*PREMIUM RATES FOR YIELD GUARANTEE AND INCOME PROTECTION CROP INSURANCE FOR GEORGIA AND SOUTH CAROLINA PEACHES**

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Introduction

Georgia (GA) and South Carolina (SC) growers have complained that the premiums are too high and the yield guarantees are too low in the current crop insurance product for peaches. Their concerns have been reflected in Congressional directives to the Federal Crop Insurance Corporation (FCIC) that require review of the current peach crop insurance product, and the development of a pilot insurance program that takes into account the cost of production or protects income from peach production. This paper provides a comparison of estimated actuarially sound premium rates for individual yield guarantee and income protection crop insurance products for GA and SC peaches. In subsequent sections of the paper we provide background on the individual yield guarantee and income protection products, discuss our procedures for estimating premium rates, present our results, and offer our conclusions.

Background on Crop Insurance Products and Premium Rates

The current crop insurance product for peaches is an individual yield guarantee. Under an individual yield guarantee, the producer receives an indemnity whenever his actual yield falls below his yield guarantee. The producer selects his yield guarantee by choosing a percentage of his historical average yield, called the actual production history (APH). The yield guarantee is the APH multiplied by the selected coverage level. The producer can choose from coverage levels (in five-percent increments) between 50 and 75 percent. Under an income protection product, the producer receives an indemnity when his actual revenue at harvest (i.e., his actual yield times the market price at harvest) is less than his revenue guarantee, calculated as the producer's APH times the price election specified in the crop insurance contract times the selected coverage level.

In the way of notation, $y_{k,i}$ represents the ith yield (measured in pounds per acre) for farm k, and p_i is the ith market price (measured in dollars per pound). The mean yield for farm k is

(1) $\bar{y}_k = E(y_{k,i})$, and

the mean market price is

(2) $\overline{p} = \mathrm{E}(p_{\mathrm{i}})$.

We consider each coverage level from 50 to 75 percent that is offered in the current peach crop insurance program, and use c_j to denote the jth coverage level (which is a percentage) written in decimal form. The yield guarantee with a jth coverage level for farm k is

(3) $Y_{\mathrm{j,k}} = \mathrm{c}_{\mathrm{j}}\ \overline{y}_{\mathrm{k}}$.

For example, the yield guarantee for 50 percent coverage is $Y_{50,\mathrm{k}} = 0.5\ \overline{y}_{\mathrm{k}}$.

For an individual yield guarantee product, the yield loss (i.e., $\max[Y_{\mathrm{j,k}} - y_{\mathrm{k,i}}, 0]$) is valued at the crop insurance price election, P. The ith loss for farm k with a jth coverage level is

(4) $L^{\mathrm{Y}}_{\mathrm{j,k,i}} = \max\,[\mathrm{P}(Y_{\mathrm{j,k}} - y_{\mathrm{k,i}}),\ 0] = \mathrm{P}\max\,[Y_{\mathrm{j,k}} - y_{\mathrm{k,i}},\ 0]$,

with mean

(5) $\overline{L}^{\mathrm{Y}}_{\mathrm{j,k}} = \mathrm{E}(L^{\mathrm{Y}}_{\mathrm{j,k,i}})$.

For an income protection product, the ith loss for farm k with a jth coverage level is

(6) $L^{\mathrm{I}}_{\mathrm{j,k,i}} = \max\,[\mathrm{P}Y_{\mathrm{j,\ k}} - p_{\mathrm{i}}\ y_{\mathrm{k,i}},\ 0]$,

with mean

(7) $\overline{L}^{\mathrm{I}}_{\mathrm{j,k}} = \mathrm{E}(L^{\mathrm{I}}_{\mathrm{j,k,i}})$.

A loss under an individual yield guarantee requires that $y_{k,i} < Y_{j,k}$, while a loss under an income protection product can be triggered by a low yield and/or a low market price.

