and the functions $g_T(\beta) = \frac{1}{T}\sum_{t=1}^{T} f_t(\beta) = \frac{1}{T}\sum_{t=1}^{T}\left[h(x_t) - \frac{1}{n}\sum_{k=1}^{n} h(y_{k,t}(\beta))\right]$ with $k = 1, \cdots, n$ and $t = 1, \cdots, T$. Under the assumption that $n > 1$, we require that the length of the simulated series is greater than its observed counterpart. Lee and Ingram (1991) argue that the value of the asymptotic variance-covariance matrix for $\widehat{\beta}_{TN}$ depends on the election of the weights matrix $W$, so that in order to obtain a consistent estimator, they suggest $W = [(1 + 1/n)\,\Omega]^{-1}$, where $\Omega$ is given by[15]:

$$\widehat{\Omega} = \frac{1}{T}\sum_{t=1}^{T} u_{t+p}u'_{t+p} + \sum_{i=1}^{p-1}\left[w(i, p-1)\left(\frac{1}{T}\sum_{t=i+1}^{T} u_{t+p}u'_{t+p-i} + \frac{1}{T}\sum_{t=i+1}^{T} u_{t+p-i}u'_{t+p}\right)\right] \tag{4}$$

where $u_{t+p} = h(x_{t+p}) - (1/T)\sum_{t=1}^{T} h(x_{t+p})$, $p$ is the number of autocovariances different from zero in $h(x_t)$ and $w(i, p-1) = 1 - \frac{i}{p}$.

We use the first four moments for the estimation of the parameters of expression (2) (i.e., mean, variance, kurtosis and skewness). Thus, the element $h_s(x_t)$ of the vector $(4 \times 1)$ of functions $h(x_t)$ is defined as $\frac{1}{\sigma^s}(x_t - \overline{x})^s$, from which we also define the $s^{th}$ element of the vector of $H_T(x) = \frac{1}{T}\sum_{t=1}^{T} h(x_t)$. For the estimation, we use data for $r_t$ as defined in (1) above, for the period between January 1984 and July 2003. Chart 1 below shows the estimation results, along with the goodness-of-fit statistic proposed by the authors, where the null

[15] This estimator for the Variance-Covariance matrix is proposed by Newey and West (1987)

hypothesis refers to the equality between the observed and simulated moments and follows a $\chi^2$ distribution with one degree of freedom.

**Chart 1**
**Estimated Parameters for the Ornstein-Uhlenbeck Model**

| Parameter | Estimator (%) |
|---|---|
| $\lambda$ | 24.5 |
| $\sigma$ | 3.1 |
| $\overline{r}$ | 6.3 |
| $\chi^2_1$ | 3.65% signif |

As it is shown, the estimated value for the equilibrium real interest rate $\overline{r}$, corresponds to 6.3%. In turn, the mean reversion is approximately 24.5%, which implies a period of mean reversion, departing from the current real interest rate, close to 20 months[16]. The standard deviation is about 3.1% and the value for the goodness-of-fit test, has a marginal significance level of 3.65%[17].

## 4.2 Pricing of the Cap Option

The cap option is defined as a threshold for the real interest rate, over which the FRECH is bound to pay the difference between the prevailing rate and the cap, calculated over the notional of the contract. In other words, if the real interest rate defined in (1), surpasses the cap at any time during the length of the contract, the hedge is made effective[18].

In order to value the cap, we perform Montecarlo experiments[19] for the process defined in (2) for the real interest rate, taking into account the parameters estimated, shown in Chart 1 above, taking in each run the present value[20] of the expected hedge and then averaging over the set of replications. As the starting point of each simulation, we use the current real interest rate, which implies that the value of the option is a function of time[21].

In what follows, we present the pricing of caps of 4%, 5%, 6.6%[22], 7% and 8%. These are mere examples of the types of caps that the FRECH could offer; and hence, any other cap suggested by a BECH can be valued accordingly.

[16] Vásquez (2003) estimates the average length of the cycle for the real interest rate to be 48 months, approximately. Assuming that the current rate is in the lowest point of the cycle, the rate would reach the equilibrium value in nearly two years.

[17] As Lee and Ingram (1989) show, the significance of individual parameters is irrelevant, and only the goodness-of-fit test based on the $\chi^2$ distribution is important.

[18] That is, if the condition is met (i.e., the real interest rate is greater than the cap in a given month), the payment is calculated as the multiplicative difference between the monthly equivalent of the observed real rate and the monthly equivalent of the cap, multiplied by the notional of the contract.

[19] The number of replications used is 10.000.

[20] The discounting rates we use correspond to the spot rates from the term structure of zero-coupon nominal public debt issues, calculated as of the 18th of August, 2003.

[21] That is, if the cap is purchased by a particular BECH in December, the price will differ from that of a cap valued today.

