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The interaction between parents and children as a relevant dimension of child well being. The case of Italy.

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This paper aims at measuring the functionings of social interaction, a relevant dimension in the description and conceptualisation of child well being by using the capability approach. In this paper we deal with a special dimension of this capability that involves the capability of interaction between parents and child. We propose a fuzzy expert system to measure this capability. To apply the model we use a data set based on a matched data source of ISTAT (Italian National Statistical Office 1998) multipurpose survey on family and on children condition in Italy to recover information on children's education, the socio-demographic structure of their families, child care provided by relatives and parents according to the type of activities in which the children are involved and Bank of Italy Survey on household income and wealth year 2000 (SHIW00). This is a first step of a more complex system allowing for a richer set of indicators on capabilities in order to measure child well being.

Introduction[1]

This paper aims at analysing the building of social interaction, as a relevant dimension in the description and conceptualisation of child well being by using Sen's capability approach (Sen, 1993). In this paper we deal with a special dimension of this capability, that of interaction between parents and child, and with its measurement. The importance of parents' role in child well being construction is well documented by evolutionary psychology and psychoanalysis, and it is an important element of social interaction, a capability that has been considered as relevant in the list endorsed in Addabbo, Di Tommaso, and Facchinetti (2004) to measure child's well being in Italy. However the interaction between parents and children can take place in different ways (playing, doing different activities, caring, talking with teachers about child's education progress…), in order to analyse the complexity of these relationship in Addabbo, Facchinetti, Mastroleo (AFM, 2006) the idea in Addabbo, Di Tommaso and Facchinetti (2004) of using fuzzy expert system and built a fuzzy expert system to analyze the interaction between father and child has been developed. Here we extend the application of this model to the interaction between mother and child (Section 2) and apply it to a wider sample of households (in AFM, 2006 we dealt only with one-child families) to analyse parents' interaction with children in households where both parents are present. Differently from AFM (2006) that used ISTAT 1998 data, in this paper we use a data set that matches two different sources of data ISTAT (Italian National Statistical Office 1998) multipurpose survey on family and on children condition in Italy to recover information on children's education, the socio-demographic structure of their families, child care provided by relatives and parents according to the type of activities in which the children are involved and the Bank of Italy Survey on household income and wealth year 2000 (SHIW00) to have information about household's income. Results on the outcome of this model and comparisons between father's and mother's interaction with child are then analysed in Section 3 and 4. This analysis shows how parents' interactions with their child combine to determine child's well being and allows one to detect cases of poor interaction with both parents. Moreover the availability in the matched data set (BFSS98) of information on household's income allows us to analyse the relation between parents' interaction with the child and family income. On one hand a higher income can provide higher possibilities for the child to participate to some paid activities with their parents (like attending shows) or to attend paid activities that allows interaction with other (like paid courses), on the other hand a higher income can be related to parents' employment positions that are highly time intensive and that therefore reduce time availability for interaction with children. Father's interaction with child results significantly lower than mother's. An interesting issue that we will pursue in the future is to try and apply the model to new sources of microdata to analyse the evolution over time of the outcome of the system.

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[1] This is a revised version of the paper presented at the Human Development and Capability Association Thematic Group on Children's capabilities, Workshop on Children's capabilities, Florence, 18-19 April 2007. We thank the participants to the workshop and the discussant for their stimulating comments.

1. Interaction between children and parents as a relevant dimension of child well being in a capability approach

The importance of parents' role in child well being construction is well documented by evolutionary psychology and psychoanalysis, and it is an important element of social interaction, a capability that has been considered as relevant in the list endorsed in Addabbo, Di Tommaso, and Facchinetti (2004) to define child well being in Italy. In this paper we aim at measuring it by using a data set based on a ISTAT (Italian National Statistical Office) multipurpose survey on family and on children condition in Italy. This data set provides information on children's education, the socio-demographic structure of their families, child care provided by relatives and parents according to the type of activities in which the children are involved. However this data set does not provide information on a factor that can affect child well being: household family income, a dimension that can interact with characteristics that affect the availability of time and of means to develop (or constrain) the interaction. In order to measure child well being in Italy with special reference to the capability of interaction with parents we have then used a data set obtained by matching two different sources of data: Istat Families and social subjects (1998) and Bank of Italy Survey on Income and Wealth (2000) by using propensity score[2]. The matched data set (BFSS98) allows us to have information on the socioeconomic characteristics of the families (from SHIW00) together with variables to proxy functionings of social interaction capability (FSS98).
BFSS98 data contains information regarding 2,031 (1,011 girls and 1,020 boys) children aged from 3 to 13 living in households where both parents are present.
In this paper we focus on the interaction between parents and children.
Mothers are more often involved with their children in playing activities (Tab.1).

Table 1 - How often do parents play with the child by age of children

	all		age 6 to 10		aged 11 to 13	
	Father	Mother	Father	Mother	Father	Mother
all days	20%	37%	22%	36%	16%	28%
more than once a week	44%	36%	45%	36%	40%	42%
once a week	11%	5%	9%	5%	13%	4%
sometimes monthly	12%	11%	12%	10%	16%	12%
sometimes yearly	5%	4%	5%	5%	5%	5%
Never	8%	7%	7%	8%	10%	9%
	100%	100%	100%	100%	100%	100%

Source: our elaborations on BFSS98 data.

Mothers are more often involved in playing with female children (though the difference is relevant only in daily activities) (Tab.2).

[2] See Addabbo, Di Tommaso, Maccagnan and Morciano (2007) for the description of the procedure followed to match the two data sets and to create the archive.

Table 2 - How often do parents play with the child by sex of children aged 3 to 13

	Girl		Boy	
	Father	Mother	Father	Mother
all days	21%	40%	19%	35%
more than once a week	43%	37%	45%	35%
once a week	10%	5%	11%	4%
sometimes monthly	12%	9%	13%	13%
sometimes yearly	4%	4%	5%	5%
Never	10%	5%	7%	8%
	100%	100%	100%	100%

Source: our elaborations on BFSS98 data.

We can observe for each child the type of activities they do with their parents and how often (Tab.3). The range of variation of each activity variable goes from 1 (never) to 6 (every day). When the parent does this activity sometimes during the year the variable takes the value 2; 3 if they do it sometimes in a month, 4 if they do them once a week, 5 more than once a week and 6 everyday. As one can see from Table 3 mothers interact with their children in different activities and, apart from going to sport events, they are more likely to interact more in these activities with their children.

Table 3 – Type and intensity of activities done with the parents Children aged 3 to 13

	Father		Mother		
Type of activities	mean	SD	mean	SD	t-test
Read stories	1.75	1.31	2.59	1.75	21.29 ***
Story telling	1.75	1.3	2.24	1.61	14.47 ***
Watch tv	5.08	1.27	5.18	1.27	3.46 ***
Watch video	3.37	1.73	3.6	1.71	4.00 ***
Movies	1.83	0.93	1.88	0.99	1.33
Go to sport ev.	1.87	1.14	1.61	1.01	-11.88 ***
listening to the music	2.53	1.72	3.3	1.88	17.83 ***
Go to park	2.64	1.52	3.02	1.7	8.66 ***
Sing, dance, playing music	1.86	1.4	2.59	1.75	18.41 ***

t-test on the difference btw means. Significant at * 10%; ** 5%; ***1%.
Source: our elaborations on BFSS98 data.

