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**Auction Reserve Prices Modelled by
Fuzzy Expert System**

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“Auction reserve prices modelled by Fuzzy Expert System”

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Abstract

The paper focuses on the issue of a reliable reserve price: important both for the sellers as for the purchaser. A too high reserve price may discourage the bidding process, but a price too low may damage the sellers. We suggest an objective methodology of constructing the evaluation of art works, based on four groups of variables, artistic values, edonic values, sociological economic macro factors, micro economic factors. Each of them consists of three main components (e.g. the artistic values relate to the artist, to the work, to the artistic current). A FM matrix similar to the Boston matrix, is also utilised to assign the work to one of four main categories of authors and art goods: stars; blue chips, portfolios and dogs, questions. The model resulting from these variables is constructed as a multi attributes valuation system by fuzzy sets theory. The ranges of values imputed to the linguistic variables are given by experts, by reference to the statistics of the past auctions in the international market. The paper is a preliminary effort to apply the Fuzzy Sets Theory to the multi attributes valuation of art goods. This theory provides a systematic framework to deal with qualitative concepts that can be translated in to quantitative parameters in a complex system of variables only by “fuzzy” relations, because of the intrinsic lack of precision and of uncertainty about the causal relation between sets of the inputs and of outputs. The system structure identifies the fuzzy logic inference flow from the input variables to the output variables. The fuzzification in the input interfaces translates analog inputs into fuzzy values. The fuzzy inference takes place in rule blocks which contain the linguistic control rules. The output of these rule blocks are

linguistic variables. The defuzzification in the output interfaces translates them into crisp variables. Being of methodological nature the paper does not aim to offer empirical results, but a system of analysis to reach them and it is open to improvements, by experts.

Doubtless there is a degree of conventionality in adopting a Fuzzy Sets Theory for the determination of art values by a multy attributes economic valuation. But one must point out that it may be reduced by increasing to empirical information available for the fuzzification of the linguistic variables in quantities and that the discretionary judgement of experts needed to fill the gap here, unlike in the current practices of valuation, is constrained and systematically organised in an objective way.

1. Introduction

According to the best accounting methods as recognised in the European rules, assets valuation, in business corporations, should be done by the two basic principles of prudence: that of prudential assessment of the capital value and that of the continuity of the firms' s activity. According to the first prudence criterion, one should avoid an over assessment that deceives the share holders and the creditors, according to the second one should avoid an under assessment that induces to undue lack of care for the preservation of the asset and the related maintenance expenses and provisions. The same rules seem appropriate as for the assets of a non profit institution, say a Foundation as for its art assets: in order to avoid deception of its supporters and creditors and to avoid lack of care in the preservation of the asset. Clearly the two rules lead to find a "fair value" that it is "in between" the highest and the lowest. The same point of view seems applicable to the basic auction price, for reasons that appear an extension of the above two principles of prudence. Indeed an over assessment here too appears imprudent because may induce some deception: in this case, of the potential purchasers. But an under assessment is imprudent too, because induces to lack of care for the asset, that in this way risks to be undersold.

The consequence of over valuation of assets as for a corporation or a Foundation may bear a loss of credibility, damaging its capability of attracting resources to its activity. A for art auction houses, the loss of credibility relating to over assessment of the basic auction prices may damage their capability of attracting purchasers. But imprudent under assessment reduces its credibility with potential sellers and thus damages the continuity of its activity. More over under pricing may reduce the revenues, whether from percentage fees or from gross receipts, depending from the type of right relating to the asset. One might argue that under pricing is not damaging because the potential purchasers are competing each other and a low basic

price induces to increased offers of purchase. But aside the risk of lack of competition, there is the fact that the valuation by an auction house with some reputation is considered an “experts” judgement: and the assignment of a low price to a given asset to be sold, normally may not be interpreted by the would be purchasers as “an under valuation” to entice their competition but as an implicit recognition either of the modesty of objective value of that asset or of a weakness of the market demand . On the other hand, over assessment by the auction houses may induce the would be purchasers to desert; and unsold assets may reduce the reputation of the house not only from the point of view of its trustworthiness but also from the point of view of its skill as for the art values.

