Consumer's choice on GM labeling: evidences from China

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[Abstract] With the development of the biotechnology, more and more GM foods enter the food chain of the mankind. What are the consumers' attitudes toward those foods? And what are their requirements for safety management derived from the emerging of those foods? By conducting a survey in Wuhan with a sample of 621 correspondents, the study collects the correspondents' attitudes on GM foods and expectations on safety managements for those foods, and analyses impacts of consumers' general preferences, specific perceptions on GM foods, and the special labeling usage behavior both on the attitudes formation in GM labeling and on the labeling choices using MNL models. The paper further proposes some suggestions in GM foods safety management based on the modeling results.

[Key words] foods; GM labeling; MNL model

1. Introduction

GM foods have been in the center of the debates for the recent decades. Although GM food debates are of broad spectrum attitudes, the core of the discussion mainly stems from two key elements: "risk and uncertainty" and "information asymmetry". The conflicting opinions rise from the conflicting interests. The perceived risks on environmental, human, ethics and other aspects by the public (Scully, 2003) make the consumers be concerned on GM foods. Existing literatures have set out to sketch characters those risks (Hohenemser & Kasoerson, 1982), the significance of those risks (Harlander, 1991), the effects of those risks on consumption behavior (Douhitt, 1995; Grobe, 1995). Previous studies on the existing risks suggest the needs of better understanding of public trusts and constructing regulatory system.

Although different views diverge in the topics on GM foods, there is an agreement on the lack of communication in GM food purchase decision, or so called "information asymmetry" problem. As genetically modification is attributes are either not revealed or practically too high to observe even after purchasing by consumers, the producers have more information on this credence characteristics (Darby and Karni, 1973) of the goods than the consumers. Without being told, Consumers can know the GM attributes only if they took the foods to the inspection agency for testing. Given such high measurement costs, systemic failure occurs mainly resulted from the information provision of the current food system (Hennessy, 2003).

As labeling can provide extra information, it is regard as a good remedy for the market failure arouse from information asymmetry for GM goods (Grossman, 1981). As label would provide selected information (including tastes, nutrition contents and more) and new information arising from developments in procession methods (Marks, 1984; Dhar & Foltlz, 2004), it enters the legislation requirement for food regulation policy in various courtiers and regions (Przyembel, 2004).

Although the contents and details of labeling law of different countries and regions varies, most of GM labeling follow two streams: mandatory labeling, which requires to label "Does contain "GM component if GM components exceed threshold percent,

and voluntary labeling, under which qualified non-GM foods may be labeled as "Does not contain" of GM components. Different labeling systems have similar functions of information communication (Hobbs，2004), converting the credence attribute of GM foods into search attributes (Mojduszka & Caswell, 2000). However the requirements and the cost sharing diverge under the absence and the presence of different GM labeling systems, and with different market structures resulted by different information transfer lead to different purchase behavior based on the quality and quantity of information available(Caswell, 1998；Caswell, 2000).

Theoretically, the primary purpose of GM labeling is to justify the distortion by market failure, but at the costs of labeling and segregation (Crespi & Marette, 2003). As the associate costs may outweigh the welfare gains brought about by the introduction of labeling, the statement "more information, better consumer welfare" does not hold. The optimal policy should the consumers status take into account, e.g. the ratio of concerned consumers (Crespi & Marette, 2003), the biotechnologies knowledge of consumers (Shigeru Matsumoto, 2004). The format of the label also influence effects of labeling: front label and back label has different meanings to the heterogeneous consumer (Shigeru Matsumoto, 2004).

Although consumers' attitudes are frequently mentioned in the core of GM debates, the concern is mainly from the producers, on consumers' perception, willingness to accept to choose GM foods, with an attention to promote GM food. Being one alternative of regulatory method, labeling are justified from an overall welfare aspect (Lence & Hayes,2005; Sobolevsky et.al, 2005), however the consumers requirement on labeling are seldom touched. Even for common foods, existing studies also have overlooked the consumer perception on the information provided by labels (Przyrembel, 2004). Furthermore, when discussion GM labeling, most literature focus on the GM foods rather than the GM labeling, apart from Louteiro & Hine's (2004) study, which quantifies the US consumers' willingness to pay for mandatory labeling using contingent valuation method. They study suggests that even with the concerns and diverge views about GM foods, the majority US consumers offers a WTP less than the costs associate with the mandatory labeling scheme.