The actuarially fair premium is the expected loss, $\overline{L}^{\mathrm{Y}}_{\mathrm{j,k}}$ for the individual yield guarantee and $\overline{L}^{\mathrm{I}}_{\mathrm{j,k}}$ for the income protection product. The pure premium rate is calculated as the ratio of the actuarially fair premium to the maximum loss. For both products considered here, the maximum loss occurs when the farm has a zero yield and equals $\mathrm{P}Y_{\mathrm{j,k}}$. The pure premium rates for farm k with a jth coverage level are

(8) $R^{\mathrm{Y}}_{\mathrm{j,k}} = \dfrac{\overline{L}^{\mathrm{Y}}_{\mathrm{j,\ k}}}{\mathrm{P}Y_{\mathrm{j,\ k}}}$, and

(9) $R^{\mathrm{I}}_{\mathrm{j,k}} = \dfrac{\overline{L}^{\mathrm{I}}_{\mathrm{j,k}}}{\mathrm{P}Y_{\mathrm{j,k}}}$

for the individual yield guarantee and income protection products, respectively.[1]

Since equations (8) and (9) have the same denominator, the relative magnitudes of the premium rates of the alternative products can be evaluated by comparing the numerators (i.e., equations (5) and (7)). For a given mean yield and coverage level, the relationship between premium rates for individual yield guarantee and income protection products is an empirical question. If $y_{k,i} \geq Y_{j,k}$, $L^{Y}_{j,k,i} = 0$ and $L^{I}_{j,k,i} \geq 0$. If $y_{k,i} < Y_{j,k}$, $L^{Y}_{j,k,i} > 0$ and $L^{I}_{j,k,i} \geq 0$. If $y_{k,i} \geq Y_{j,k}$, $L^{I}_{j,k,i}$ is more likely to be positive when $\text{cov}(p, y_k) < 0$ than when $\text{cov}(p, y_k) = 0$. However, when $y_{k,i} < Y_{j,k}$, $L^{I}_{j,k,i}$ is more likely to equal zero when $\text{cov}(p, y_k) < 0$ than when $\text{cov}(p, y_k) = 0$. Thus, information that $\text{cov}(p, y_k) < 0$ (or $\text{cov}(p, y_k) = 0$) is not sufficient to determine the relative sizes of $\overline{L}^{Y}_{j,k}$ and $\overline{L}^{I}_{j,k}$.

Procedures for Estimating Premium Rates

Farm-level yield data for GA and SC are available from the Risk Management Agency (RMA), FCIC, for farms participating in the FCIC program, but only from 1986 onward. We limit our analysis to farms with four or more years of actual yields through 1997. For GA, there are 60 such farms located in three regions, including eight farms in the North region, 24 farms in the Central region, and 28 farms in the South region. For SC, the data are available for 149 farms in ten counties, including 94 farms in the Upper State region, 51 farms in the Ridge region, and four farms in the Coastal Plains region. The average sample sizes are 5.8 years for GA farms and 6.4 years for SC farms.

It is not practical to estimate parametric yield and revenue distributions for the individual farms with such small sample sizes. We could estimate “empirical premium rates” for the individual farms as in Skees and Reed, but Goodwin and Ker argue that large sample sizes are required to obtain accurate empirical premium rates unless smoothing methods are used to estimate a continuous distribution from the discontinuous empirical distribution. Our approach is to simulate smooth farm yield and revenue distributions by augmenting the limited farm data with state- and county- (region-) level data that are available for longer time periods.

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[1] The actual premium rate differs from the pure premium rate for various reasons (e.g., to include reserves for catastrophic events, to cover administrative costs, etc.).

We use the following yield and price models:

(10) $S_t = \alpha_0 + \alpha_1 T_t + u_t$,

(11) $p_t = \exp(\delta_0 + \delta_1 S_t + w_t)$.

(12) $C_{m,t} = S_t + \beta_m + v_{m,t}$, and

(13) $y_{k,t} = C_{m,t} + \phi_k + e_{k,t}$,

where S_t is the state-level yield (pounds/acre) in year t; T_t is a time-trend variable; p_t is the constant 1996 dollar state-level price ($/pound) in year t; $C_{m,t}$ is the yield (pounds/acre) for county m in year t; $y_{k,t}$ is the yield (pounds/acre) for farm k in county (region) m in year t; u_t, w_t, $v_{m,t}$, and $e_{k,t}$ are disturbance terms; and $\alpha_0, \alpha_1, \delta_0, \delta_1, \beta_m$, and ϕ_k are parameters to be estimated.