On the other hand, because the two conflicting prudential criteria lead to a valuation in between, there is the risk of subjective discretion: how to let the customer on the demand and on the offer side to believe that the basic auction value always correspond to a prudent “in between” criterion and that the way to reconcile the two conflicting principles is consistently pursued in a given way?

2. Methods, techniques and material studied

We believe that this result may be reached combining a systematic methodology of consideration of the variables affecting the art market values, based on a theoretical groundwork¹ supported by empirical research with a mathematical modelling of them that takes in to account the complexity of the factors and the uncertainty relating to their appreciation, that may be identified by the Fuzzy Sets Theory (henceforth FST). This theory² provides a systematic framework to deal with qualitative concepts that can be translated in to quantitative parameters in a complex system of variables only by “fuzzy” relations, because of the intrinsic lack of precision and of uncertainty about the causal relation between sets of the inputs and of outputs. The system structure identifies the fuzzy logic inference flow from the input variables to the output variables. The fuzzification in the input interfaces translates analog inputs into fuzzy values. The fuzzy inference takes place in rule blocks, which contain the linguistic control rules. The output obtained by the aggregation of these rule blocks is a linguistic variable. The

¹ On the determinants of art market values see especially Frey and Pommerhene (1991), Trosby (1994) and Lazzaro and Mossetto (1997)

² Originally proposed by Lofti Zadeh as a quantitative tool to represent uncertainty and to formalise qualitative concepts with no precise definition.

defuzzification in the output interfaces translates them into crisp variables. There are basically two types of FST models: those that are “action oriented” and those who are “judgement oriented”. In the first type, the connection between the variables is meant to realize a sequence of actions, otherwise ordered by an human mind or by a mathematical system with a binary logic model (for example the sequence of actions of a washing machine). The second type is meant to solve: a) problems of multi criteria decision making or b) problems of multi criteria assignment of an attribute or of a valuations. The first kind, conventionally called *Multi attribute decision making (MADM)*, aims to determine an optimal alternative by comparing a given set of possible alternatives with respect to a set of attributes. Since it is a multiple criterion, strictly ordering to find the optimal alternative it is not possible. The the aggregation of these attributes, with the FST, is the first issue to be solved. Once the attributes are aggregated, the problem becomes a single-criterion one: therefore the optimal choice may be done, applying a ranking procedure. The attributes are the inputs of the system, the number (fuzzy or crisp) that results from the aggregation is the desired output. In the crisp case, one, thus, obtains a natural ranking of the alternatives, ordered to choose the best; in the fuzzy case , the solution it is less easy, as there is not a unique ranking of fuzzy sets.

As said above, multi criteria problems may relate not to decision-making but to assignment of a given character, or of a given ranking of value or of a given cardinal e. g. quantitative measure e.g. a given economic (monetary) value. Here the problem is not that of deciding *what to choose*, but how (and how much) to judge a phenomenon. Obviously when the judgement is merely to assign a *quality* as “industrial district” or “person below the poverty line” the solution is much easier than when one has to assign an order (a value) in the ranking of an index, say, in a “freedom index” or in a “quality of life index” or in an index of poverty or a rating in bank lending ³. Even more delicate is the task of assigning a quantitative value, as our case of economic valuation of art assets. It appears to us that rather than a crisp value, here, one has to aim to a fuzzy one, to be comprise between a minimum and a maximum, possibly with a small distance among them. In any event, methodologically a *multi attributes valuation system*, by FST, let us call it MAVS follows the same principles than MADM. And actually one might even say that the two are two faces of the same coin, since to choose the best alternative implies a ranking