Most studies in biotechnology issues are mainly on developed countries and areas, such as EU, US and Japan(Huffman,2003; Kiesel et al ,2005; Crespi & Marette, 2003; Crespi & Marette, 2003), expect for in few studies on the overall welfare, where developing countries consist of a minor part in the cross models (Lence & Hayes,2005). Actually, the results of those welfare studies would be more powerful with the solid micro-foundation on the behavior of the individual agents. Moreover, when talking about GM theme, China is the one of the countries can not be ignored among all the developing countries. Being the leading GM producer, consumer, technology owner among developing countries, China is important not to itself but to the world. China has the forth largest area sown with GM crop, 90% of cotton sown is GM varieties. As most GM outputs are mainly for domestic use, China becomes a large GM consumer. The level of GM food consumption is even higher with the import of GM soybean and GM rapeseed, which values at 13 billion dollar in 2004 (Ma, 2004). The discussion of the commercialization of GM rice even suggests that China may have rapid increase volume of GM foods available for consumption.

Past literature has also shown that the Chinese diet is different from westerns diet, and the consumption behaviors of Chinese individual are quite different even on the ordinary foods(dairy , meat and so on), the nutrition label users are different from US （Su & Tsoi,1998）. Consumers also show ambivalence in GM foods, with a long tradition of welcome products with high technology, Chinese consumers was quiet cheerful to GM foods; but the conflicts views on GM also alerts consumers' concerns on GM foods, the discussions about regulation, banning, labeling, ethics and more are undergoing. Most famed studies on GM food in China is by the group of Huang, their study touches the micro aspects of GM food production, their study suggests that the adoption of GM rice by small and poor farm households can not only bring economic improvement due to the higher yields and but also benefit form improved health (Huang et al, 2005). Other study are limited to the consumers' perception and acceptance of GM foods (Zhong & Ding, 2002; Zhang, 2004) . However there lack linkages between the studies on GM regulation policy and the micro-foundation on consumers' behavior, which is the essential factor in optimal policy decision (Crespi

& Marette, 2003; Shigeru Matsumoto, 2004). Actually the needs for justification of GM legislation are not the sole to China, but also for other countries and areas. Seldom have any studies directly elaborated on the consumers' needs for policy, even with the background in GM producer countries. The consumers' component in legislation is so much ignored, instead the process of regulation GM is dominated by "biopolitics" in some countries (Andree, 2002). Most of the policy implications in those studies are drawn indirectly after the study of GM food consumption perception, behavior or market. So a study on the consumer choices on GM labeling is essential.

Moreover, the transition economy in China made the economic institutions given the unique background of labeling regulation and enforcement. A study on the consumer choices on GM labeling in China may reveal unique element for decision making. The Chinese government is keen on protect the consumers' right to know, mandatory labeling is required since the introduction of new regulation in 2001. Given the current status of consumers and the nature of the labeling requirement, is mandatory labeling the one that fits the consumers' need? The paper set out to reveal the factors that determines the consumers' choice on GM food labeling by analysis the survey data on Wuhan consumer's preferences.

2. The model

2.1 Theoretical Framework

Economists view consumers as rational individuals, hence utility maximization models with certainty are employed to study the consumers' choice under information symmetry. As asymmetric information is more close to the reality, especially in the food market，random utility framework is more appropriate for analyzing issues in these area. Kiesel et al (2005) has developed and applied such model to analyze the labeling effects on the demands for fluid milk. Here we adopt his idea and to analyze the demand for information of food GM content through labeling choices. Following

Kiesel et al (2005), it is assumed that the consumers maximize the expected utility by choosing the preferred food and other consumption goods given the uncertainty of the food attribute. The model is as below:

$$\begin{aligned} &\max_{\mathbf{x},\mathbf{m}} E[U(\mathbf{x},\mathbf{m},r)] \\ &st. \quad Y = \mathbf{qx} + \mathbf{pm} \\ &\qquad \mathbf{p} = p(L_j) \end{aligned} \tag{1}$$