Fathers' involvement in activities with their children is greater (though not more than mothers') in more passive types of activities like watching tv and video and lower in more active types (like reading and storytelling, or singing, dancing and playing music). The gap between parents' involvement is lower in activities that probably both parents do together with their children, like watching tv and video, going to the park and going to watch movies. Probably this is due to the fact that those types of activities are often organized and socialized by both parents (Rivellini, Di Giulio 2005).

Better educated mothers are more often than average involved in activities like reading stories, going to a park or to watching movies (Tab.4a)

Table 4a – How often are mothers involved in different types of activities with their children according to their level of education

	Mother's education level							
Activities	Primary	t-test	Secondary	t-test	High School	t-test	Degree	t-test
Reading Stories	2.43	-4.57 ***	2.52	-1.98 **	2.74	4.35 ***	2.72	3.77 ***
Story telling	2.09	-5.94 ***	2.23	-1.63	2.31	0.84	2.26	-0.70
Watching tv	5.38	8.24 ***	5.17	-0.11	5.12	-2.11 **	5.10	-2.91 ***
Watching video	3.67	3.45 ***	3.60	1.42	3.69	4.03 ***	3.46	-2.64 ***
Going to watch movies	1.73	-5.99 ***	1.84	-0.25	1.93	4.42 ***	1.95	5.46 ***
Sport Shows	1.41	-9.09 ***	1.64	2.35 ***	1.64	2.35 ***	1.55	-2.13 ***
Listening to music	3.40	3.15 ***	3.29	0.19	3.42	3.68 ***	3.11	-4.64 ***
Going to a park	2.79	-5.77 ***	3.09	3.09 ***	3.09	3.09 ***	3.07	2.50 ***
Singing and dancing	2.70	3.32 ***	2.61	0.72	2.62	1.01	2.43	-4.46 ***

t-test on the difference wrt average involvement. Significant at * 10%; ** 5%; ***1%.
Source: our elaborations on BFSS98 data.

Fathers with elementary level of education are more involved in watching tv with their children and listening to music and less in other types of activities (Tab.4b).

Table 4b – How often are fathers involved in different types of activities with their children according to their level of education

	Father's education							
Activities	Elem.	t-test	Sec.	t-test	High school	t-test	Degree	t-test
Reading tales	1.44	-12.55 ***	1.76	-0.42	1.82	1.84 *	1.91	5.25 ***
Story telling	1.58	-7.34 ***	1.84	2.74 ***	1.69	3.08 ***	1.88	4.29 ***
Watching tv	5.14	1.85 **	5.1	0.27	5.04	-2.10 **	5.02	-2.90 ***
watching video	3.07	-8.18 ***	3.36	0.26	3.47	3.46 ***	3.4	1.42
Going to the cinema	1.78	-0.66	1.75	-2.35 ***	1.97	9.98 ***	1.83	2.14 **
Going to sport shows	1.8	-3.57 ***	1.85	-1.4	1.97	3.81 ***	1.78	-4.44 ***
Listening to music	2.66	2.74 ***	2.53	-1.03	2.58	0.42	2.66	2.74 ***
Going to the park	2.49	-4.25 ***	2.76	4.60 ***	2.58	-1.3	2.44	-5.89 ***
Singing and dancing	1.81	-1.35	1.85	0.1	1.85	0.1	1.91	2.27 **

t-test on the difference wrt average involvement. Significant at * 10%; ** 5%; ***1%.
Source: our elaborations on BFSS98 data.

The descriptive statistics analysed in this section show a lower degree of involvement of fathers in 1998 on different activities with their child.[3] By using a subset of variables on caring activities that can be found in ISTAT 1998 and

[3] On the involvement of fathers in childcare see also Tanturri (2005).

ISTAT 2003 we can see (Table 5) that there is a higher involvement of fathers in 2003 in those activities and, if this can be associated later in the child's life, with a higher involvement in other types of activities with the child[4], we would expect by applying the same model to new data to observe an improvement in fathers' interaction with their child.

Table 5 – Descriptive statistics on the caring activities performed by fathers year 1998 vs year 2003

Type of caring activities	How often 1998	How often 2003	ttest H_0: mean 2003= mean 1998
Feed him/her	3,95	4,4	13,49 ***
Helping in going to bed	4,21	4,69	15,12 ***
Dress him/her	3,77	4,19	11,63 ***
Bath	3,03	3,23	6,17 ***
Change napkin	3,24	3,19	-2,10 **

Significant at * 10%; ** 5%; ***1%.
Source: Our elaborations on ISTAT Famiglie e Soggetti Sociali surveys 1998 and 2003

Each variable takes the value 1 (never) 2 (sometimes in a year), 3 (sometimes in a month), 4 (once a week), 5 (sometimes in a week), 6 (everyday).

2. A Fuzzy expert system to model interaction between children and their parents

The issue that we will try to measure in this paper is intrinsically complex, problematic and subject to interpretation. The interaction between children and parents is made of different dimensions: from playing together to activities like watching movies or being present in the daily life. The evaluation of these activities are described in an imprecise way. Conventional mathematics enables processing of precise information. Because of this, the efficiency of many classical decision-making methods was considerably limited all the more, as in some systems imprecise information is the only accessible one. Following the attempt expressed in Addabbo, Di Tommaso, Facchinetti (2004) we have therefore used the domain of mathematics dealing with imprecise information: Fuzzy Set Theory. This theory in connection with conventional mathematics enables the processing and use of any information (Piegat, 1999). Fuzzy set theory has been already used to measure functionings (Cheli and Lemmi, 1995; Chiappero Martinetti, 1996). However the idea followed is different from the one developed in this paper. They use data to build the slopes of fuzzy variables membership functions and then they aggregate them using different averages. We do not use data, but only experts' opinions to build a picture of interactions between several items involved. The power of Fuzzy Expert Systems comes from the ability to describe linguistically a particular phenomenon or process, and then to represent that description with a small number of very flexible rules. In a Fuzzy Expert System, the knowledge is contained both in its rules and in fuzzy sets, which hold general description of the properties of the phenomenon under

[4] On the link between father's involvement in childcare and in other activities done with the child see Tanturri (2005) and Rivellini, Di Giulio (2005).

consideration. A Fuzzy Expert System (FES) utilizes fuzzy sets and fuzzy logic to overcome some of the problems that occur when the data provided by the user are vague or incomplete. One of the major differences between a FES and another Expert System is that the first can infer multiple conclusions. In fact it provides all possible solutions whose truth is above a certain threshold, and the user or the application program can then choose the appropriate solution depending on the particular situation. This fact adds flexibility to the system and makes it more powerful. FES use fuzzy data, fuzzy rules, and fuzzy inference, in addition to the standard ones implemented in the ordinary Expert Systems. Functionally a fuzzy system can be described as a function approximator. More specifically it aims at performing an approximate implementation of an unknown mapping $f : A \subseteq R^n \rightarrow R^m$ where A is a compact of R^n. By means of variable knowledge relevant to the unknown mapping, it is possible to prove that that fuzzy systems are dense in the space of continuous functions on a compact domain and so can approximate arbitrarily well any continuous function on a compact domain [Kosko, 1992, Wang, 1992].