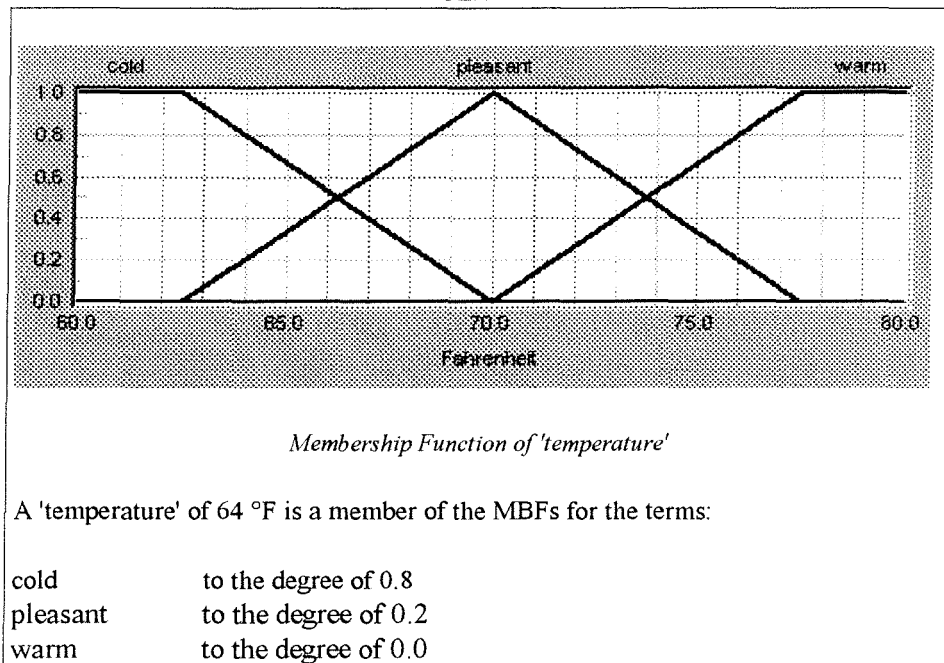
³ Facchinetti and Mastroleo used fuzzy expert systems for several problems of MADM and MAV, as firms merit of credit in bank lending, insurance fraud evaluation, identification of the character of industrial district.

too. But in dealing with the uncertainty factor, decision making implies a *judgment of preference*, while MAV implies a *judgement of facts*.

The variables acting as inputs in our MAVS by FST derive from analysis based on theoretical and empirical research on the art market⁴. They enter in our system as linguistic variables to be translated in “linguistic terms”, that imply a judgement of changes of their value by words.

For example, to translate the real variable 'temperature' into a linguistic variable, in a fuzzy expert system designed to solve the control problems of the functioning of a washing machine, three terms, 'cold', 'pleasant' and 'warm' are defined. Depending on the current temperature level each of these terms describes the 'temperature' more or less well. Each term is defined by a membership function (MBF). Each membership function defines for any value of the input variable the associated degree of membership of the linguistic term. The membership functions of all terms of one linguistic variable are normally displayed in one graph. The following figure plots the *membership functions* of the three terms for the example 'temperature'.

TABLE 1



⁴ Rich amount of data relating to the auctions may be found in the yearly books of, non-available also on CD.

In this example we see that the same value 64 °F involves two linguistic attributes, cold and pleasant, with two different degrees. This is due to the fact that human knowledge is imprecise in nature, and the same temperature may be cold for me and pleasant for you. Fuzzy Set Theory was originally proposed as a quantitative tool to represent uncertainty and to formalise qualitative concepts with no precise definition. It provides a systematic framework to deal with fuzzy quantifiers with different types of uncertainty.

Linguistic variables have to be defined for all input, intermediate variables and outputs that enter in the final assignment of a monetary value in euros expressed not in a crisp punctual way, but by a narrow band. The membership functions are defined using a few definition points only. In our MAVS, the linguistic variables are expressed in linguistic terms as “very important, important, relatively important, not important”. They give origin to points that lead up and down in a “rank“ of monetary values.