$\mathbf{m}$ …… quantity of food

$\mathbf{x}$ …… quantity of consumption goods other than food

$\mathbf{p}$ …… price of food

$\mathbf{q}$ …… price of consumption goods other than food

r …… random term

Y …… budget

L_j …… food GM labeling system

The consumer consumes food n kinds of consumption good and 2 kinds of food: m_1 presents traditional food（or non-GM food） and m_2 presents GM food. The expected utility of the consumers is determined by the quantity of foods and other consumption goods and a random term r, which denoted the subjective attributes of the food. The quantity of consumption goods is subjected to the individual's income level Y, while the price of the foods has three alternatives regarding to the labeling system. Under three possible labeling systems, which include mandatory labeling system L_1, voluntary labeling system L_2 and no labeling system L_3, the prices differ given the presence of the labeling costs. If the price vector of food is $\mathbf{p} = (p_1, p_2)$, while p_1 denotes the price for non-GM food, and p_2 denotes the price for GM food.

The price for food without labeling is $\mathbf{p}^n = (p_1^n, p_2^n)$, under the perfect information condition and ignore the information costs. The price for food under voluntary labeling is $\mathbf{p}^v = (p_1^v, p_2^v) = (p_1^n + c, p_2^n)$, c is the costs for segregation and labeling as the producers claim and insure that the food the produced is GM free. Under mandatory labeling system, the labeling costs add into the GM food. If t denotes the concerning labeling costs, the price vector is $\mathbf{p}^m = (p_1^m, p_2^m) = (p_1^n, p_2^n + t)$. If the final costs of food consist of marginal cost and labeling cost, and both of the costs are constant, the price for food is determined only by the labeling system chosen. It explains the second constraint $\mathbf{p} = p(L_j)$ in (1).

The random term r needs more explanation. In their study for milk labeling, Kiesel et al (2005) regard the randomness as the results of the uncertainty about the products attributes, the variance of which is determined for the labeling information, previously acquired human capital and search time. Teisl et al (1996) also considered the role of information provided by labeling in the utility function. They introduces the term of "information extraction" in their study on the optimal form of labeling. In Teisl's study the quantity of information extracted, which is determined by the maximum information provided by the label, individual's cognitive ability and time used in the information exaction process, enters into the utility function directly as the quantity of food does. However the extracted information in the utility function is not separable from the quantity of food, which is not clearly justified in Teisl's study. MAPP's works proposed subjective quality as a new perspective in the study of food quality. Subjective quality, which is mainly constituted by user-oriented quality, is measurable by the end-user and is subject to change according not to products but to users.

Although such perceptive is quite subjective, it explains why extra information alters the consumer's choice. With the reference of those studies, the model in this paper regards the random term r as the subjective quality of food, the distribution of which is determined by the prior attitudes of GM foods A_i, the information extracted from GM label I_{ij} and other minor factors.

$$R \sim (\mu(A_i, I_{ij}), \sigma^2(A_i, I_{ij})) \tag{2}$$

Again, under the presence of mandatory labeling, voluntary labeling and the absence of labeling, the corresponding random terms r^1, r^2 and r^3 are independent with the rest. I_{ij} denoting the information extracted from label j by consumer i in (2) is subject to the consumer's cognition ability C_{ij} and the maximum information provided by the label $D_j = D(L_j)$ (Teisl et al, 1996). As GM labeling in China are always in the form of standardized few extra words in the packaging, time for the information extraction (reading and etc) and labeling technology variations are not considered.

$$I_{ij} = I(D_j, C_{ij}) \tag{3}$$

Combine (2) and (3), we get

$$R \sim (\mu(A_i, D_j, C_{ij}), \sigma^2(A_i, D_j, C_{ij})) \tag{4}$$

Then let consider the optimization procedure. Under given labeling system, the consumer reaches his maximized expected utility $E[U(\mathbf{x}^*, \mathbf{m}^*, r^k \mid L_k)]$ by choosing consumption bundle $(\mathbf{x}^*, \mathbf{m}^*)$. If such utility level is the highest among all the maximized expected utility under all possible labeling systems, or $E[U(\mathbf{x}^*, \mathbf{m}^*, r^k)] > \bigvee_{j, j \neq k} E[U(\mathbf{x}^{**}, \mathbf{m}^{**}, r^j)]$, L_k is the labeling that the consumer prefers.