The following are the main phases of a FES design [Altrock, 1995 and Piegat, 1999]:

- identification of the problem and choice of the type of FES which best suits the problem requirement. A modular system can be designed. It consists of several fuzzy modules linked together. A modular approach may greatly simplify the design of the whole system, dramatically reducing its complexity and making it more comprehensible;
- definition of input and output variables, their linguistic attributes (fuzzy values) and their membership function (fuzzification of input and output);
- definition of the set of heuristic fuzzy rules. (IF-THEN rules);
- choice of the fuzzy inference method (selection of aggregation operators for precondition and conclusion);
- translation of the fuzzy output in a crisp value (defuzzification methods);
- test of the fuzzy system prototype, drawing of the goal function between input and output fuzzy variables, change of membership functions and fuzzy rules if necessary, tuning of the fuzzy system, validation of results.

In this section we will try to apply the logical system of indicators looking at useful data and by proposing a fuzzy set scheme to measure them.
The source of data described in Section 1 is going to affect the system developed in this paper, however our aim is to develop in a further step of analysis a larger system with more indicators than the ones currently available that can be collected in a further step of this research directly or by making use of different sources of data. In this paper we propose a system to measure interaction between parents and child by extending the application in AFM (2006) by applying the system to the interaction of both parents with their children and by analysing the outcome with reference to the observed characteristics of parents and area where the family lives (Section 3 and 4).
The system we propose has: 16 input variables, 7 intermediate variables, 1 output variable, 8 rule blocks, 155 rules, 82 membership functions. The variables are so identified:

degree_mother=Mother's level of education	input
G1_mother=She reads tales	input

G2_mother=She invents tales	input
G3_mother=Shewatches television with the child	input
G4_mother=She watches videocassettes with the child	input
G5_mother= She goes to the cinema with the child	input
G6_mother= She goes to sport shows with the child	input
G7_mother= She hears music with the child	input
G8_mother= She goes to the park with the child	input
G9_mother= She sings, dances, plays with the child	input
Homework_mother=Mother's assistance in doing homework	input
KindOfGame_mothe=Kind of games they do together	input
Teach_mother=Relations with teachers	input
Tpaid_mother=Mother’s working hours	input
Tplay_mother=Mother’s play frequency with the child	input
Tunpaid_mother=Mother’s housework's hours	input
Mavailability=Availability evaluation	intermediate variable
Meducation=Education evaluation	intermediate variable
MEntAct=Entertainment activities evaluation	intermediate variable
Mtime=Mother availability	intermediate variable
Mplay=Favourite game evaluation	intermediate variable
Mgame=Game frequency evaluation	intermediate variable
Mschool=Time for school activities availability	intermediate variable
Mint=Interaction with Mother	output

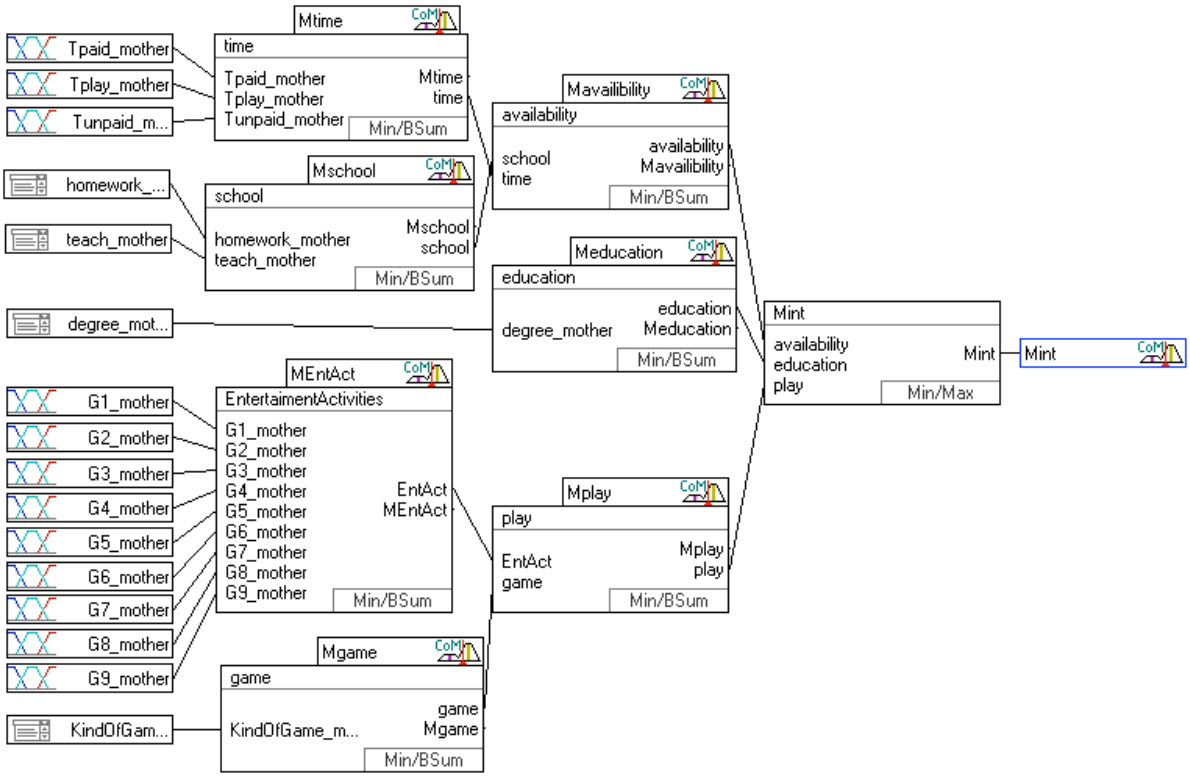


Figure 1. Interaction with mother: a fuzzy representation

Some variables are described in a categorical way and other by a typical fuzzy input with a different number of granules described by fuzzy numbers with linear memberships. The categorical variables are used when the fuzzification is not useful. For example, a variable like "KindOfGame_mothe" has this structure:

fg1=They play with videogames/computers

fg2=They play with building toys/puzzles

fg3=They play with table games

fg4=They play with rule games

fg5=They play with movement plays

fg6=They build or repair objects

fg7=They draw/paint

fg8=They play making housework

fg9=They play with different toys

It assumes only discrete integer values, these values are equivalent to linguistic terms and each term can accept the membership degree 1 or 0 (true or false) only. When this type of variable enters the fuzzy system, the experts give a linguistic judgement to every term, like the judgements expressed in Table 6.

