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Choices of Wine Consumption Measure of Interaction Terms and Attributes

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Interpreting interaction terms in econometric modelling is fussy. McFadden (2001) explains the complexity of consumers' choice faced with complex attributes of good. He emphasizes the difficulty of econometric models to reveal the psychologist process which is most of the time non directly observable, but induces behavioral effects. The models logit and probit are the more used modelling consumers' choice. However, they omit the interaction effects among the explanatory variables during the process of choice. These blended effects are however declared in the modifications of the consumption decision. The difficulty is then to interpret the coefficients associated with these interaction variables. Ai Norton (2003) have demonstrated, in the case of non linear models, that these coefficients could not be appreciate with a simple t-test. To solve this problem, we propose a decision rule enforceable whatever the nature of the estimators and for each kind of models, linear and non-linear. We build a simple rule decision, which offers an easy lecture and then becomes very convenient. We carry out an application of this decision rule to the choices of the wine consumers confronted with increasingly sophisticated products: which arbitrations to realize between the color, the degree or the type of wine when these various attributes combine on the labels and on increasingly broad rays? How to take into account these combinations of attributes for better understanding the processes of choice of the consumers? Using data from ONIVINS - Recensement exhaustif des premiers contrats de vente non AOC de 1987 `a 2003 (fctv03) - we give an experimental result describing the arbitration of wine consumers between color, degree and type of French wine.

Choices of wine consumption : Mesure of interaction terms and attributes

Magali Aubert¹ – Véronique Meuriot²

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1. Introduction

Interaction effects are very seldom treated in econometrics. The explanation of a phenomenon is however sensitive to this type of information (Asher & Popkin, 1984). In the consumer theory, for example, decisions are made at the end of an arbitration which is often badly perceived by the standard econometric models. Interpreting decisions of consumers' choice requires taking into account psychological factors which are not always perceptible in the step of econometric estimation. This complexity is notably reported by McFadden (2001) when he relates a history of econometric modellings in that context :

'The characterization of alternatives in the [multinomial logit] model in terms of their "hedonic" attributes was natural for this problem, and followed the psychometric tradition of describing alternatives in terms of physical stimuli'(p.354).

He specifies a little further that :

'[...] most applications of the standard model leave out dependence on experience, and much of the power of this model lies in its ability to explain most patterns of economic behaviour without having to account for experience or perceptions' (p.356).

Nonlinear models like logit or probit are the most used modelling consumers' choice because they allow discrimination among decisions. Nevertheless, a weakness of these models, and of econometric models in their standard use, is to omit interaction effects among explanatory variables in the choice process. These blended effects are however declared by the modifications of consumption decision when an individual must arbitrate between several goods combining several attributes but various ways. The supply of consumption goods is today ever more heterogeneous, even complex, insofar as a same good can associate various characteristics of single goods. In most cases, the combination of attributes is not perceived as purely additive. The association of attributes singly enhance is only exceptionally perceived like the exact addition of the utility provided by each attribute taken separately. Restoring this process of consumers' choice requires the introduction of interaction effects in econometric models, that they are linear or not. The way to introduce these interactions is to add combinations of attributes to individual explanatory variables. These combinations are introduced by the product of couples of variables. The model is increased in these interaction effects, and these effects are estimated as all the others variables coefficients. The difficulty is to interpret coefficients associated to these interaction variables. Unlike the natural³

³ The term « natural » is related to non blended variables.

explanatory variables whose coefficients signify elasticities (in linear models) or variations in relation to a reference (in nonlinear models), estimate coefficients of combinations of variables are much more discerning. In linear models the t-test gives straight significance of such a coefficient. Ai & Norton (2003) proved that statistical significance in nonlinear models cannot be tested with just a t-test : they are conditioned by independent variables. In this case, we must take into account *non unit* modifications of the utility introduced by the natural variables combination.

In this paper, we discuss the significance of interaction coefficients and suggest a decision rule able to arbitrate among several values of these coefficients at the end of the estimation process, in linear and nonlinear models. In a second section, we develop definition and implications of interaction terms according to models used, linear and non linear. In a third section, we explicit the decision rule useful to interpret interaction terms estimate. In a fourth section, we carry out an application of this rule of decision on a segment of the French wine consumption market. We conclude about usefulness and performance of this decision rule distinguishing processes of consumers' choice when they are confronted with complex goods.