The system is structured in four blocks to reduce the ranges of price variations to deal with. Indeed there are art works that have an economic value ranging in billions of euro and other that have economic values of tens or hundreds of euros. We therefore the system starts by the assignment of an “expert” of the work to be considered to one of four quadrant of a FM art market matrix (FM-AMM) that Forte and Mantovani have devised in analogy the Boston matrix employed to classify the corporations. Unlike the Boston matrix where the income flows are considered together with the changes in capital values, the FM AMM focuses only on the capital values, because, obviously, the art works normally do not give a consistent flow of monetary income, because their benefits mostly flow to the owners as final consumers or/and to the public directly by low admission tickets or indirectly as “external economies” of various kind. In the FM.AMM, the two quadrants in the upper row, on the left and on the right, have to do respectively with the works of the “stars” (classified in super star, star and starlets), and authors whose works belong to the “blue chips”(…). In the lower row the quadrant on the left includes the authors (and works without author) who are “questions”. The quadrant on the right includes the “minor” authors and the “dogs”. The two quadrants on the left are characterised by high variability of their market values in a greater range of variation. The two quadrants on the right, on the contrary, are characterised by a substantial market values ‘stability within a much smaller range of variation

TABLE 2.

<p>I STAR Superstars Stars Starlets</p>	<p>II BLUE CHIPS Top chips Blue chips medium Blue chips lower range</p>
<p>III QUESTIONS Possible increase Random Possible decline Lemons</p>	<p>PORTFOLIOS & DOGS Portafolio-High Portafolio-medium Portafolio-low Portafolio-miscellanea Dogs</p>

STAR: from 500.000 to 40.000.000⁵

SUPERSTARS: more than 5.000.000

STARS: from 2.000.000 to 5.000.000

STARLETS: from 500.000 to 2.000.000

BLUE CHIP from 50.000 to 500.000

TOP CHIPS: from 250.000 to 500.000

BLUE CHIPS medium from 125 to 250

BLUE CHIP low range from 50 to 125

PORTFOLIOS and DOGS from 0 to 50.000

PORTFOLIOS- High from 25.000 to 50.000

PORTFOLIO-Medium: from 10.000 to 25.000;

PORTFOLIOS- Low from 2.500 to 10.000

PORTFOLIOS -MISCELLANY: less than 2.500 bust not likely to decline

DOGS: less than 2.500 likely to further decline

⁵ All values in euro

QUESTIONS

POSSIBLE INCREASE: authors whose works are likely to be undervalued.

RANDOM: authors with unclear future.

POSSIBLE DECLINE: authors whose works are likely to be overvalued.

LEMONS: works of dubious authenticity.

