Measuring efficiency of the Farm Credit System

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Abstract:

The paper measures the U.S. Farm Credit System's technical efficiency from 2000 to 2009 using a stochastic frontier production function model with quarterly unbalanced panel data. The paper's results suggest that the FCS has not efficiently utilized their inputs. On an average, the system realizes only 9.7% of their technical abilities in raising their loans, leases and investment. The efficiency of the whole system is estimated to slightly increase over time even during financial crisis period from 2007. Among the system, a significant difference in efficiency between the 5 Banks and the Associations has been found. On average, the Banks have higher technical efficiency of 62.4% compared to that of 7.7% of the associations. The efficiency of the latter increases by a small rate over time during 2004-2009 periods while efficiency of the former is more time-varying and experiences the opposite pattern. No evidence about the impact of financial crisis on the system efficiency was found.

Keywords: Farm Credit System, agricultural lenders, technical efficiency, financial crisis, stochastic frontier production function, financial reform

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Introduction

As a government-sponsored enterprise and a network of borrower-owned financial institutions, the Farm Credit System (FCS) is considered a successful model for the US manufacturing credit system (Lind, 2010). In the recent Obama financial reform, the FCS is one of those financial institutions exempted from many reform regulations including securities trading, new bank tax, etc. This paper measures the FCS's technical efficiency from 2000 to 2009. The technical efficiency will indicate whether the FCS has utilized its government sponsorship and privileges in obtaining inputs to produce outputs efficiently. The paper will also examine any difference in efficiency of the five Banks versus the eighty four Associations. The change of the system's efficiency over time and the impact of the recent financial crisis 2007-2009 on the system efficiency will also be explored.

The FCS is a nationwide network of borrower-owned lending institutions and affiliated service entities that was created to provide a reliable and permanent source of credit to American agriculture. As of January 1, 2010, the System had five Banks and 88 Associations throughout the nation. The Banks lend wholesale loans to their affiliated Associations, other Banks, and non-System lenders. Some Banks can also make retail loans directly to cooperatives and other eligible entities. The Banks obtain funds through the issuance of Systemwide Debt Securities, common and preferred equities, subordinated debt, and from internally generated earnings. The Associations provide retail loans to farmers, ranchers, producers or harvesters of aquatic products, farm related businesses and rural homeowners. The Associations may also purchase loan participations from other System entities and non-System lenders. The majority of the Associations' funds are borrowings from their affiliated Banks. Recently, the FCS has attempted to expand its lending authority beyond traditional farm loans, which is opposed by commercial banks and is not allowed by the enacted 2008 farm bill.

Having a unique organization structure and flow of funds plus benefits received as a government-sponsored enterprise such as implicit federal guarantees or tax exemptions [1], whether the FCS has efficiently produced credits to agricultural sectors has not been focused in literature. The system's ability to explore their efficiency under exogenous changes such as financial crisis or economic downturn is also neglected. The last paper about the FCS efficiency was done in 1991 by Collender et all. The paper investigated the profit efficiency of FCS direct-lending associations in 1989 using DEA and linear programming techniques to calculate nonparametric profit frontiers. In addition to the need of a more appropriate approach to measure the FCS's efficiency, there exists a need for an update study to assess the FCS'efficiency, esp. in the recent economic downturn. The study will help the Farm Credit Administration and the U.S policy makers have more insight assessment for their decision making process.

The remainder of the paper is organized as follows. Section 2 discusses literature review on technical efficiency measurement. Section 3 describes the stochastic frontier production function model. Section 4 presents the empirical results and implications. Section 5 concludes the paper and discusses further research.

Literature review

In measuring bank efficiency, two major methods often used in literature are non parametric and parametric approaches. The dominant non parametric approach is Data Envelopment Analysis (DEA) which estimates the frontier using non-parametric mathematical linear programming. The three main parametric methodologies include the stochastic frontier approach (SFA), the thick frontier approach (TFA), and the distribution-free approach (DFA). The parametric methodologies specify a functional form for the cost, profit, or production relationship among inputs, outputs, and environmental factors, and allow for random error.