Table 6. Kind of game performed and experts' assessment

IF: KindOfGame_mothe	THEN: game
fg1=They play with videogames/computers	low
fg9=They play with different toys	low
fg3=They play with table games	medium
fg4=They play with rule games	medium
fg6=They build or repair objects	medium
fg8=They play making housework	medium
fg2=They play with building toys/puzzles	high
fg5=They play with movement plays	high
fg7=They draw/paint	high

A judgement has also been given with regards to the type of activities mother and child do together as in Table 7.

Table 7 Type of activities[5] and experts' assessment

G1: Reading tales	(high)
G2: story telling	(high)
G3: watching tv	(low)
G4: watching videotapes	(low)
G5: going to the movies	(medium)
G6: attending sport shows	(medium)
G7: listening to music	(high)

[5] Note that here the values of the activity variables go from 1 (every day) to 6 (never), in the descriptive statistics in Table 3 and 4 in Section 1 the order was reversed.

G8: going to a park	(high)
G9: singing, dancing and playing together	(high)

The two input variables can be fuzzified to provide the intermediate variable 'play' that gives a measure of the quality of playing and entertainment activities that mother and child do together.
We have inserted in the model as intermediate variable "mother's education". A higher level of education in this model leads to a higher level of interaction under the hypothesis that a more educated parent can have more ability in engaging in certain activities or game with the child (like home-working, story telling or reading tales). We assume that, taking home-working into account, a more educated mother is more productive in this activity. Taking the activity of listening to music, we assume that a more educated parent can have a wider musical knowledge and can transmit it to the child doing this activity together.
An example of a typical fuzzy input is "Tpaid_mother". It provides, for difference, mother's presence. The description of this fuzzy input is in Table 8.

Table 8. Tpaid_mother variable: definition points

Term Name	Shape/Par.	Definition Points (x, y)		
Low	Linear	(30, 1)	(38, 0)	(41, 0)
Medium	Linear	(30, 0)	(38, 1)	(41, 0)
High	Linear	(30, 0)	(38, 0)	(41, 1)

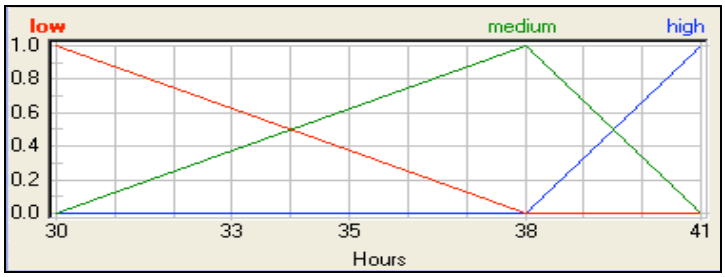


Figure 2. Tpaid_mother variable: layout

The intermediate variable 'school' in Table 9 has to do with how much time the mother spends with his child both in doing homework (input variable homework) and in the relationship with child's teachers (input variable teach). The intermediate variable 'availability' regards both directly or indirectly mother's availability of time to be spent with his child: how often does the mother play with his child (input variable Tplay_mother), the time that he devotes to care and housework inside the family (input variable Tunpaid_mother) (the assumption is that a higher number of hours in these activities increases the value of interaction) and his paid working hours (input variable Tpaid, a higher number of hours of work reduces the time available to play and interact with the child and it is considered as an indirect indicator of mother's availability) and this is the rule block that we have fixed with experts' suggestions:

Table 9. Tpaid_mother variable: its influence in Mtime rule block

#.	Tpaid	Tplay	Tunpaid	Ftime
1	low	everyday	low	medium_high
2	low	everyday	medium v high	high
3	medium v high	everyday	low	medium_low
4	medium	everyday	medium	medium_high
5	medium	everyday	high	high
6	high	everyday v sometimes	medium	medium_low
7	high	everyday	high	medium_high
8	low v medium	sometimes	low	medium_low
9	low	sometimes	medium	medium_high
10	low	sometimes	high	high
11	medium	sometimes v never	medium	medium_low
12	medium	sometimes	high	medium_high
13	high	sometimes v never	low	low
14	high	sometimes v never	high	medium_low
15	low	never	low v medium	medium_low
16	low	never	high	medium_high
17	medium	never	low	low
18	medium	never	high	medium_low
19	high	never	medium	low

The same system (with the same rules and variables) has then been replicated in order to compute father's interaction with children on a wider sample of children (aged 3-13 and living in households where both parents are present whereas in AFM,2006 only one child-households where selected) and on a different data set (here we use the matched BFSS98 data in AFM, 2006 we used a subsample of FSS98 data). Results on both Fuzzy expert systems are presented and commented in the following sections.

3 Results

The source of data that we have used for the implementation of the system is BFSS98 data described in Section 1 that contains information regarding 2,031 (1,011 girls and 1,020 boys) children aged from 3 to 13 living in households where both parents are present. The system produces very sensible results consistent with experts' evaluation of the records involved in the analysis. For a better understanding of the final results, for all the variables we describe in Table 10 range, type and if their linguistic attributes are allotted in an increasing or decreasing way.

Table 10. Description of the variables on mothers included in the model

#	Variable Name	Type	Min	Max	Monotonicity
1	Degree_mother		1	4	decreasing
2	G1_mother		1	6	decreasing
3	G2_mother		1	6	decreasing
4	G3_mother		1	6	decreasing
5	G4_mother		1	6	decreasing
6	G5_mother		1	6	decreasing
7	G6_mother		1	6	decreasing
8	G7_mother		1	6	decreasing
9	G8_mother		1	6	decreasing
10	G9_mother		1	6	decreasing
11	Homework_mother		0	1	increasing
12	KindOfGame_mothe		1	9	non monotone

#	Variable Name	Type	Min	Max	Monotonicity
13	Teach_mother		0	1	increasing
14	Tpaid_mother		30	41	decreasing
15	Tplay_mother		1	6	decreasing
16	Tunpaid_mother		3	18	increasing

In Table 11 we have listed all the variables, the intermediate variables defuzzified and in the last column the final output regarding the worst 20 cases in terms of mother interaction with the child, while in Table 12 we have listed the best cases with respect to mother's interaction The evaluation of the intermediate variables is very useful to understand how the different components affect the final result. The worst cases in terms of mother's interaction are characterized by low levels of mother education, low frequency of interaction in games between mother and children (the opposite holds for the best cases).