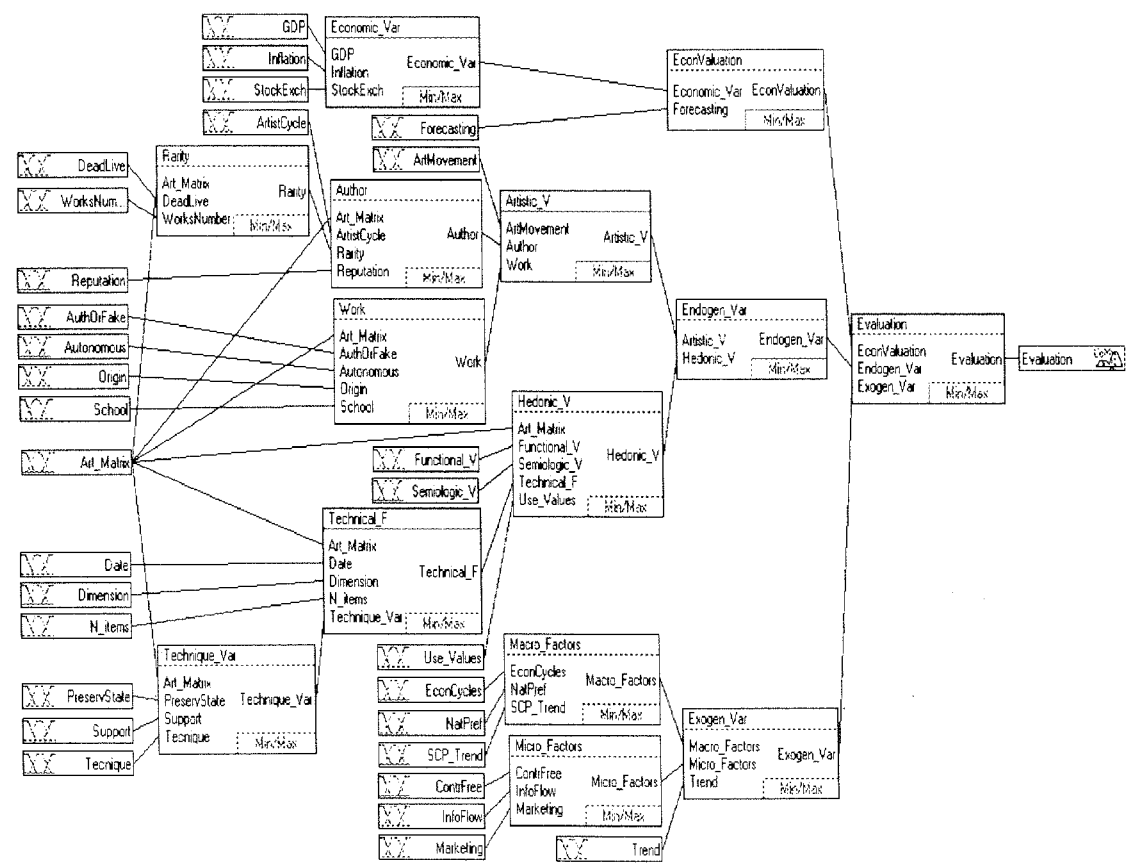
Each quadrant, as one can see, is divided into sub categories, because they include a bloc of different linguistic variables, that may be translated in different ranges of values. To identify the stars, the blue chips, the portfolios one shall, first, look to the market prices in auctions in the international free market by the authors of the considered works, taking the top values realised. The values are expressed in euros of constant purchasing power. For authors whose works have never been in auctions in the free art markets but have been dealt in the controlled markets the expert, to classify them in the matrix, has the task of guessing the likely equivalent in the free market. For authors who never (or only very rarely for minor pieces) were sold in auctions, the expert has to make the classification by analogy with authors who passed in the auctions. However, it may be that he cannot do that safely at the beginning of the operation of our MAVS. In this case he shall put them in the questions, likely with a random value, so that the process of linguistic classification will begin in the next stage. The linguistic classification shall often proceed differently for the stars and for the authors belonging to the blue chips and portfolios. Indeed for the stars, may be easier to identify from the outset the subclass or group of subclasses of linguistic variable to which they are likely belong. For the blue chips and portfolios, normally the operation of the MAVS shall be started by the mere identification of the general linguistic variable that leads to a given quadrant, leaving to the further bloc of linguistic variables the task of the sub classification. For works identified as "dogs" the MAVS shall stop there. For lemons, it may be worth to proceed further. Practically the initial distinction in quadrants implies that the MAVS does not work with a unique system of parameters as for the translation of inputs of linguistic variables in ranges numerical values. The aggregation in rule blocs of intermediate variables shall differ in the various quadrants.

3. Results

The following figure shows the whole structure of this fuzzy system including input interfaces, rule blocks and output interfaces. The connecting lines symbolize the data flow. As said above, actually the figure in reality has to be

replicated in order to get four blocks, each with the initial linguistic variable pertaining to one of the four quadrants, which work differently in transforming the inputs in intermediate rule blocks and outputs.

Figure 1



The linguistic variables, as said at the beginning, have been studied by borrowing from the current economic analysis and from empirical testing. We have grouped them in four categories of factors, each consisting of three sub categories, distinguishing the exogenous linguistic variables pertaining to the work and his author and the exogenous linguistic variables relating to the political, cultural, economic, sociological and legal “environment”, as follows.

TABLE 3

endogenous variables	{	1. artistic values	{	of the author
				of the work
				of the artistic movement
		2. edonic values	{	functional
				semiologic
				technical
exogenous variables	{	3. socio-economic macro-factors	{	national preference and
				political factors
				socio-cultural trends
				macro economic cycles
		4. market micro economic factors	{	free or controlled marke
				information flows
				marketing

These factors enter in or MAVS as linguistic variables that cause variation in the initial range of values, in a *tentative* sequence that is ordered according to a logic of valuation in which some factors appear preliminary to others, while the scheme of determinants of the market value of art works above presented follows a mere classificatory ordering. Therefore the tentative sequence of the MAVS above depicted, which needs to be adjusted, by experience, does not need to correspond at all to the schematic ordering of factors presented above.