State-level peach yield data for GA and SC are available for 1919 onward from the National Agricultural Statistical Service (and its predecessor agencies). We estimate equation (10) for each state using data from 1955-1998 (n=44) since there appears to have been a structural change in the yield series for both GA and SC about 1955. There is no evidence of trend (at conventional significance levels) in yields for either state, so we set $\alpha_1 = 0$ for both GA and SC.[2]

Annual peach production is determined by bearing acreage and yield per acre. Because peach trees are perennials, the year-to-year percentage changes in peach bearing acreage are small relative to the year-to-year percentage changes in peach yields. Also, peaches for the fresh market are not storable across crop-years. We treat peach supply as fixed within a given year, so that shifts in supply (due to variations in yield) trace out the inverse demand function given by equation (11). We estimate equation (11) for each state with data for 1956-1998 (n = 43) as reported by the National Agricultural Statistics Service.[3] Although tests for functional form (Maddala, pp. 220-23) are inconclusive, the

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[2] Details of the statistical results for the yield and price models are available upon request.
[3] Only state-wide price data are reported. The price data are not available for 1955, when freezes wiped out the GA and SC peach crops.

exponential functional form is used here because it gives the highest squared correlation between the actual and predicted prices for both GA and SC.[4]

The point estimates and 95 percent confidence limits for the price flexibilities at the mean and maximum sample values of state-level yields are:

		price flexibility		
State	S_t (pounds/acre)	lower limit	point estimate	upper limit
GA	6,086.7 (mean)	-0.72	-0.49	-0.25
	11,236.0 (max)	-1.32	-0.90	-0.47
SC	8,259.7 (mean)	-0.67	-0.44	-0.20
	12,761.0 (max)	-1.04	-0.68	-0.32

The reciprocal of the absolute value of the price flexibility is the lower limit of the absolute value of the price elasticity (Houck). Although the lower limits of the 95 percent confidence intervals for the GA and SC price flexibilities are greater than one in absolute value at the maximum observed yields, our point estimates of the direct price flexibilities at those yields are less than one in absolute value, indicating that demand is elastic over the observed range of yields. Thus, state-level peach revenues vary directly with yield so that revenues increase (decrease) as yield increases (decreases) over the range of observed state yields. Our results are consistent with the estimated peach price flexibilities for California from three studies summarized by Nuckton (p. 68). Each study found that California peach prices were inflexible with respect to California peach production.

Yield data for three GA regions (North, Central, and South) are available from the Georgia Agricultural Statistics Service for 1988-1997 (n = 10), and for the ten SC counties from the South Carolina Agricultural Statistics Service for 1955 and selected years from 1958-1997 ($38 \leq n \leq 41$).[5] Our estimate of β_m from equation (12) is the mean difference between $C_{m,t}$ and S_t.

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[4] The predicted values of p_t are calculated as $\exp(\hat{\delta}_0 + \hat{\delta}_1 S_t + \hat{\sigma}^2/2)$, where the carets denote least squares estimates and σ^2 is the variance of the disturbance terms of the price model. The term $\hat{\sigma}^2/2$ adjusts for the estimated difference between the log of the mean of the p_ts and the mean of the logs of the p_ts (Kmenta, pp. 511-12). The squared correlations between the actual and predicted prices are 0.30 for GA and 0.31 for SC.

[5] The SC yield for 1955 was zero, so we set SC county yields to zero for that year.

Substituting from equations (10) and (12) and recalling that $\alpha_1 = 0$ here, equation (13) can be rewritten as

(14) $y_{k,t} = \alpha_0 + \beta_m + \phi_k + u_t + v_{m,t} + e_{k,t}$.

According to Equation (14), farm k's yield in year t is explained by

(a) the parameter α_0, the mean state-level yield;

(b) the county-specific parameter β_m, the mean difference between the yield of county (region) m and the state-level yield;

(c) the farm-specific parameter ϕ_k, the mean difference between the yield of farm k and county (region) m;

(d) the random disturbance term u_t that affects the yields of all farms in the state in year t (e.g., a state-wide freeze);

(e) the random disturbance term $v_{m,t}$ that affects the yields of all farms in county (region) m in year t (e.g., a county- (region-) wide freeze); and

(f) the random disturbance term $e_{k,t}$ that affects only farm k's yield in year t (e.g., a localized hailstorm or frost).