Table 11 – The worst 20 cases in terms of mother's interaction

ID	degree_mother	G1_mother	G2_mother	G3_mother	G4_mother	G5_mother	G6_mother	G7_mother	G8_mother	G9_mother	homework_mother	KindOfGame_mothe	teach_mother	Tpaid_mother	Tplay_mother	Tunpaid_mother	Mavailibility	Meducation	MEntAct	Mgame	Mplay	Mschool	Mtime	Mint
236	3	6	6	6	6	6	6	6	6	6	0	8	0	0	6	59.68689	0.24998	0.5	0	0	0	0	0.66666	0.16666
666	4	6	6	4	6	6	6	6	6	6	0	8	1	70	6	40.88516	0.5	0	0	0	0	0.5	0.33332	0.16666
959	4	6	6	1	6	6	6	6	6	6	0	8	1	0	6	57.91793	0.5	0	0	0	0	0.5	0.66666	0.16666
1088	3	6	6	1	6	6	6	6	6	6	0	8	0	40	6	49.85699	0	0.5	0	0	0	0	0.33332	0.16666
1102	3	6	6	6	6	6	6	6	6	6	0	8	0	0	6	62.00068	0.24998	0.5	0	0	0	0	0.66666	0.16666
1157	4	6	6	2	6	5	6	6	6	6	0	8	0	0	4	55.80553	0.24998	0	0.08332	0	0.01766	0	0.66666	0.16666
1451	2	6	6	1	4	5	5	6	5	6	0	0	0	42	5	39.41192	0	0.5	0.1875	0	0.07494	0	0.33332	0.16666
1496	4	6	6	2	4	6	6	6	5	6	0	8	0	0	6	62.41658	0.24998	0	0.08332	0	0.01546	0	0.66666	0.16666
1863	4	6	6	1	6	6	6	6	6	6	0	8	1	0	5	61.21471	0.5	0	0	0	0	0.5	0.66666	0.16666
1987	4	6	6	1	6	6	6	6	6	6	0	8	1	0	6	68.7009	0.5	0	0	0	0	0.5	0.66666	0.16666
1993	4	6	6	6	6	6	6	6	6	6	0	8	1	28	6	48.52005	0.5	0	0	0	0	0.5	0.66666	0.16666
1995	4	6	6	1	4	5	6	6	6	6	0	8	0	0	6	62.24395	0.24998	0	0.08332	0	0.03122	0	0.66666	0.16666
2146	3	6	6	2	6	6	6	6	6	6	0	8	0	0	6	63.18389	0.24998	0.5	0	0	0	0	0.66666	0.16666
359	3	6	6	6	6	5	6	5	6	5	0	0	0	0	4	54.57807	0.24998	0.5	0.3571	0	0.03156	0	0.66666	0.17528
977	3	6	6	4	4	6	6	6	4	6	0	8	0	5	6	60.71033	0.24998	0.5	0.14284	0	0.01494	0	0.66666	0.1766
1548	3	6	6	4	6	5	5	4	5	6	0	8	0	0	6	60.99316	0.24998	0.5	0.34998	0	0.05078	0	0.66666	0.18206
2459	4	6	6	2	3	5	5	6	6	6	0	8	1	0	6	55.24076	0.5	0	0.14284	0	0.02752	0.5	0.66666	0.18502
58	4	6	6	4	4	6	3	6	6	6	0	2	0	0	4	59.29016	0.24998	0	0.1875	0.5	0.2796	0	0.66666	0.1864
99	4	6	6	4	4	6	3	6	6	6	0	2	0	0	4	59.53975	0.24998	0	0.1875	0.5	0.2796	0	0.66666	0.1864
100	4	6	6	4	4	6	3	6	6	6	0	2	0	0	4	59.53975	0.24998	0	0.1875	0.5	0.2796	0	0.66666	0.1864

Table 12 – The best 20 cases in terms of mother's interaction

ID	degree_mother	G1_mother	G2_mother	G3_mother	G4_mother	G5_mother	G6_mother	G7_mother	G8_mother	G9_mother	homework_mother	KindOfGame_mothe	teach_mother	Tpaid_mother	Tplay_mother	Tunpaid_mother	Mavailibility	Meducation	MEntAct	Mgame	Mplay	Mschool	Mtime	Mint
757	1	5	5	1	4	5	5	3	4	4	1	4	1	0	2	51.84819	1	1	0.5	1	0.75	1	1	0.91666
764	1	5	5	1	3	5	6	4	2	2	1	6	1	35	2	51.995	1	1	0.5	1	0.75	1	0.79166	0.91666
1227	1	1	1	1	1	5	6	6	2	6	1	4	1	0	2	50.01464	1	1	0.5	1	0.75	1	1	0.91666
1472	1	4	5	1	5	5	6	4	2	5	1	4	1	20	1	48.68841	1	1	0.5	1	0.75	1	1	0.91666
1473	1	4	5	1	5	5	6	4	2	5	1	4	1	20	1	48.68841	1	1	0.5	1	0.75	1	1	0.91666
2025	1	1	1	1	1	5	6	6	2	6	1	4	1	35	2	45.86509	1	1	0.5	1	0.75	1	0.79166	0.91666
1750	1	2	2	1	2	6	6	2	2	6	1	1	1	28	1	53.15515	1	1	0.5	1	0.78002	1	1	0.92858
2128	1	2	2	1	1	4	1	2	1	1	1	6	1	0	1	51.48316	1	1	0.5	1	0.7949	1	1	0.93102
274	1	1	1	1	4	6	6	6	2	6	1	4	1	18	2	52.61741	1	1	0.5	1	0.78568	1	1	0.93134
1873	1	1	4	1	2	6	6	1	5	5	1	6	1	36	1	50.83729	1	1	0.5	1	0.7935	1	1	0.93182
302	1	1	2	3	3	4	6	6	5	6	1	4	1	30	1	41.19566	1	1	0.5	1	0.79164	1	1	0.9333
1621	1	1	3	1	1	4	3	4	3	1	1	6	1	0	1	66.55856	1	1	0.5	1	0.78788	1	1	0.93334
10	1	2	5	1	3	3	5	1	3	3	1	4	1	30	2	43.04523	1	1	0.5	1	0.79464	1	1	0.9365
1780	1	2	5	1	3	3	5	1	3	3	1	4	1	24	2	43.09032	1	1	0.5	1	0.79464	1	1	0.9365
1781	1	2	5	1	3	3	5	1	3	3	1	4	1	24	2	43.09032	1	1	0.5	1	0.79464	1	1	0.9365
1222	1	2	1	1	2	3	2	1	3	3	1	6	1	30	1	44.41226	1	1	0.5	1	0.80558	1	1	0.93828
2077	1	2	2	1	4	5	6	3	5	5	1	6	1	48	1	40.30643	1	1	0.5	1	0.80954	1	0.66666	0.9386
55	1	1	1	2	2	6	6	2	2	6	1	4	1	35	2	47.7937	1	1	0.5	1	0.8077	1	0.79166	0.9394
2264	1	1	1	1	2	6	5	3	4	3	1	6	1	20	1	46.75103	1	1	0.5	1	0.81252	1	1	0.93998
533	1	1	5	5	5	6	6	2	3	6	1	6	1	45	1	36.52819	1	1	0.65	1	0.88338	1	0.66666	0.96154

Fathers with the lowest performance in terms of their interaction with children show a higher than average number of weekly hours of paid work, less availability in terms of time and in their interaction with the school and are characterized by a poor level of education (Tab.13).