As previously said the starting point of the valuation process consists in the Identification of the quadrant of the matrix from where to start. Here we have indicated some preliminary variables: whether the author is a

“master” head of a school or member of a school or an autonomous artist and whether is dead or living and where the work comes from. There might be other factors that induce the expert to choose one of the quadrants. However they should not be changed from one valuation to the other. And in any case, if they belong to the list that is considered as for the linguistic inputs of the MAVS, they should not be taken out from it, for the next steps of the procedure.

Some comments may be, at this point, useful to clarify what we mean by the various linguistic variables under consideration and how enter as inputs in the valuation process.

The artistic variables, about the author and the artistic movement, shall be identified by the expert not according his personal judgement but according to that of the prevailing judgements, that *presumably determine that of the market*. The concept of “reputation”, developed by the economists, in areas different from the artistic one, it is also relevant here. As for the value of the specific work under consideration it should be noted, among others, that normally for the art works of a given (important) author, in a given art movement, there is a product cycle: the beginning has more originality but there may be an upward trend to a peak, after which there is a decline. The date of the work there fore is important and if the works is undated it has, *coeteris paribus*, less vale.

As for the functional factors, we mean first of all the “informational factors”: an art work may have had and may still have a function of “information” about figures and facts of religion, history, private life of personalities. In addition, it may be that the art work had (and may be still has) a practical function as some vases. And this factor may add value, because it may increase the rarity of the art work.

Empirical research on the big data set of the art auction prices may be useful to give a “linguistic” assessment to the group of functional variables that we have named as “semiologic” which pertain to the kind of figures, the colours and similar factors, that seem to obey to some statistical law, at least in relation to certain kinds of works.⁶ Some time, however, these factors are author-related. For instance flowers add value to Van Gogh’ paintings.

It is probably in the area of technical factors that systematic empirical research is particularly relevant. As for dimensions several empirical

⁶ As for the importance of this factor in arts works see Santagata (1998). More generally see Floch (1998).

researches by Forte and Mantovani ⁷ have shown that the works of great dimension (those greater than a square meter), generally have values much greater than those of average dimension (those ranging between an half and one square meter) and those of average dimension generally have a value greater than those of small dimension (less than half square meter) in a way that may justify, a first broad approximation, the consideration of the value per square cm, but needs further more specific enquiry in relation to the type of work and artistic movement considered. Another important technical variable is the type of material employed that has effects on the quality and resistance to the atmospheric factors of the work.

A third variable, that we have catalogued among the technical ones, because it is mostly an endogenous variable, but one may properly define as a micro economic one, primarily relating to the supply side of the market, has to do with the "rarity" of the considered works. While rarity is primarily an absolute concept pertaining to the supply side, it is also, to an extent, a relative concept pertaining to the demand side of the market. One fact affecting rarity on the demand side, doubtless, it is the appreciation of the good: works of low interest tend to be fungible commodities, so that the fact that there are few pieces of a given author of a given kind does not matter much, because other goods of other authors are considered good substitutes to these works. But rarity, viewed on the demand side, has also to do with other factors, affect the preferences, as the peculiarity of the provenance or the fact that in that painting there are details unusual for that author and the like. Factors of imputed rarity that art experts with knowledge of what are the market tastes may be able to detect.

A final group of technical factors has to do with the state of preservation and with whether the work is or not signed and whether the signature is or not clearly visible and clearly authentic. Works without these requisites may risk to be "lemons".

The macro socio economic factors mostly operate on the demand side, but some have an origin on the supply side. The purchasing power of the demand for the different types of art goods has an obvious effect on their value. And the "tastes" of the purchasers various nations are not indifferent to the nationality of the authors and of the artistic movements. An important degree of nationalism or national fashion here exists and can be easily tested

⁷ See for instance Forte F. and Mantovani M., (1999 b), as for the American and European paintings of informal art, in the periods between 1976-86 and 86-96. As for the drawings see Mantovani M., II part of Forte F. and Mantovani M., 2000 in Candela and Scorcu, 2000.