The non-parametric linear programming-based approach has several disadvantages. First, it is unable to decompose deviations from the efficient production frontier into firm effects and external factors effects, thus it considers all deviations from the frontier as inefficiencies. Second, it assumes deterministic frontier which is constructed using extreme observations, thus it may be severely influenced by the presence of outliers in the data (Wilson, 1993). Third, this approach may result in a large proportion of the sample being characterized as perfectly efficient because in many cases it is unable to form a reference technology which includes other observations in the data set. These banks in those cases are therefore "self-referencing" and their inefficiency estimate is equal to zero. That influences the relative ranking of the efficiency measures (Neff, Garcia, and Nelson ,1993). Fourth, this approach measures efficiency based on a one time period. It is not account for technical progress over year and the fact that technical efficiency for a certain firm might vary overtime. Firth, deterministic non-parametric approach does not allow uncertainty in the estimation of efficiency scores. Estimates of economic efficiency from studies which assumes away uncertainty are likely to be misleading. By ignoring relevant uncertainty, such estimates often explicitly and erroneously classify as inefficient activities that are indeed optimal for the decision maker (Pasour and Bullock, 1975).

Considering the disadvantages of non-parametric linear programming methodology, in this paper we use stochastic frontier production function model to estimate the technical efficiency of the FCS. The stochastic frontier model represents several advantages over the non parametric one. First, it decomposes deviations from the efficient production frontier into firm effects and external factors effects. Under this approach, random errors which are the result of external events beyond the firm's control such as financial crisis, climate, and government policy are accounted for in the measurement of efficiency. Second, the model allows uncertainty in the estimation of efficiency scores which the deterministic non-parametric approach does not. Third, the stochastic frontier model data accounts for time variations in efficiency by using panel data rather than cross-section data at one point in time. Pasiouras (2007) stated that the use of panel data accounts for time variations in efficiency given the possibility that managers might learn from previous experience in the production process, or there may be regulatory or environmental factors that affect the performance of banks over time thereby indicating that inefficiency effects would change in some persistent pattern over time. Panel data has also been argued to be better in estimating efficiency by Baltagi and Griffin, (1988); Cornwell et al., (1990); Kumbhakar, (1993); Carbo et al., (2002) because the use of panel data over a cross-section provides more degrees of freedom in the estimation of the parameters.

The parametric approach is not without defect since they require a particular function form to be estimated as well as assumptions about the distribution of efficiency. However, Berger and Mester, (1997); Bauer et al, (1998); Vander Vennet, (2002) when compared different functions and models estimated under different assumptions pointed out that the results are not significantly different . Gong and Sickles (1992) showed that the stochastic model outperforms the DEA model since the econometric model is close to the given underlying technology.

The technical efficiency of the FCS is defined as the ratio of its mean production to the corresponding mean production if it utilized its levels of inputs most efficiently. The technical efficiency measurement is therefore more appropriate for the Farm Credit system's characteristics and their politically-stated goal of providing maximum service at minimum cost subject to maintaining long-run viability. Also, the paper chooses to examine technical efficiency as opposed to another type of efficiency as stated by Kumbhakar and Lovell (2000) that technical efficiency is a purely physical notion that can be measured without recourse of price information and having to impose a behavioral objective on producers.

Theoretical Model

Following Battese and Coelli (1992), the frontier production function f(.) is defined as the maximum feasible output that can be produced by a bank with a given level of inputs and technology. The actual production function of a bank can be written as:

$Q_{it} = f(x_{it};\beta)\exp(v_{it} - u_{it}) \quad 0 \leq u_{it} < \infty$ (1)

$i = 1,2\ldots,n \quad t = 1,2\ldots T$

Where: Q_{it} represents actual output of bank i in period t, $f(x_{it};\beta)$ is the bank production function of inputs x_{it} and unknown parameters β in the t^{th} period of observation, β represents the effect of a given input on the quantity of outputs produced; v_{it} is a random noise that captures the effects of omitted variables/measurement errors which is assumed to be i.i.d normal $(0, \sigma_v^2)$; u_{it} is a one-sided (non-negative) residual term representing the bank effects which is assumed to be i.i.d truncated normal (μ, σ_u^2).