2. Defining and interpreting interaction terms

Theoretical bases of econometric modelling⁴ advocate to describe a phenomenon (the explained variable) starting from variables (explanatory) independent between them. This modelling exercise is carried in a context *ceteris paribus* : the information contained in the selected explanatory variables must provide the possible best estimate of the phenomenon one have to explain. The standard model is :

$$Y = \alpha + \sum_{i=1}^n \beta_i X_i + \varepsilon \quad (1)$$

where Y a phenomenon to explain,

α a constant,

X_i explanatory variables,

β_i estimate coefficients,

ε estimate error, representing all the information not take into account by the model.

⁴ We make reference to the first probabilistic econometric works of Haavelmo (1940, 1944).

The performance of modeling is thus closely related to the informative capacity of the explanatory variables. However, most of the time the econometrician is out this framework and must be satisfied with a rough estimate, appreciated notably by the value of the coefficient of determination. One is entitled to wonder whether, whereas the most relevant variables were selected, there would not be an information residual in interaction terms between these variables. Bowles (1970) indicates the absence of theoretical bases as the main difficulty. He emphasizes the relevance of interaction terms :

'[...] The crucial deficiency is not in the lack of the data but the absence of a theory of learning to guide us in establishing a model for our estimation. One consequence of this lack of theory has been the tendency of researchers to ignore interaction effects of inputs'. (1970, p.13)

Interaction terms inform about complementary relations among explanatory variables. One distinguishes straightforward effects (explanatory variables coefficients) and blended effects (interaction terms) relative to combinations. The phenomenon is better explained and the estimate residual, ε , is reduced. Asher & Popkin (1984) reveal that omission of interaction effects can leads to wrong results. They prove that introducing interaction effects increases the understanding of this discrepancy, while their omission maintains odd discrepancies .

The impact of the estimation of interaction terms is pregnant especially for consumers' choice models. When the consumer must express a choice face to several goods offering similar attributes, how appraising his decision-making processes ? The knowledge about interaction effects can be a response.

Introducing interaction terms depends on some explanatory variables or on another effect[3]⁵.

In the quantitative case, the model is :

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \varepsilon \quad (2)$$

The model including interaction between two variables X_1 and X_2 is :

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_{12} X_1 X_2 + \varepsilon \quad (3)$$

In the linear model, marginal effects are :

⁵ Interaction terms do not introduced collinearity between variables. The formula for a collinearity relationship is : $\alpha_1 X_1 + \alpha_2 X_2$ while the interaction variable is noted : $(\alpha_1 X_1)(\alpha_2 X_2)$. It is based on the weighted product of the explanatory variables. See, for example, Friedrich (1982).

$$\frac{\partial Y}{\partial X_1} = \beta_1 + \beta_{12}X_2 \quad (4)$$

$$\frac{\partial Y}{\partial X_2} = \beta_2 + \beta_{12}X_1 \quad (5)$$

and the interaction marginal effect is :

$$\frac{\partial^2 Y}{\partial X_1 \partial X_2} = \frac{\partial^2 Y}{\partial X_2 \partial X_1} = \beta_{12} \quad (6)$$

In the non linear model, because the form of the distribution function is respectively :

Logit :

$$F(W) = \frac{e^w}{1+e^w} = \frac{1}{1+e^{-w}}$$

Probit :

$$F(W) = \int_{-\infty}^w \frac{1}{\sqrt{2\pi}} e^{-\frac{t^2}{2}} dt$$

So marginal effects are (for logit model):

$$\frac{\partial Y}{\partial X_1} = (\beta_1 + \beta_{12}X_2) \frac{e^{(\beta_1 + \beta_{12}X_2)}}{1 + e^{(\beta_1 + \beta_{12}X_2)^2}} \quad (4')$$

$$\frac{\partial Y}{\partial X_2} = (\beta_2 + \beta_{12}X_1) \frac{e^{(\beta_2 + \beta_{12}X_1)}}{1 + e^{(\beta_2 + \beta_{12}X_1)^2}} \quad (5')$$

and the interaction marginal effect, from (6'), is :