by empirical research. For instance Sorge in a doctor dissertation under the guidance of Forte and Mantovani have found that, as for expressionists, nearly half of the purchase of French authors is done in the French market, where presumably the purchasers or French culture are dominant⁸. The same research by Sorbe shows that the average values of the American informal art' works have an average value seven time that of the works of the European informal movements in the same set of market⁹. It likely that this big difference, at least to an to an extent, has to be explained by the different purchasing power in the American market combined with a national preference of the American private and public collectors for the American artists. But the "national preferences" are not limited to the nationalistic factor. There are also preferences based on the "nationality" of the authors and of the artistic movements related to "cultural" in the broad sense of this term, inclusive also of cultural traditions. For instance, there appears to be a strong USA preference for the French artists that is among the explanation of the record prices of the French impressionists. Socio cultural international trends generally have a strong influence on the demand: "fashions" do matter in arts, as, *mutatis mutandis*, in clothing and internal decoration or architecture. Expert may know, by statistics and occasional empiricism, that, for instance, the trend of the Flemish paintings of the seventeen century is now up and that the trend of another art movement is now downward. Some time politics and political economy has a strong influence on art trends. Chinese art is experiencing and upward trend in relation to the Chinese political and economic development and the increasing opening of China to the international economic and political community.

Forte and Mantovani have found that for the art market there is a cycle as for the stock market and for the macro economies and that there are a strong relations between the business cycles and the art markets cycles and between the stock exchange cycles and those of the art markets, however with lags and intensity that change according to the type of market: for free art markets these relations are more pronounced both in the time dimension and in the intensity.¹⁰

Coming to the micro economic factors listed in Table 3, one first must consider for which market the valuation is done. As noted at the beginning, art market values, *ceteris paribus* are greater in the free art markets than in the controlled markets. We have presented in Table 2 a matrix where the euro

⁸ Cfr. Sorge M. (1999)

⁹ See Sorge (1999)

¹⁰ See Forte F. and Mantovani M., (1999 c) *Bancaria*

values are referred to the free markets, for the purpose of classification of the art works , because these are the broadest markets with more numerous public transactions, so that the reference to them appears useful in order to make the initial identification of the quadrant where to start the MAVS- However after the valuation has been done referring to the free market, if the relevant market is a controlled market a parameter of conversion must be introduced to downgrade it.¹¹ The clause of *ceteris paribus* must be kept in mind: the best pieces are more frequently sold in the free markets than in the controlled ones, so that the mere reference to the difference between the average values of the art works of given authors or art movement sold in the free market to those of the same authors or/and art movements in a given controlled art market may overstate the specific difference that *similar works* of the same authors and movements tend to have in the two different markets.

Among the micro economic factors is also relevant the information flow.¹² Forte and Mantovani have tested it by Indices of diffusion of different artists of comparable values¹³, in the international Museums finding an interesting relation between this kind of diffusion and the market value of them ¹⁴. Temporary shows and other various forms of promotion too have a strong influence on the market values.

Obviously here one must distinguish those that have already been done in the past so that enter in the market value as appreciated by the demand and those that might be done in the future with a likely effect of improvement of the demand and of the trend of the market prices.

As one can see, in our MAVS there are two intermediate steps: one with the aggregation of the endogenous variables and another with the aggregation of the intermediate input thus obtained with the two groups of exogenous variables.

One may dispute this sequence: which, however, in our view it is justified by the different variability and information set of the two classes of variables, the first being more intrinsic to the art work and the art knowledge, the second being more extrinsic and related to macro and micro variations of the political, economic, cultural, legal “environment” and to the knowledge about its behaviour.

¹¹ See Forte F. and Mantovani M., (1998)

¹² See Trimarchi 1997

¹³ Considering the various determinants of the prices.

¹⁴ Cfr. Forte F. and Mantovani M., (1999), ISAE

4. Conclusions

Doubtless there is a degree of conventionality in adopting a FST for the determination of art values by a MAV. But one must point out that it may be reduced by increasing to empirical information available for the fuzzification of the linguistic variables in quantities and that the discretionary judgement of experts needed to fill the gap here, unlike in the current practices of valuation, is constrained and systematically organised in an objective way.

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