The disturbance term which stands for deviation of the systems from the efficient production frontier are decomposed into two components: random errors v_{it} and non-positive firm effects u_{it}. The non-positive firm effects u_{it} aka inefficiency u_{it} is a one-sided (non-negative) residual term which are results of factors under the firm's control such as technical inefficiency and economic inefficiency. The firm effects are assumed to have exponential specification which must either increase at a decreasing rate, decrease at an increasing rate or remain constant. It can be assumed to have a half-normal, truncated half-normal, exponential or gamma distribution, with a positive mean. Following Battese and Coelli (1992), Kumbhakar and Lovell (2000), Forbes (2010), in this paper the technical efficiency term was assumed to have a half-normal distribution i.i.d normal (μ, σ_u^2) because it was found to generate the most plausible distribution of efficiency scores. The random errors v_{it} is a random noise that captures the effects of omitted variables/measurement errors which are the result of external events beyond the firm's control such as financial crisis, climate, and government policy. v_{it} is assumed to be i.i.d normal $(0, \sigma_v^2)$

The firm effects can be written as:

$u_{it} = u_i \eta_{it} = u_i \exp\{-\eta(t-T)\}$ (2)

$i = 1,2\ldots,n$

$t \in g(i),\ t = 1,2\ldots,T$

where η is unknown scalar parameter that determines the behavior of the bank effects over time t; g(i) represents the set of Ti time periods among the T period involved for which observations for bank i are obtained.

Following Fukuyama (2008), our model also defines a bank as "producing efficiently in a given period if it cannot simultaneously expand its loans and securities investments while contracting its problem loans and inputs. Inefficient banks produce fewer loans and securities investments and more problem loans using more inputs than are needed. Technological change occurs when a bank which is efficient in one period can produce more loans and securities investments and generate fewer problem loans using fewer inputs in subsequent periods"

Let $\varepsilon_{it} = v_{it} - u_{it}$, following the model specified by equation (1) and (2), then $E[\exp(-\eta_{it} u_{i}) | \varepsilon_{it}]$ provides the measure of TE of bank i in period t. Equation (2) shows the exponential behavior of the firm effects over time. The firm effects and therefore of the TE of bank i in period t depend on η and number of remaining periods (t- T). The firm effects will decrease at an increasing rate, remain constant, or increase at a decreasing rate over time when $\eta > 0$, $\eta = 0$ or $\eta < 0$, respectively. $\eta > 0$ is likely to be appropriate when the banks' level of technical efficiency does not improve over time. When $\eta = 0$ the banks technical efficiency is time-invariant. If $\eta < 0$, the banks tend to improve their level of technical efficiency over time.

In assessing banking performance, the literature offers four approaches to identify relevant banking inputs and outputs: the production approach, the intermediation approach, the operating approach and the revenue or (value added) approach. Under the production approach, the number of a bank's accounts or its related transactions is the best measure for output, while the number of employees and physical capital are considered as inputs (Sufian, 2007). The intermediation approach defines total loans and securities as outputs, whereas deposits, labour, and physical capital are inputs. The operating approach classifies total revenue (interest and non-interest income)as banks' output and the total expenses (interest and non-interest expenses) as inputs(Leightner and Lovell, 1998). More recently, Drake et al. (2006) proposed the revenue approach (or value added approach) in DEA. The value added approach identifies deposits and loans as outputs (Pasiouras, F., Tanna, S., Zopounidis, C., 2007). Due to data availability, we choose to use intermediation approach to identify for the FCS's inputs and outputs. We identified the banks' loans, leases and investment as outputs [2], while inputs include system bonds, notes, other borrowings, labor, and fixed assets.

We then use a Cobb Douglass functional form as the system production function

$$\ln Q_{it} = \beta_{0t} + \beta_{1t} \ln B_{it} + \beta_{2t} \ln L_{it} + \beta_{3t} \ln A_{it} + \sum \beta_{4t} D_{k} + v_{it} - u_{i} \eta_{it} \qquad (3)$$

Where: Q_i represents outputs which include Loans, Leases, and investment. Due to data availability, Net loan (including Loans, Leases, and investment) is used as a single output for the system. Inputs include D, L and A. D represents the system bonds, notes and other borrowings/payables; L represents proxy for labors, which is obtained by dividing the total salary by total assets following Pasiouras et all (2007), Carbo et al. (2002), Maudos et al. (2002), Weill

(2004), Carvallo and Kasman (2005), Beccalli et al. (2006); and A is fixed assets. In this model, we also use year-specific dummies D_k with k=2001, 2002,…, 2009 to account for the presence of technical progress and time specific effects for the year 2001, 2002,…2009 respectively. The year dummy variables are included to control for technical progress and time-specific variations in the data that cannot be captured by the observed variables, they are also account for yearly shifts of the frontier. The coefficients of the dummy variables indicate the marginal change in output per year associated with the occurrence of technological progress in each cross section (Blair,1974).