And we use indirect utility function $V_{ij} = V_j(\mathbf{p}, \mathbf{q}, Y, L, I_{ij}, A_i)$ to describe the variation in the expected utility subject to the influential factors. $V_j(\bullet)$ is the functional form of the indirect utility function, its specification presents the individuals preferences. At the utility maxima is $V_{ij}^* = V_j(L^*, C_{ij}^*, A_i \mid \bar{\mathbf{p}}, \bar{\mathbf{q}}, \bar{Y})$, the possibility of choose L_j as the preferred labeling is given by

$$P(L_j = 1) = \Phi_j(A_i, C_{ij}^*, V_{ij}^*) \tag{5}$$

j has three options, $P(L_1 = 1)$、$P(L_2 = 1)$ and $P(L_3 = 1)$ which are the probabilities to choose mandatory labeling, voluntary labeling and no labeling respectively . The sum of the possibilities is one, that is $\sum_{j=1,2,3} P(L_j = 1) = 1$.

2.2 Econometrics specification

Multinomial logit model is employed to analyze the problem with discrete labeling choice. The general form is with linear form as: $p_{ij} = \frac{e^{\gamma_j' x_i}}{\sum_t e^{\gamma_t' x_i}}$, which present consumer i's probability to choose option j. In this study, each individual has three labeling options, and no labeling is as the base choice. After standardized, consumer i's probability to choose mandatory labeling is $p_{im} = \frac{e^{\gamma_m' x_i}}{1 + e^{\gamma_m' x_i} + e^{\gamma_v' x_i}}$; his probability to choose voluntary labeling is $p_{iv} = \frac{e^{\gamma_v' x_i}}{1 + e^{\gamma_m' x_i} + e^{\gamma_v' x_i}}$; his probability to choose no labeling is $p_{in} = \frac{1}{1 + e^{\gamma_m' x_i} + e^{\gamma_v' x_i}}$.

The odds ratio is $\ln\left(\frac{p_{im}}{p_{in}}\right) = \ln\left[\frac{e^{\gamma_m' x_i}}{e^{\gamma_n' x_i}}\right] = \gamma_m' x_i - \gamma_n' x_i = (\gamma_m' - \gamma_n') x_i = \beta_m' x_i$ and

$\ln\left(\frac{p_{iv}}{p_{in}}\right) = \ln\left[\frac{e^{\gamma_v' x_i}}{e^{\gamma_n' x_i}}\right] = \gamma_v' x_i - \gamma_n' x_i = (\gamma_v' - \gamma_n') x_i = \beta_v' x_i$.

As mentioned in (5), optimal utility level V_{ij}^{*}, the prior acquired attitudes towards GM food and technology A_i and individual's cognitive ability towards GM labeling C_{ij} are all factors that affects labeling presences. Eight variables are selected to reflect the variation in those factors. As the utility of the consumers are not directly measurable, it is determined by the consumer's preference. So socio-demographic variables including gender, age, education level and monthly living expenditure, is used to approximate it. Although the specific variables used differs, the treatment of using socio-demographic variables as preference approximation can be seen in various studies in food choice study, see Huffman (2003). The prior attitudes toward GM has four indicators: the judgment of the correspondence on four statements: whether GM technology has important implication to solve the problem to feed China, whether GM technology has adverse impact on environment, whether GM technology is able to enhance the living of human being, and whether GM foods has side-effects on descendants. The cognitive ability of GM labeling is not directly measurable， hence the degree of attention paid to food label was adopted after two approximation process. One is using result of behavior to reveal ability; the other is using general labeling to approximate that of GM labeling.

3. Application

3.1 Data

The survey was conducted in July, 2004. Seven suburbs of Wuhan city has been divided into 1000 community locations according to probability map, from which 80

locations according to the proportionally to the population size of the suburban areas. Within the suburbs, the community locations were selected randomly. An average of 8 respondents was also randomly selected for each community location. A total of 619 observations were obtained after the elimination of invalid observation.

Although labeling has costs, one specified costs can not be identified as our study associates with no particular food. In the survey, the question is "If food GM labeling will increase the price, which do you prefer, mandatory labeling system, voluntary labeling system and no labeling system? " It turns out that more than 90% of the correspondences choose labeling regardless of the associate cost, and more than half prefer mandatory labeling.