Table 13 – The worst 20 cases in terms of father's interaction

ID	degree_father	G1_father	G2_father	G3_father	G4_father	G5_father	G6_father	G7_father	G8_father	G9_father	homework_father	KindOfGame_fathe	teach_father	Tpaid_father	Tplay_father	Tunpaid_father	Favailibility	Feducation	FEntAct	Fgame	Fplay	Fschool	Ftime	Fint
529	4	6	6	1	6	6	6	6	6	6	0	8	0	50	6	11.5274	0	0	0	0	0	0	0.09358	0
947	4	6	6	6	6	6	6	6	6	6	0	0	0	40	6	17.07815	0	0	0	0	0	0	0.30234	0
959	4	6	6	1	6	6	6	6	6	6	0	8	0	40	6	16.93482	0	0	0	0	0	0	0.29806	0
1674	4	6	6	6	6	6	6	6	6	6	0	0	0	48	6	17.95926	0	0	0	0	0	0	0.3318	0
1987	4	6	6	1	6	6	6	6	6	6	0	0	0	40	6	18.73559	0	0	0	0	0	0	0.33332	0
1162	4	6	6	6	6	6	5	6	6	6	0	0	0	48	6	13.85972	0	0	0.09998	0	0.00664	0	0.17998	0.00442
1110	4	6	6	2	6	6	5	6	6	5	0	8	0	40	5	17.55254	0	0	0.21426	0	0.04946	0	0.31752	0.01176
2136	4	6	6	2	2	6	4	6	6	6	0	0	0	48	6	16.74837	0	0	0.14284	0	0.0261	0	0.28696	0.0174
961	4	6	6	2	2	6	6	6	3	6	0	8	0	45	2	17.53418	0	0	0.1875	0	0.0372	0	0.33332	0.0248
251	4	6	6	1	6	6	6	5	6	6	0	8	0	40	4	16.85939	0	0	0.16664	0	0.08332	0	0.29582	0.02778
1486	4	6	6	1	6	6	6	5	6	6	0	8	0	40	4	14.62112	0	0	0.16664	0	0.08332	0	0.24232	0.02778
1244	4	4	4	4	4	5	6	5	3	5	0	8	0	60	2	16.06813	0	0	0.5	0	0.12388	0	0.33332	0.03534
505	4	6	6	2	2	5	4	5	3	5	0	8	0	40	4	24.50729	0	0	0.37498	0	0.0994	0	0.33332	0.0432
930	4	6	6	2	2	5	4	5	3	5	0	8	0	40	4	24.39902	0	0	0.37498	0	0.0994	0	0.33332	0.0432
943	4	6	6	2	2	5	4	5	3	5	0	8	0	49	4	23.3931	0	0	0.37498	0	0.0994	0	0.33332	0.0432
1494	4	6	6	1	6	6	4	6	6	6	0	8	0	48	2	17.6389	0	0	0.14284	0	0.07142	0	0.33332	0.0476
40	4	6	4	2	6	6	4	6	2	6	0	8	0	45	2	11.39198	0	0	0.37498	0	0.11818	0	0.33332	0.05224
2303	4	5	2	1	3	5	6	6	2	6	0	8	0	50	2	16.92036	0	0	0.5	0	0.20826	0	0.33332	0.06406
162	4	6	6	1	1	3	3	3	4	2	0	0	0	56	6	17.77175	0	0	0.5	0	0.22	0	0.32488	0.07406
1551	4	6	6	1	2	6	5	6	2	6	0	0	0	40	2	18.1884	0.08332	0	0.25	0	0.08924	0	0.44442	0.08332

The best cases amongst father's interaction are characterized by a higher presence in the relation with child's school and his/her homework.

Table 14 – The best 20 cases in terms of father's interaction

ID	degree_father	G1_father	G2_father	G3_father	G4_father	G5_father	G6_father	G7_father	G8_father	G9_father	homework_father	KindOfGame_fathe	teach_father	Tpaid_father	Tplay_father	Tunpaid_father	Favailibility	Feducation	FEntAct	Fgame	Fplay	Fschool	Ftime	Fint
1113	3	3	4	1	6	6	6	6	4	4	1	6	0	0	1	28.00146	0.75	0.5	0.5	1	0.7858	0.5	1	0.76392
1189	2	6	6	1	6	5	5	1	4	4	1	6	1	36	2	22.95486	1	0.5	0.5	1	0.78132	1	0.75	0.76392
889	3	4	4	1	4	6	6	4	2	2	1	6	0	36	1	20.40554	0.75	0.5	0.5	1	0.78568	0.5	1	0.7647
735	2	4	2	1	2	4	4	1	1	4	1	6	0	37	1	20.15119	0.75	0.5	0.5	1	0.78226	0.5	1	0.76514
2019	1	5	5	2	5	5	5	6	3	6	1	6	1	45	1	13.29562	0.86932	1	0.37498	1	0.60634	1	0.49244	0.76648
583	2	5	6	2	6	6	6	1	5	6	1	6	1	4	3	16.16619	0.95768	0.5	0.54998	1	0.79556	1	0.7368	0.76668
104	2	2	2	1	2	4	4	4	3	2	1	1	0	36	1	22.06188	0.75	0.5	0.5	1	0.79166	0.5	1	0.7681
2183	3	4	3	1	4	5	5	4	3	2	1	6	1	60	2	16.15955	0.75	0.5	0.5	1	0.7935	1	0.33332	0.76852
1307	3	1	4	2	2	6	4	4	1	2	1	7	1	36	1	18.39417	1	0.5	0.5	0.5	0.54464	1	1	0.76984
663	2	2	2	1	2	4	4	2	2	3	1	6	0	0	1	24.43018	0.75	0.5	0.5	1	0.79688	0.5	1	0.77082
1727	3	5	1	3	3	3	3	3	2	2	1	4	1	0	1	28.77392	1	0.5	0.5	1	0.81034	1	1	0.78068
300	3	2	4	1	6	6	5	2	2	4	1	6	1	40	2	13.24713	0.81248	0.5	0.5	1	0.82962	1	0.41664	0.78432
703	2	4	3	2	6	6	6	6	6	1	1	4	1	50	2	11.35987	0.75	0.5	0.55554	1	0.8572	1	0.33332	0.78572
1713	3	4	3	2	6	6	6	6	6	1	1	4	1	40	2	11.80058	0.80932	0.5	0.55554	1	0.8572	1	0.41242	0.78572
1171	3	1	6	1	6	6	6	2	2	2	1	6	0	0	2	24.20889	0.75	0.5	0.5	1	0.84098	0.5	1	0.78704
1342	1	3	3	2	2	4	3	3	4	4	1	6	1	36	2	11.7355	0.88398	1	0.5	1	0.70626	1	0.56752	0.8107
1320	1	4	4	2	4	4	2	3	2	3	1	6	1	38	3	14.15498	0.83332	1	0.5	1	0.71338	1	0.44442	0.81202
1104	1	6	6	2	2	6	4	1	6	1	1	4	1	40	1	15.91605	0.953	1	0.5	1	0.77498	1	0.68986	0.84522
1743	1	6	6	1	2	2	6	2	6	4	1	6	1	24	2	14.19476	1	1	0.5	1	0.71056	1	0.85906	0.9
969	1	2	2	2	2	4	4	5	3	3	1	6	1	36	2	25.80121	1	1	0.5	1	0.71444	1	0.75	0.90196

We have then focused our attention on the worst cases in terms of both outcomes in terms of father and mother interaction (Table 15).