MLE is used to estimate the model. As shown by Battese and Coelli (1992)[3], the logarithm of the likelihood function is:

$$\ln L = -\frac{1}{2}(\sum_{i=1}^{N} T_i)\{\ln(2\pi\} + \ln(\sigma_S^2) - \frac{1}{2}\sum_{i=1}^{N}(T_i - 1)\ln(1-\gamma) - \frac{1}{2}\sum_{i=1}^{N}\ln\left\{1 + (\sum_{t=1}^{T_i}\eta_{it}^2 - 1)\gamma\right\}$$
$$- N\ln\{1-\Phi(-\tilde{z})\} - \frac{1}{2}N\tilde{z}^2 + \sum_{i=1}^{N}\ln\{1-\Phi(-z_i^*)\} + \frac{1}{2}\sum_{i=1}^{N} z_i^{*2} - \frac{1}{2}\sum_{i=1}^{N}\sum_{t=1}^{T_i}\frac{\varepsilon_{it}^2}{(1-\gamma)\sigma_S^2} \tag{4}$$

where $\sigma_s = (\sigma_u^2 + \sigma_v^2)^{1/2}, \gamma = \sigma_u^2 / \sigma_S^2, \varepsilon_{it} = y_{it} - x_{it}\beta, \eta_{it} = \exp\{-\eta(t - T_i)\}, \tilde{z} = \mu / (\gamma\sigma_S^2)^{1/2}$

$\Phi(\ )$ is the cumulative distribution function of the standard normal distribution, and

$$z_i^* = \frac{\mu(1-\gamma) - s\gamma\sum_{t=1}^{T_i}\eta_{it}\varepsilon_{it}}{\left[\gamma(1-\gamma)\sigma_S^2\left\{1 + (\sum_{t=1}^{Ti}\eta_{it}^2 - 1)\gamma\right\}\right]^{1/2}}$$

Maximizing the above log likelihood give estimates of the coefficients $\eta, \mu, \sigma_v, and \sigma_u$

The minimum-mean squared error predictor of the technical efficiency of the i[th] firm at the t[th] time period TE_{it}= exp($-U_{it}$) is:

$$E[\exp(-U_{it}|E_i] = \left\{\frac{1-\Phi[\eta_{it}\sigma_i^* - (\mu_i^*/\sigma_i^*)]}{1-\Phi(-\mu_i^*/\sigma_i^*)}\right\}\exp\left[-\eta_{it}\mu_i^* + \frac{1}{2}\eta_{it}^2\sigma_i^{*2}\right]$$

Where E_i represents the (T_i x 1) vector of E_{it} 's associated with the time periods observed for the i[th] firm, where $E_{it} = V_{it} - U_{it}$

$$\mu_i^* = \frac{\mu\sigma_v^2 - \eta_i' E_i \sigma^2}{\sigma_v^2 + \eta_i'\eta_i\sigma^2};$$

$$\sigma_i^{*2} = \frac{\sigma_v^2\sigma^2}{\sigma_v^2 + \eta_i'\eta_i\sigma^2}$$

Where η_i represents the (T_i x 1) vector of η_{it} 's associated with the time periods observed for the i^{th} firm

Data

We estimate the model by maximum likelihood estimation using quarterly unbalanced panel data for the FCS five banks and associations from Jan 2001 to Dec 2009. All data are deflated using US CPI indices (base =2009). Descriptive statistics of variables used in the model are presented in table 1.

Empirical results and discussion

The empirical results of the model are reported in table 2. All estimated coefficients have expected signs and are statistically significant at 5% level. All inputs, with the exception of labor have positive effects on output. The negative coefficient of labor explains the negative effect of labor-assets ratio on the bank productivity. The coefficients of year dummy variables all have positive signs. Those coefficients increase in magnitude with respect to year, which indicates the increasing marginal change in output per year associated with the occurrence of technological progress. The estimated coefficient for year 2008 and 2009 increased significantly from less than 0.66 in previous years to 0.8 in 2008 and 0.92 in 2009. The estimated time effects therefore imply that the FCS has experienced improvement in technical progress over time despite of the financial crisis.