$$\frac{\partial^2 Y}{\partial X_1 \partial X_2} = \frac{\partial^2 Y}{\partial X_2 \partial X_1} = (\beta_1 + \beta_{12}X_2)(\beta_2 + \beta_{12}X_1) e^{(\beta_1 + \beta_{12}X_2)(\beta_2 + \beta_{12}X_1)} \frac{1 - e^{(\beta_1 + \beta_{12}X_2)(\beta_2 + \beta_{12}X_1)}}{1 + e^{(\beta_1 + \beta_{12}X_2)(\beta_2 + \beta_{12}X_1)}} + \frac{\beta_{12} e^{(\beta_1 + \beta_{12}X_2)(\beta_2 + \beta_{12}X_1)}}{\left[1 + e^{(\beta_1 + \beta_{12}X_2)(\beta_2 + \beta_{12}X_1)}\right]^2}$$

Thereafter, we develop only the linear model (arguments can be transposable to nonlinear models from equations (4'), (5') et (6')). Nevertheless, we observe that in the nonlinear case the interaction term is wider than the estimate coefficient β_{12} produced by the estimate, but must be recomputed using equation (6'), as explained in Ai & Norton (2003).

3. Decision rule

The estimation of the interaction term in the linear case is directly performed at the time of the estimation of the model. Its significance is given by a t-test. However, the interpretation of this interaction coefficient is not so easy than those of the natural explanatory variables. Because β_{12} conveys a residual blended effect between explanatory variables, we must distinguish four possible cases :

- The combination contributes nothing else : variables are independent,
- The combination overvalues attributes,
- The combination leads to an undervaluation of attributes,
- The combination leads to disutility.

Arbitration between these cases differs according to the sign of β_1 and β_2 :

	β_1 and $\beta_2 > 0$	β_1 and $\beta_2 < 0$	$\beta_1 > 0$ and $\beta_2 < 0$ with $ \beta_1 > \beta_2 $
Independance	$\beta_{12} = 0$		
Overvaluation	$\beta_{12} > 0$ $\beta_1 + \beta_2 + \beta_{12} > \beta_1 + \beta_2$	$\beta_{12} \in]\beta_1 + \beta_2; 0[\cup]0; +\infty[$	$\beta_{12} > \beta_1$
Undervaluation	$\beta_{12} < 0$ with $0 < \beta_1 + \beta_2 + \beta_{12} < \beta_1 + \beta_2$	$\beta_{12} \in]\beta_1; \beta_2[$ with $ \beta_1 > \beta_2 $	$\beta_{12} \in]\beta_2; 0[\cup]0; \beta_1[$
Disutility	$\beta_{12} < 0$ with $\beta_1 + \beta_2 + \beta_{12} < 0$	$\beta_{12} \in]-\infty; \beta_1 + \beta_2[$	$\beta_{12} < \beta_2$

Table 1 – The decision rule

Adaptation to nonlinear models : this decision rule also fits over nonlinear models if one respects formulations of equations (4'), (5') et (6') adapted from Ai & Norton (2003). For a straightforward use of the decision rule, it is enough to write :

$$(\beta_1 + \beta_{12} X_2) \frac{e^{(\beta_1 + \beta_{12} X_2)}}{1 + e^{(\beta_1 + \beta_{12} X_2)^2}} = \delta_1 \quad (7')$$

$$(\beta_2 + \beta_{12} X_1) \frac{e^{(\beta_2 + \beta_{12} X_1)}}{1 + e^{(\beta_2 + \beta_{12} X_1)^2}} = \delta_2 \quad (8')$$

$$(\beta_1 + \beta_{12} X_2)(\beta_2 + \beta_{12} X_1) e^{(\beta_1 + \beta_{12} X_2)(\beta_2 + \beta_{12} X_1)} \frac{1 - e^{(\beta_1 + \beta_{12} X_2)(\beta_2 + \beta_{12} X_1)}}{1 + e^{(\beta_1 + \beta_{12} X_2)(\beta_2 + \beta_{12} X_1)}} + \frac{\beta_{12} e^{(\beta_1 + \beta_{12} X_2)(\beta_2 + \beta_{12} X_1)}}{[1 + e^{(\beta_1 + \beta_{12} X_2)(\beta_2 + \beta_{12} X_1)}]^2} = \delta_{12} \quad (9')$$

and replace $(\beta_1, \beta_2, \beta_{12})$ by $(\delta_1, \delta_2, \delta_{12})$.