Table 15 – Worst cases in terms of children interaction with their fathers and mothers

ID	959	1088	1102	1987	2146	2459
degree_mother	4	3	3	4	3	4
degree_father	4	3	4	4	4	4
G1_mother	6	6	6	6	6	6
G1_father	6	6	6	6	6	6
G2_mother	6	6	6	6	6	6
G2_father	6	6	6	6	6	6
G3_mother	1	1	6	1	2	2
G3_father	1	4	6	1	4	2
G4_mother	6	6	6	6	6	3
G4_father	6	6	6	6	6	3
G5_mother	6	6	6	6	6	5
G5_father	6	6	6	6	6	5
G6_mother	6	6	6	6	6	5
G6_father	6	6	6	6	6	5
G7_mother	6	6	6	6	6	6
G7_father	6	6	6	6	6	6
G8_mother	6	6	6	6	6	6
G8_father	6	6	6	6	6	6
G9_mother	6	6	6	6	6	6
G9_father	6	6	6	6	6	6
homework_mother	0	0	0	0	0	0
homework_father	0	0	0	0	0	0
KindOfGame_mothe	8	8	8	8	8	8
KindOfGame_fathe	8	5	4	0	8	4
teach_mother	1	0	0	1	0	1
teach_father	0	0	0	0	0	0
Tpaid_mother	0	40	0	0	0	0
Tpaid_father	40	50	48	40	0	45
Tplay_mother	6	6	6	6	6	6
Tplay_father	6	6	4	6	6	6
Tunpaid_mother	57.91793	49.85699	62.00068	68.7009	63.18389	55.24076
Tunpaid_father	16.93482	17.72025	14.19334	18.73559	25.47336	16.49249
Mavailibility	0.5	0	0.24998	0.5	0.24998	0.5
Favailibility	0	0	0	0	0.24998	0
Meducation	0	0.5	0.5	0	0.5	0
Feducation	0	0.5	0	0	0	0
MEntAct	0	0	0	0	0	0.14284
FEntAct	0	0	0	0	0	0.14284
Mgame	0	0	0	0	0	0
Fgame	0	0.5	1	0	0	1
Mplay	0	0	0	0	0	0.02752
Fplay	0	0.24998	0.5	0	0	0.52754
Mschool	0.5	0	0	0.5	0	0.5
Fschool	0	0	0	0	0	0
Mtime	0.66666	0.33332	0.66666	0.66666	0.66666	0.66666
Ftime	0.29806	0.32298	0.19236	0.33332	0.66666	0.27748
Mint	0.16666	0.16666	0.16666	0.16666	0.16666	0.18502
Fint	0	0.16666	0.16666	0	0.16666	0.18502

Table 15 allows one to detect the intermediate variables that contribute to the worst results in terms of interaction between both parents and children. There are 6 children who show a value of the output of the system below 0.20. The worst cases in terms of father and mother interaction with children score rather badly in terms of time devoted by fathers to school activities (meeting teachers, home working), in terms of their time availability that is reflected in a very low score on their game activities with the child and in terms of mothers' education and playing activities with their children. Five cases out of 6 show the minimum level of fathers' education and 3 out of 6 show the minimum mothers' level of education. By analysing the characteristics of fathers and mothers of these children we can find that 5 of them live in the South of Italy, in 5 cases out of 6 the mother is housewife, while in 4 out of 6 the father is blue collar and he works more than 40 hours a week.

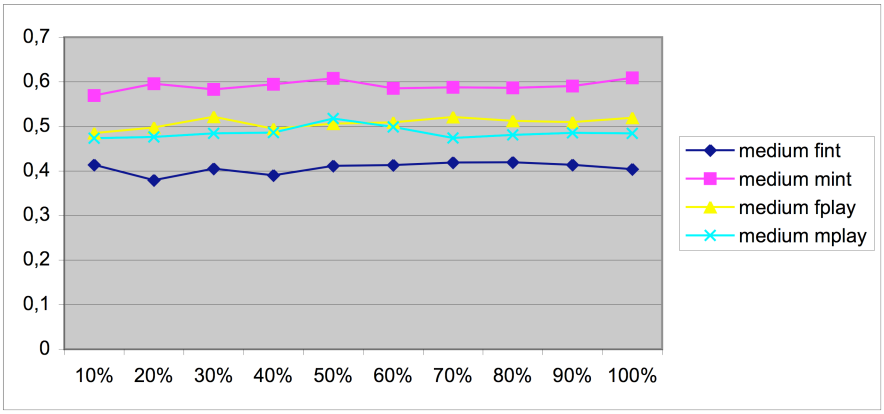
Table 16 – Parents' interaction with their children along the Family equivalent income distribution

	medium fint	medium mint	medium fplay	medium mplay
10%	0.41	0.57	0.48	0.47
20%	0.38	0.60	0.50	0.48
30%	0.41	0.58	0.52	0.48
40%	0.39	0.59	0.49	0.49
50%	0.41	0.61	0.51	0.52
60%	0.41	0.59	0.51	0.50
70%	0.42	0.59	0.52	0.47
80%	0.42	0.59	0.51	0.48
90%	0.41	0.59	0.51	0.49
100%	0.40	0.61	0.52	0.48

Source: our elaborations on BFSS98 data.

The output does not show a high degree of variation along the family equivalent income distribution. Figure 3 shows how in any part of the distribution the output of our FES in terms of mother's interaction is at a higher level with respect to father's, while on average mother's output in terms of the intermediate variable 'play' is very close to father's outcome (and in certain points of the equivalent family income distribution is even lower).

Figure 3 – Average father and mother interaction and intermediate variables on father and mother interaction in playing activities along income distribution



4. Modelling the fuzzy output in its interaction with individual and environmental factors

In this Section we analyse the distribution of the output variables of the two fuzzy expert system models and their interaction with other individual and environmental variables.

Descriptive statistics show that the crisp output obtained from the fuzzy expert system of the model on social interaction between parents and child is significantly higher for mothers than for fathers for every age group analysed.

Table 17 – Descriptive Statistics on the output of the fuzzy system on parents' interaction with their children

	Father		Mother			
Children's age	mean	S.D.	mean	S.D.	gap f-m	Obs.
from 3 to 5	0,41	0,15	0,61	0,14	-0,20	490
from 6 to 10	0,41	0,14	0,59	0,15	-0,18	978
from 11 to 13	0,40	0,15	0,56	0,15	-0,17	563
whole sample	0,41	0,14	0,59	0,16	-0,18	2031

Source: our elaborations on BFSS98 data.