The estimate for η is negative and statistically significant at 5% implying the system's non-negative firm effects increase over time and the system faces a time –varying technical efficiency. Table 3 presents the predicted technical efficiencies of Farm Credit System for 2000-2009. The estimated efficiency of the system is quite stable; it goes up by a very small rate every year over the ten year periods, even during the recent 2007-2009 financial crisis. The estimates are consistent with the FCS's performance and the FCS position in the U.S agricultural lending market before and during the financial crisis. According to the FCS 2009 annual information statement, FCS's Net income went up to \$2.92billion in 2008, and \$2.85billion in 2009 from less than \$2.7billion in previous years. The CRS Report for Congress by Monke (2010) reported that the FCS's market share of total farm debt in both real estate and non-real estate loan has been increasing steadily since 2000. Henderson et al. (2010) also concluded from the Agricultural Finance Databook that the U.S agricultural banks outperformed banks nationwide during the recent financial crisis.

One might argue that the FCS's good performance during the financial crisis can be partially explained by the negative effects of the financial crisis and stock market losses on other agricultural lenders. Loss or failures of other agricultural lenders have driven farmers to the FCS as an alternative lender for less risky transaction and more ability to meet capital requirements. The $106 million loss on investments in Fannie Mae stock and Lehman Brothers securities of Farmer Mac in the fall of 2008 or the failure of New Frontier Bank in Greeley, Colorado- the 11th-largest farm lender among commercial banks, with a $780 million agricultural loan portfolio in April 2009 are two examples. However, one can not deny that the FCS is not immune to the financial crisis due to the fact that the FCS is very dependent on the bond market and therefore its ability to sell bonds to fund its loans has been affected by the financial crisis (Monke 2010). Taking the U.S agricultural lending market and other exogenous factors into consideration, it can be concluded that the FCS's has done well in maintaining their efficiency level during the challenging time.

However, similar to Collender et al. 's results about the FCS profit efficiency in the long run, the estimates of the system efficiency suggest the FCS has not efficiently utilized their inputs. The mean of technical efficiency values of 9.7% indicates that on an average the system realizes only 9.7% of their technical abilities in raising their loans, leases and investment. As shown in Table 4 and 5, on average the five Banks have higher technical efficiency of 62.4% compared to that of 7.7% of the associations.

The estimates of the system efficiency also show opposite patterns of efficiency between the system's five Banks and the associations. The efficiency of the latter decreased slightly over the 2000-2003 periods then slightly goes up over time after 2003, while efficiency of the former demonstrates an opposite pattern and more time-varying. The quite stable efficiency of the whole system therefore can be explained as a result of the offset between the efficiency variation among the banks and the associations. The more time-varying efficiency of the five banks is the results of the five banks' dependence on the bonds and securities market. They are therefore more affected by exogenous factors or economics conditions. The associations are safer in terms of obtaining inputs.

Technical efficiency for each individual of the five banks: AgFirst Farm Credit Bank, AgriBank- FC, CoBank- ACB, Farm Credit Bank of Texas, U.S. AgBank, FCB were also estimated. The estimation of efficiency for each banks are not different from that of the five banks.

Concluding remarks

The paper measures the technical efficiency of the U.S Farm Credit system using a stochastic frontier production function model with quarterly unbalanced panel data. The empirical results suggest that the FCS has not efficiently utilized their inputs. A significant difference and opposite pattern in efficiency over time between the 5 Banks and the Associations are found. The paper results suggest more effort should be made to improve the Farm Credit System's efficiency. It is also important that the Farm Credit Administration and the U.S. policy makers take further steps in investigating whether the FCS'organization structure and operation are healthy in providing a reliable and permanent source of credit to American agriculture.

Although the paper found no evidence about the impact of financial crisis on the system efficiency, its approach and estimates are not enough to conclude that the FCS efficiency is not affected by the financial crisis. Further research is necessary.