4. Empirical example : the case of French wine market

The database used is a census of all first 'mise en marché'. Completeness is guaranteed by the compulsory nature of the questionnaire.

This database is implemented by ONIVINS from 1987 to 2003.

The questionnaire is composed of three parts:

The first one describes contractors characteristics.

The second one describes products: quantity, quality, color, price of degree/hl...

The third one defines the contract financial terms.

Anonymity must be guaranteed. The first part is so limited to general information. We know neither name nor localisation at municipal level

In a contract, we can have several different products exchanged. All characteristics relative to those products are defined. For each one, we have price, quantity... All products are distinguished and that's why we work with the unity "product".

We estimate a linear model based on characteristics of French wine as :

- color : red = 1, others = 0,
- degree,
- type : table wine = 0, country wine = 1

The dependent variable, Y, is the price of the hectolitre degree, expressed in euros. The results are :

Results: Model without / with interaction terms

Variable	Without IT	With IT
color	-0.299**	0.327 **
degree	0.296**	0.305**
type	1.096**	1.602**
color*degree		-0.036 **
color*type		-0.764 **
Intercept	0.326**	0.115 [†]
N		660599
R ²		0.28 0.30
Significance levels : † : 10% * : 5% ** : 1%		

We can observe that introducing interaction terms increases the quality of the model, based on the R² value.

Using the decision rule, we can conclude to the under valuation for both of the combinations :

- **Color and degree**

We observe that β_1 and β_2 are positives but β_{12} is negative :

$$\beta_1 = 0.3272809 ; \beta_2 = 0.3053606 ; \beta_{12} = -0.0359309$$

$$\beta_1 + \beta_2 = 0.63264089 \text{ and } \beta_1 + \beta_2 + \beta_{12} = 0.5967099 \Rightarrow \beta_1 + \beta_2 + \beta_{12} < \beta_1 + \beta_2$$

So, we are in the case of *undervaluation*.

- **Color and type**

We observe that β_1 and β_2 are positives but β_{12} is negative :

$$\beta_1 = 0.3272809 ; \beta_2 = 1.602212 ; \beta_{12} = -0.7639122$$

$$\beta_1 + \beta_2 = 1.924929 \text{ and } \beta_1 + \beta_2 + \beta_{12} = 1.1655807 \Rightarrow \beta_1 + \beta_2 + \beta_{12} < \beta_1 + \beta_2$$

So, we are in the case of *undervaluation* too.

In both cases, we conclude that the combination of attributes does not increase the utility of the *wine* product. Consumers do not pay much for a red wine with more degrees (combination color / degree) – which is often considered as “bad” wine – that for red country wine (combination color / type) – which is not usually considered as a good product. A good red wine must be an AOC, while the worst is a red table wine in the consumers practices. This is why the estimate result validates undervaluation and not disutility. These combinations reveal an undervaluation of consumers’ preferences within the French wine market.

5. Conclusion

Observing Ai & Norton advices, we have built a decision rule for interaction terms. The arbitration between these combined effects is often omitted in the exercises of applied econometrics because it is complex. This decision rule increases not only the comprehension of consumers' preferences but also makes it possible to qualify their behaviors. One of its advantages is to be very simple of use : once the model estimated, it is enough to control the sign of the coefficients and to calculate their sum ; then, we apply the decision rule as presented in table 1 to qualify the contribution of interaction terms. Another advantage is that this decision rule applies as well to the linear models with the nonlinear models.

References

- Ai, C. & Norton, E.C., (2003) Interaction terms in logit and probit models, *Economics Letters*, **80**, 123-129.
- Asher, M.A., Popkin, J., (1984). The Effect of Gender and Race Differentials on Public-Private Wage Comparisons: A Study of Postal Workers, *Industrial & Labor Relations Review*, **38**, 16-25.
- Bowles, S., (1970) Towards an Educational Production Function, in *Education, Income and Human Capital* (Ed.) W. Lee Hansen, New York : NBER, pp.13-14.
- Friedrich, R.J., (1982) In Defense of Multiplicative Terms In Multiple Regression Equations, *American Journal of Political Science*, **26**, 797-833.
- McFadden, D., (2001) Economic Choices, *American Economic Review*, **91**, 351-378.
- Piccolo, D., D'Elia, A., (2008) A new approach for modelling consumers' preferences, *Food Quality and Preference*, **19**, 247-259.