Table 1 Choices of GM labeling

Labeling choice	number	Percent(%)
mandatory	329	53.2
voluntary	236	38.1
no labeling	54	8.7
Sum	621	100.0

*source: from own survey.

Table 2 Explanatory variable list

indexes	Variables	count	precentage (%)
Biotechnology are important to solve the problem of feeding China (WB)	Not important(WB0=1)	294	47.3
	important (WB0=0)*	327	52.7
Biotechnology has negative effects on environments (ENV)	No negative effects (ENV0=1)	259	41.7
	Has negative effects (ENV0=0)*	362	58.3
Biotechnology can increase the quality of our life (MODS)	Can not increase (MODS0=1)	205	33.0
	Can increase (MODS0=0)*	416	67.0
Biotechnology foods has negative	Do not know (NEG1=1)	170	27.4

effects on our descendants (NEG)	No negative effects (NEG2=1)	123	19.8
	Has negative effects (NEG3=1)*	328	52.8
Monthly living expenditure (LEXP)	n.a.(LEXP0=1)	33	5.3
	RMB 300and below (LEXPA=1)	110	17.7
	RMB 301-600 (LEXPB=1)	235	37.8
	RMB 601-1000(LEXPC=1)	156	25.1
	RMB 1000 above (LEXPD=1) *	87	14.0
Gender (SEX)	Male (SEX=1)	359	57.8
	Female (SEX=0) *	262	42.2
Education level(EDU)	Junior middle school and below (EDUA=1)	138	22.2
	High school and TAFF (EDUB=1)	187	30.1
	College and above (EDUC=1) *	296	47.7
Attention paid to labels when purchasing foods (FLB)	much attention(FLBA=1)	212	34.1
	General attention(FLBB=1)	270	43.5
	Seldom attention(FLBC=1)	99	15.9
	No attention (FLBD=1) *	40	6.4
Number of observations		621	100.0

*the variables with * are treated as base group, which are not included in the regressor。

source: from own survey.

3.2 Results

All the variables in Table 2 are included in the regression at the first stage. The categories variables are converted into the dummy variables and the one category was selected as the base category. Then insignificant variables are excluded in the reduced model. A joint test on the excluded variables suggests they are not significant at 0.05 level. (LR=19.80<21= ch-sq0.05,12). The log Likelihood Ratio Tests of variables in full model and reduced model are compared in Table 4 below. Most variables get an increased significant level except the marginal deduction significant level of one

variable. Hence the result of the reduced form was used in the further analysis.

Table 3 Significance of index (log Likelihood Ratio Tests）

Index	Degree of freedom	Full Model		Reduced Model	
		Chi-Square	Sig.	Chi-Square	Sig.
WB	2	7.774	0.021	7.209	0.027
ENV	2	0.461	0.794	--	--
MODS	2	5.281	0.071	6.084	0.048
NEG	4	21.193	0.000	29.235	0.000
SEX	2	0.036	0.982	--	--
AGE	4	7.630	0.106	--	--
LEXP	8	14.927	0.061	15.805	0.045
EDU	4	2.206	0.698	--	--
FLB	4	22.612	0.000	24.898	0.000
		103.981(32)		94.195(20)	

The reduced regression has 5 indicators, which were expressed by ten dummy variables and grouped into three types. The reduced regression has three indicators on GM technology attitudes, which are all significant affects GM labeling choice. Their specific effects are in different. Although consumers' attitudes on GM technology contribution to feeding China influence the GM labeling choice, it does not have specified attribution pattern. Consumers' perception of GM technology on enhance mankind's lives is also factors in determination of the labeling choice. A person with positive attitude on GM technology in enhancing mankind's lives is more likely to choose voluntary labeling. The regression also shows the different attitudes on statement of 'GM food has side effects on descendant' have significant effects in labeling choice. The probability for those who believes that the side effects do exist to choose voluntary labeling is more than twice (2.155) than the chances for him to agree no labeling adoption. And his chance to choose mandatory labeling is even higher (3.842). If an individual is not sure about the side-effects, he/she is more likely to

behave conservatively, as the corresponding parameters are not significant.