Footnotes:

1. The tax benefits for FCS include an exemption from federal, state, municipal, and local taxation on the profits earnedby the real estate side of FCS. For investors who buy FCS bonds to finance the system, the interest earned is exempt from state, municipal, and local taxes. (see CRS Report RS21278, Farm Credit System, by Jim Monke.)

2. The FCS are not allowed to have deposits.

3. Derivation of the MLE is from Battese and Coelli (1992),

4. There are 2 negative values in FCS data (FCS Call reports)

Tables:

Table 1. Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max
Netloans	1416711	4442072	0	5.48e+07
Fixasset	3735.768	3735.768	0	92376.36
Labor	.0078939	.0389903	-.0006927 [4]	.59306
Totalpayable	11401.19	42223.54	0	481785.3

Table 2. Maximum likelihood estimates of stochastic frontier functions for Farm Credit System

Variable	**Parameter**	**Coeficient**	**p-value**
Constant	β_0	21.8129	0.000
		(2.680733)	
lnfixasset	β_1	.0320588	0.000

		(.0047358)	
lnlabor	β_2	-.1649902	0.000
		(.0071116)	
lntotalpay~e	β_3	.085585	0.000
		(.004032)	
D01		.1321866	0.000
		(.0067543)	
D02		.3197731	0.000
		(.0086087)	
D03		.4717016	0.000
		(.0103837)	
D04		.5463099	0.000
		(.0115044)	
D05		.5550947	0.000
		(.0126638)	
D06		.583994	0.000
		(.0143873)	
D07		.663674	0.000
		(.0162469)	
D08		.8094526	0.000
		(.0179979)	
D09		.9209551	0.000
		(.0197671)	
mu	μ	3.071939	0.000
		(.0883406)	
eta	η	-.0000906	0.137
		(.000061)	
sigma2	σ^2	1.023318	
		(.087608)	
sigma_v2	σ_v^2	.0082192	
		(.0001845)	
sigma_u2	σ_u^2	1.015099	
		(.0876103)	

gamma	$\gamma = \sigma_u^2/\sigma_S^2$	.9919681
		(.0007129)
	Log (likelihood)	3151.9877

Table 3: Predicted time varying efficiency values of Farm Credit System for 2000-2009

Summary of Technical efficiency			
YEAR	Mean	Std. Dev.	Freq.
2000	.06985047	.12496746	629
2001	.08613733	.13709271	507
2002	.09293543	.14064947	434
2003	.09809167	.14869237	400
2004	.10387062	.15530408	394
2005	.10667962	.15930639	391
2006	.10751528	.15953122	392
2007	.10992655	.1608103	392
2008	.11177851	.16402506	379
2009	.11454105	.16678341	367
Total	.09788863	.1507697	4285

Table 4: Predicted time varying efficiency value for the 5 districts 2000-2009:

Year	Obs	Mean	Std. Dev.	Min	Max
2000	8	.4604805	.0998232	.3669545	.5539899
2001	8	.4601025	.0998468	.3665544	.553634
2002	8	.4597244	.0998703	.3661543	.553278
2003	17	.6809495	.2506795	.3657542	.9305074

2004	20	.6480564	.2436095	.3653542	.9304346
2005	20	.6477981	.2437629	.3649541	.9303618
2006	20	.6475397	.2439163	.364554	.9302889
2007	20	.6472812	.2440696	.364154	.9302158
2008	20	.6470226	.244223	.3637539	.9301428
2009	20	.646764	.2443763	.3633538	.9300696
Total	161	.6230301	.2340805	.3633538	.9305074

Table 5: Predicted time varying efficiency value for associations 2000-2009:

Year	Obs	Mean	Std. Dev.	Min	Max
2000	621	.0648182	.1170965	.0040849	.9570352
2001	499	.0801419	.1291263	.0040788	.9569898
2002	426	.0860474	.1319485	.0053923	.9569443
2003	383	.0722207	.0683496	.0053618	.4393097
2004	374	.0747698	.0752449	.0053313	.5448173
2005	371	.0775088	.0837751	.0053011	.5446374
2006	372	.0784817	.0849055	.0052709	.5442775
2007	372	.0810365	.0883196	.0052409	.5439174
2008	359	.0819599	.0913526	.005211	.5435572
2009	347	.0838654	.0939574	.0051813	.5431969
Total	4124	.0773872	.1015068	.0040788	.9570352

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