Table 18 – Descriptive Statistics on the output of the fuzzy system on parents' interaction with their children by area where the family lives

	Father		Mother			
Area	mean	S.D.	mean	S.D.	gap f-m	Obs.
North West	0.41	0.13	0.61	0.15	-0.20	420
Nort East	0.39	0.14	0.58	0.15	-0.18	361
Centre	0.41	0.16	0.63	0.15	-0.17	359
South	0.41	0.16	0.58	0.16	-0.18	595
Islands	0.42	0.16	0.55	0.18	-0.18	296

Source: our elaborations on BFSS98 data.

The gap between mother and father interaction is higher in the North West regions of Italy and lower in the Centre. In every area the crisp value for parents' interaction is higher for mothers (it ranges from 0.55 in the Islands to 0.63 in the Centre of Italy, whereas the value of father's interaction reaches its lowest value in the North East, 0.39, and its highest value in the Islands, 0.42). The descriptive analysis on father and mother's interaction with their child by type of profession shows that the worst value for father's interaction is to be found amongst fathers who have a contract of collaborators (collaborazione coordinata e continuativa). A closer view to these eight cases shows a higher average number of hours of work and a relatively low level of education. Mothers in this type of position have the highest level of interaction with their child amongst the professional groups analysed, their level of weekly hours of work is on average lower and they are characterized by a higher level of education. One should notice that this group of workers is relatively underrepresented in the data set and their lower presence amongst parents can be also connected to their lower mean number of children linked to their high work instability and their reduced access to benefits as far as parenthood is concerned. Further analysis on more recent data could add more

insights on the differences found according to parents' employment condition. Mothers who are manager have been found to have a relatively high value for the interaction with child (almost 20 percentage points more than fathers in the same job position) a higher value on average than can be found amongst mothers who are housewives. Amongst employed men, those in white-collar and teacher position show the highest value for interaction with child.

Table 19 – Descriptive Statistics on the output of the fuzzy system on parents' interaction with their children by parents' employment position

	Father's interaction			Mother's interaction		
Area	mean	S.D.	Obs.	mean	S.D.	Obs.
blue-collar	0.40	0.15	699	0.58	0.15	251
white-collar	0.44	0.14	492	0.60	0.15	502
manager	0.41	0.13	199	0.64	0.15	62
Self-employed	0.39	0.14	496	0.58	0.18	147
Collab.	0.29	0.18	8	0.72	0.14	12
retired	0.47	0.19	31	0.63	0.11	16
unemployed	0.46	0.15	104	0.55	0.19	40
housewife				0.59	0.15	1000

Source: our elaborations on BFSS98 data.

By controlling for other individual and environmental variables and estimating an OLS model on the factors affecting the value of the output obtained for parents' interaction with children aged 3 to 13 (Tab.20), one can see that mother's interaction decreases in the South of Italy and as the child grows up, it increases with father's interaction. Father's interaction with child increases if he's unemployed or white-collar. The higher father's interaction with child that we can observe for white collar employees (that include also teachers) is consistent with other empirical analysis on father's involvement and may be connected (considering also the rules applied in the design of the model) to a lower probability that he's involved in long working hours. Mother's interaction positively affects father's interaction with the child. The positive and significant interaction term in the other parent's interaction suggests a complementarity between parents in the interaction with the child and/or the sharing of a parenthood model requiring both parents' involvement in the child's growth.

Tab.20 – OLS regression of parents' interaction with their children

	Father's interaction	Mother's interaction
log child's age	0.004	-0.039**
	(0.32)	(-3.54)
girl (=1 if child is a girl)	0.006	-0.002
	(0.69)	(-0.21)
parent's age	0.000	0.000
	(0.15)	(0.17)
South	0.012	-0.041**
	(1.21)	(-3.85)
number of children (child included)	-0.006	0.003
	(-1.01)	(0.42)
father unemployed	0.079**	0.011
	(2.99)	(0.44)
Mother unemployed	-0.051	-0.032
	(-1.85)	(-0.66)
Father white-collar	0.034**	0.008
	(2.84)	(0.65)
Mother white-collar	0.006	-0.001
	(0.54)	(-0.10)
Father manager	0.011	0.018
	(0.72)	(0.85)
Mother manager	0.012	0.028
	(0.60)	(1.22)
Father self-employed	-0.006	0.000
	(-0.46)	(0.03)
Mother self-employed	-0.016	-0.014
	(-1.09)	(-0.72)
log equivalent family income	0.002	-0.004
	(0.32)	(-0.65)
other parent's child's interaction	0.094**	0.109**
	(3.16)	(3.22)
Constant	0.318**	0.666**
	(4.40)	(10.11)
Observations	2031	2031
R-squared	0.04	0.04
Robust t statistics in parentheses		
* significant at 5%; ** significant at 1%		

Source: our elaborations on BFSS98 data.

Conclusions

This paper explores the possibility of using fuzzy expert system to measure interaction between parents and child in Italy, an important dimension of children's well being according to the capability approach. The definition that we have given of interaction is related to parent's level of education, time availability, and with how often they play with the child and with the types of games and activities they do together.

The tree that we have developed in this paper to measure interaction has been implemented to ISTAT multipurpose 1998 matched with Bank of Italy survey on income and wealth data 2000. The data used allows us to recover information on variables that can be considered as functionings of the capability of interaction and of relevant factors affecting the development of this capability.

The outcome of the model assigns at the end a crisp value to *interaction* between parent's that has been analysed by child's age, area where the family lives and parents' job position. First descriptive results on this value is shown in this paper. The crisp output obtained from the fuzzy expert system is significantly higher for mothers than for fathers for every age group analysed. By controlling for parents' individual variables, family equivalent income and area where the family lives, we observe a higher level of interaction amongst fathers who are teachers or white collar workers, or amongst unemployed fathers, whereas mother's interaction with her child decreases if they live in the South of Italy and as children grow. The positive and significant interaction term in the other parent's interaction that we found suggests a complementarity between parents in the interaction with the child and/or the sharing of a parenthood model requiring both parents' involvement in the child's growth and calls for further econometric model estimation.

The scheme that we have constructed allows us to carry out simulations of different theoretical views on the building of children's capabilities, as well as simulations on how children living in different areas or having different household structures have different well being and different functionings, by entering in the same fuzzy set scheme values for functionings referring to children from different areas or different household types currently available. Another further development of this application we are currently working with, is to include other dimensions of social interaction.

The source of data affects the system developed in this paper, we aim at developing a larger system with more indicators than the ones currently available that can be collected in a further step of this research directly or by making use of different sources of data. This research is inserted in a wider project that involves experts from other disciplines that can provide theoretical reasoning for the rules that we assume in the fuzzy scheme as well on the implications of the obtained results for the building of child well being and child's development.

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