Our estimate of ϕ_k is the mean difference between $y_{k,t}$ and $C_{m,t}$ ($n \geq 4$).

Adapting procedures from Atwood et al., and Prescott and Stengos, we simulate 10,000 yields and prices for each state, 10,000 yields for each county (region) in the state conditional on the simulated state yields, and 10,000 yields for each farm in the county (region) conditional on the simulated county (region) yield. We calculate the simulated farm revenues from the simulated state-level prices and the simulated farm yields. The simulated variables are computed as yield (price) forecasts plus simulated yield (price) forecast errors. The yield (price) forecasts are based on the point estimates of the parameters of equations (10) - (13). The simulated forecast errors are computed from simulated sampling errors in estimation of the parameters of equations (10) - (13) based on the point estimates and bootstrapped estimates of the parameters, and simulated disturbance terms based on the residuals from estimating equations (10) - (13).

We use the simulated yields and prices in equations (1) - (9) to calculate premium rates for individual yield guarantee and income protection products for each coverage level for each of the 60 GA farms and the 149 SC farms. In computing the premium rates, we set the crop insurance price election, P, equal to $\overline{p}$, the mean of the simulated state-level prices (i.e., \$0.34/pound for GA and \$0.31/pound for SC).

Results

Table 1 provides summary statistics for the premium rates for the two products. For both states, the mean premium rate for the income protection product is higher than the mean premium rate for an individual guarantee product for each coverage level. The null hypothesis that the mean difference between premium rates for the products is zero is rejected at the one percent level at each coverage level for both GA and SC.[6] Note that the mean difference in premium rates for the income protection and individual yield guarantee products increases as the coverage level increases for both states. Summary statistics for the ratios of premium rates (not shown) show that the rates for the two products also diverge in a relative sense as the coverage level increases for both GA and SC. The mean of the ratio of the income protection premium to the individual yield guarantee premium is 1.013 with 50 percent coverage and 1.066 with 75 percent coverage for GA, and 1.032 with 50 percent coverage and 1.069 with 75 percent coverage for SC.

Plots of the estimated premium rates for the two products against mean yield show that the premium rates for the two products decrease at a decreasing rate as mean yield increases in both GA and SC. Since the premium rates are bounded by zero and one, we use the logistic functional form (Greene, pp. 227-28) in explaining the premium rates with mean yields for a given coverage level. Based on preliminary analyses, the GA models allow for an intercept shift for Central farms relative to North and South farms, and a common mean yield coefficient across the three regions. The SC models allow for intercept and mean yield coefficient shifts for Ridge farms relative to Upper State and Coastal Plain farms. Over the range of mean yields used in estimation, the fitted premium rates for Central GA are lower than any other region, and the fitted rates for North and South GA are lower than the fitted rates for the Upper State and Coastal Plain

[6] The premium rates are not normally distributed since they are bounded by zero and one. Thus, the paired t-test of the equality of means of the premium rates of the two products for a given coverage level is only approximate.

of SC. The fitted rates for the SC Ridge are less (greater) than the fitted rates for the other SC regions for yields of about 8,500 pounds per acre and lower (higher).[7, 8]

Table 2 provides a comparison of the fitted premium rates for individual yield guarantee and income protection products at 50, 65, and 75 percent coverage levels for the GA and the SC regions. Note that:

- holding mean yield constant, the fitted income protection rate equals or exceeds the fitted yield guarantee rate for all coverage levels in all regions except for coverage levels below 65 percent in Central GA;[9]
- holding mean yield constant, the ratio of income protection to yield guarantee rates increases as the coverage level increases except at low yield levels in South GA and Upper State SC;
- holding the coverage level constant, the ratio of income protection to yield guarantee rates increases as the mean yield increases; and
- the increases in the ratio of income protection to yield guarantee rates as the coverage level increases are smaller at low yield levels than at high yield levels.