[22] This rate is equivalent to the 4-year spot rate of the term structure for government UVR-indexed debt.

Additionally, taking into account the said asymmetry present in the contracts, in the sense that in case of a sufficiently strong real interest rate hike the FRECH could face an exhaustion of the funds for the hedge, which coupled with the "limited liability" clause of the contracts would make suboptimal the *ex post* coverage in such a scenario, we calculate a discount premium for the value of the option to account for this possibility.

With this in mind, we estimate the probability of the Fund's exhaustion and the average deficit that would prevail in those extreme scenarios, using the same Montecarlo experiments described above. This information is thence used to calculate the value of the discount premium applied to the gross price of each cap option, to take into account the effect of the limited liability on the side of the FRECH, embedded in each contract.

### 4.2.1 Standard Caps

As we suggested before, the value of each standard cap is estimated independently, at levels of 4%, 5%, 6%, 6.6%, 7% and 8%. It is worth stressing that the 6.6% cap is equivalent to the 4-year spot rate of the term structure for government UVR-indexed debt. We thus calculate 10.000 different interest rate paths for the interest rate described in (2), of 48 months long, using the estimated parameters displayed in Chart 1. We average the present value of the excesses of the real interest rate over each cap, calculated over a notional of $4 trillion pesos (about $1.3 billion dollars).

Chart 2 below shows the gross[23] and net prices for these options as well as the probability in each case that the Fund is exhausted, with the corresponding average deficit. We also calculate, for reference purposes, the annual equivalent cost in basis points of each option[24].

[23] That is, without applying the discount premium.

[24] This is calculated as the rate for which the following equation holds:

$$\frac{\textit{option price}}{\textit{notional}} = \frac{m}{1+i_1} + \frac{m}{(1+i_2)^2} + \frac{m}{(1+i_3)^3} + \frac{m}{(1+i_4)^4}$$

where $m$ corresponds to the equivalent interest rate margin that the BECHs must forego if they buy a cap and $i$ is the corresponding spot rate from the term structure of zero-coupon nominal public debt issues.

**Chart 2**
**Cap Values (billions of pesos) and Equivalent Annual Cost in Basis Points**

| 4 years | | | | | |
|---|---|---|---|---|---|
| Cap (%) | Value of Cap | Prob. Exhaustion | Average Deficit | Net Value Cap | Cost in Basis Points |
| 4.0 | 335.25 | 0.9920% | 63.51 | 334.62 | 2.7990% |
| 5.0 | 264.24 | 0.4360% | 60.98 | 263.97 | 2.1992% |
| 6.0 | 203.54 | 0.1270% | 56.31 | 203.46 | 1.6994% |
| 6.6 | 171.95 | 0.0451% | 53.23 | 171.93 | 1.4328% |
| 7.0 | 152.89 | 0.0191% | 51.72 | 152.88 | 1.2662% |
| 8.0 | 111.91 | 0.0010% | 37.67 | 111.90 | 0.9330% |

As expected, the cap's price and haircut are negatively related to the cap level[25]. Hence, for a cap of 4% a BECH would have to pay $334.62 billion pesos (equivalent to $111.54 million dollars), whereas in case of a 6.6% cap the price drops to $171.93 billion pesos (approximately $57.3 million dollars). In terms of margin, the BECHs would have to forego 280 basis points per annum to purchase a 4% cap and conversely, 143 b.p. per annum for a 6.6% cap.

# 5 Conclusions and Policy Recommendations

The World Bank has suggested a change in the type of hedging instrument offered by the FRECH, to make it more compatible with the needs of the BECH. The new instrument corresponds to a set of European Cap options for the real interest rate. This paper values these derivatives.

In particular, we explore different levels of standard caps, for a period of 4 years and a notional amount of $4 trillion pesos (about $1.3 billion dollars). This length for the contract matches the actual average duration (measured as the McCaulay duration) of the mortgage assets of the BECHs. As an example, we explore the pricing of cap levels at 4%, 5%, 6%, 6.6%, 7% and 8%. The 6.6% corresponds to the 4-year spot rate of the UVR-indexed public debt spot curve.

Apart from the versatility of this type of derivatives, the cap options described here have the advantage of being flexible enough to be tailor-made for the specific hedging needs of each BECH. Moreover, and bearing in mind that the price of these types of options are a function of the date of the design of the contract, other specific needs of hedging could be easily priced, including contracts for shorter or longer periods and multiple or single caplets.

[25] It is important to note that the Fund does not charge a fee for the design of the caps, as it is normally done with such derivatives.

In short, the use of the European Cap options for the real interest rate described in the paper cope with two issues implied in the design of the collar-swap currently available, which the BECH have manifested to be unappealing, i.e., inflexibility, asymmetry.

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