Monthly living expenditure is the only socio-demographic indicator that remains in the reduced regression, and the consumers group with below 300RMB monthly living expenditure is selected as the base group. Consumers with higher monthly living expenditure are more likely to choose have a labeling system regarding the costs of it. Among all the consumers of different expenditure group, consumers with a monthly expenditure of 601-1000 RMB are more likely to choose labeling system, and mandatory labeling is the one they prefer more. The consumers with a monthly expenditure over 1000 RMB are the group that prefers labeling in second place and their preferences between mandatory labeling and voluntary labeling is marginally different. For the consumer group with a monthly expenditure between 300 RMB and 600 RMB, they differ from the base group in the higher possibility to choose voluntary labeling.

Consumers' differences in their attention to general food labels are important explanation in GM labeling choices. Those paying highly attention to those labels are more likely to choose mandatory labeling. Those paying general attention also have the highest possibility in choosing mandatory labeling, however, they also have a higher possibility to choose voluntary labeling compared to the possibility to choose no labeling.

Table 4 Regression results

GM labeling choices	variable	coefficient	Std. Error	Wald	Sig.	Exp(B)
A Mandatory	Intercept	-0.541	0.509	1.126	0.289	--
	WB0	0.244	0.342	0.508	0.476	1.276

labeling	MODS0	0.393	0.353	1.244	0.265	1.482
	NEG1	1.346	0.431	9.764	0.002	3.842
	NEG2	-0.487	0.397	1.503	0.220	0.615
	LEXP0	0.375	0.738	0.258	0.612	1.455
	LEXPB	0.586	0.397	2.177	0.140	1.796
	LEXPC	1.649	0.514	10.288	0.001	5.204
	LEXPD	1.207	0.625	3.727	0.054	3.345
	FLBA	1.256	0.414	9.203	0.002	3.513
	FLBB	1.265	0.380	11.058	0.001	3.543
B Voluntary labeling	Intercept	-0.549	0.515	1.140	0.286	--
	WB0	-0.270	0.343	0.618	0.432	0.763
	MODS0	0.768	0.356	4.648	0.031	2.155
	NEG1	1.192	0.440	7.340	0.007	3.294
	NEG2	0.072	0.399	0.033	0.857	1.075
	LEXP0	0.965	0.722	1.787	0.181	2.624
	LEXPB	0.731	0.402	3.299	0.069	2.076
	LEXPC	1.504	0.522	8.318	0.004	4.502
	LEXPD	1.197	0.636	3.542	0.060	3.310
	FLBA	0.373	0.420	0.789	0.375	1.452
	FLBB	0.998	0.375	7.084	0.008	2.713

4. Conclusion and Discussion

This study investigates food GM labeling requirement of the Chinese consumers. The study suggests that the current mandatory labeling legislation in China is the option that meets the public's need most. However the fact that more than 1/3 of the surveyed agrees voluntary labeling system suggests the heterogeneity in GM labeling requirements resulted from the heterogeneous demand for GM information of food. MNL model is employed to test the factors lead to diverge labeling preferences. The regression results suggest the prior acquired attitudes towards GM food and technology, consumers' preferences and their cognitive ability towards GM labeling affect their labeling requirement in different ways. Our result agrees the previous

related study; for example, in his study on GM milk consumption, Huffman (2003) also accentuates the pre–understanding of GM has significant effects on GM milk participation. As his study does not differentiate the contents of the pre- understanding of GM acquired from previous information, it to be identified as having negative effects. His study also suggested socio-demographic attributes do no affects the willingness to pay for GM foods, but our study shows the individuals with different living standards has different requirement in GM labeling. Cognitive ability towards GM labeling is seldom mentioned as a single factor in the previous study, which is mentioned as part of the individual difference presented by education, socio-demographic and so on. This study suggests that it is a significant factor that differentiates the GM labeling requirement.

Those results give policy makers implications in policy making. The prior acquired attitudes towards GM is depends on the information accumulated and the way the individual process related information. In the short run, while the information process keeps unchanged, the dramatic new information may change the attitudes and thus changes the labeling requirements. In a long time frame, the flow of information also may strengthen or change the labeling requirements. Public education on GM food knowledge is the one way of information transfer and diffusion which led to success information accumulation of the individual consumers. Also the information provision from credible source or institutes also can alter consumers' labeling requirements. It suggests that those methods are potentially used as tools when making the GM food development strategy. However, what is the most reliable source for GM information and how those information affects consumers labeling choice needs further study.

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