In general, the differences in the crop insurance product designs have little effect at low coverage levels and mean yields, but are larger at high coverage levels and mean yields.

Since equations (8) and (9) have a common denominator, the ratios of premium rates are equivalent to ratios of pure premiums for the two products. Offutt and Lins report estimated premiums for individual yield guarantee and income protection products for Illinois corn under the assumption that farm yields follow a beta distribution, prices follow a Weibull distribution, and that yields and prices are independent. Under their assumptions, the ratios of premiums for an income protection product versus an individual yield guarantee product are 1.45 for 50 percent coverage, 1.42 for 65 percent coverage, and 1.40 for 75 percent coverage. We draw two inferences from a comparison of the ra-

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[7] Details of the logistic regression results are available upon request.
[8] In Kahl et al., we provide a comparison of our estimated premium rates for an individual yield guarantee to the current FCIC premium rates. The current FCIC rates are "flat" in that they do not vary with the grower's yield experience. In general, our fitted rates are above (below) current rates for growers with below (above) average yields. Also, our fitted rates increase less than current rates as the coverage level increases except at very high farm-level yields.
[9] There are stronger negative correlations between our simulated prices and farm yields in Central GA than in the other regions. The mean correlations are –0.25 in North GA, -0.37 in Central GA, -0.27 in South

tios for corn and peaches. First, given that the ratio of premiums for income protection versus an individual yield guarantee for Illinois corn falls as the coverage level increases, the differences in premiums for corn are larger at low coverage levels than at high coverage levels. Our analysis shows that the ratio increases as the coverage increases in most cases for GA and SC peaches, making the differences in the product premiums more pronounced at higher coverage levels. Second, the ratios reported by Offutt and Lins for Illinois corn are higher than the ratios for GA and SC peaches. Yield shortfalls appear to contribute more to revenue shortfalls for GA and SC peaches than for Illinois corn. However, Offutt and Lins do say that the income protection premiums would be expected to decrease if prices and farm yields are negatively correlated. Unlike Offutt and Lins, our model does not assume independence of prices and farm yields.

Although our estimated premium rates for individual yield guarantee and income protection products differ in a statistical sense, the differences may not be significant in an economic sense. As discussed above, the demand for peaches appears to be elastic over the range of relevant yields for both GA and SC, so that peach revenues in GA and SC vary directly with state-level yields. Farm-level demands should be more elastic, and so an individual yield guarantee product would be a close substitute for an income protection product. Over the range of mean yields we used in estimation of the premium rate models, the largest percentage difference in pure premiums is at 75 percent coverage of the highest yield in Upper State SC (1.322 = 0.033/0.025). The difference in premium levels in this situation is $46.36/acre ($0.31/pound * 0.75 * 24,515 pounds/acre * [0.033 – 0.025]), or 0.61 percent of the mean revenue per acre. The mean yield at which the ratio of the fitted income protection and yield guarantee premiums is at a maximum need not coincide with the mean yield at which the difference in the fitted income protection and yield guarantee premium levels is at a maximum. For North and South GA, and Coastal Plain and Ridge SC, the maximum difference in income protection and yield guarantee premiums occurs at the maximum mean yields used in estimation of the premium rate model parameters. For Central GA, the maximum difference of $30.62/acre occurs when the mean farm-level yield is 13,310 pounds/acre and equals 0.68 percent of

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GA, -0.25 in Upper State SC, -0.24 in Ridge SC, and –0.17 in Coastal Plain SC. Central GA farms account for more than 80 percent of GA peach production in most years.

mean revenue per acre; and for Upper State SC, the maximum difference of $60.19 occurs when the mean farm-level yield is 16,640 pounds/acre and equals 1.17 percent of mean revenue per acre.

When the pure premiums for the income protection and yield guarantee products are evaluated at county- (region-) average yield levels, the difference between the premiums for 75 percent coverage is less than $50/acre and is less than 10 percent of the yield guarantee premium except for Cherokee County in Upper State SC. For a 50 percent coverage level, the difference in the income protection and yield guarantee premiums is less than $12/acre and is less than 4.5 percent of the yield guarantee premium at county- (region-) average yield levels for all counties (regions).

Conclusions

We use simulated state-level prices and farm-level yields for GA and SC peaches to estimate actuarially fair premium rates for two crop insurance products – an individual yield guarantee product and an income protection product. Comparisons of these rates lead to the following general conclusions:

- the premium rates for both products decrease at a decreasing rate as the mean farm-level yield increases;
- the premium rate for an income protection product equals or exceeds the premium rate for an individual yield guarantee product for a given coverage level and average farm yield except for coverage levels below 65 percent in Central GA;
- the premium rate for an income protection product decreases less than the premium rate for an individual yield guarantee product as average yield increases, so that income protection becomes more expensive relative to an individual yield guarantee as average yield increases; and
- although the income protection and yield guarantee premium rates differ in a statistical sense, they do not appear to differ in an economic sense except at high coverage levels for growers with very high yields. For most GA and SC peach growers, yield insurance is a close substitute for revenue insurance.

Table 1. Summary Statistics for Premium Rates for Individual Yield Guarantee (R_j^Y) and Income Protection (R_j^I) Peach Crop Insurance Products for Alternative Coverage Levels (j) for 60 Georgia (GA) and 149 South Carolina (SC) Farms.

		Coverage Level j (Percent)					
State	Item	50	55	60	65	70	75
GA	Mean of R_j^Y	0.252	0.258	0.265	0.272	0.280	0.288
		(0.021)[a]	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
	Mean of R_j^I	0.256	0.264	0.272	0.281	0.291	0.301
		(0.022)	(0.022)	(0.021)	(0.021)	(0.021)	(0.020)
	Mean of $R_j^I - R_j^Y$	0.004	0.005	0.007	0.009	0.010	0.013
	Paired t-test	6.439	7.783	9.714	12.323	15.686	19.519
SC	Mean of R_j^Y	0.226	0.234	0.242	0.250	0.259	0.268
		(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
	Mean of R_j^I	0.232	0.241	0.251	0.261	0.271	0.282
		(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
	Mean of $R_j^I - R_j^Y$	0.006	0.007	0.009	0.010	0.012	0.014
	Paired t-test	27.647	33.244	39.300	43.857	45.586	45.025

[a] Numbers in parentheses are standard errors.

Table 2. Fitted Premium Rates for an Individual Yield Guarantee Product ($\hat{R}_j^Y$) and the Ratio of Fitted Premium Rates for Income Protection and Individual Yield Guarantee Products ($\hat{R}_j^I / \hat{R}_j^Y$) for Selected Average Yields ($\bar{y}$) and Coverage Levels (j) for Georgia and South Carolina Peaches.[a]

Location	($\bar{y}$) [b]	$\hat{R}_{50}^Y$	$\hat{R}_{65}^Y$	$\hat{R}_{75}^Y$	$\hat{R}_{50}^I / \hat{R}_{50}^Y$	$\hat{R}_{65}^I / \hat{R}_{65}^Y$	$\hat{R}_{75}^I / \hat{R}_{75}^Y$
North GA	2,289	0.417	0.431	0.441	1.019	1.020	1.022
	10,217	0.119	0.146	0.167	1.037	1.096	1.129
Central GA	3,070	0.181	0.214	0.239	0.969	1.007	1.038
	13,735	0.023	0.035	0.047	0.974	1.108	1.202
South GA	1,089	0.479	0.488	0.493	1.017	1.013	1.012
	11,133	0.101	0.125	0.146	1.039	1.106	1.145
Upper State SC	718	0.499	0.510	0.515	1.010	1.003	1.000
	24,515	0.012	0.018	0.025	1.079	1.226	1.322
Ridge SC	4,477	0.278	0.300	0.315	1.018	1.021	1.026
	20,693	0.049	0.071	0.090	1.094	1.164	1.194
Coastal Plain SC	3,354	0.379	0.400	0.413	1.016	1.017	1.018
	7,140	0.232	0.260	0.281	1.027	1.045	1.056

[a] Fitted premium rates for the GA and SC regions are from the logistic equations discussed in the text.
[b] Average yields (pounds/acre) are the minimum and maximum simulated farm-level yields used in estimation of the logistic equations.

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