

Article

The evaluation in the urban projects planning: a logical-deductive model for the definition of "warning areas" in the Esquilino district in the city of Rome (Italy)

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Variable	Mean	Standard Deviation	Levels/Intervals	Frequence [%]
Total selling price [€]	445,159	260,681	<250,000 €	55
			251,000 € - 300,000 €	59
			301,000 € - 400,000 €	134
			400,000 € - 500,000 €	53
			501,000 € - 600,000 €	40
			601,000 € - 700,000 €	20
			701,000 € - 900,000 €	12
			901,000 € - 1,100,000 €	10
			>1,100,000 €	17
Total floor area [m ²]	109	58	< 40m ²	18
			41m ² -80m ²	118
			81m ² -100m ²	83
			101m ² -120m ²	69
			121m ² -150m ²	48
			151m ² -200m ²	38
			>200m ²	26
Presence of lift [1-presence, 0-absence]	0.85	1.62	0	59
			1	341
Floor [n.]	2.69	0.35	0	23
			1	84
			2	101
			3	63
			4	70
			5	37
			6	19
			7	3
			to be restructured	139

Quality of the residential unit maintenance state			good	151
			excellent	110
Distance from Piazza Dante [km]	0.92	0.60	0-500m	115
			501m-1000m	155
			1001m-1500m	45
			1501m-2000m	57
			2001m-2400m	28
Distance from Piazza dell'Indipendenza [km]	1.26	0.62	0-500m	70
			501m-1000m	75
			1001m-1500m	100
			1501m-2000m	109
			2001m-2600m	46
Distance from Piazza Vittorio Emanuele II [km]	0.74	0.49	0-500m	199
			501m-1000m	90
			1001m-1500m	72
			1501m-2000m	38
			2001m-2600m	1
Distance from Piazza dei Cinquecento [km]	1.06	0.48	0-500m	38
			501m-1000m	190
			1001m-1500m	117
			1501m-2000m	42
			2001m-2400m	13
Distance from Piazza Esedra [km]	1.20	0.53	0-500m	34
			501m-1000m	163
			1001m-1500m	93
			1501m-2000m	79
			2001m-2600m	31
Distance from Casa dell'Architettura [km]	0.75	0.41	0-500m	133
			501m-1000m	178
			1001m-1500m	78
			1501m-1800m	11
Distance from the Porta Maggiore Monument [km]	1.28	0.53	0-500m	26
			501m-1000m	113
			1001m-1500m	153
			1501m-2000m	54
			2001m-2500m	54
Distance from the Termini railway Station [km]	0.99	0.46	0-500m	63
			501m-1000m	174
			1001m-1500m	112
			1501m-2000m	40
			2001m-2300m	11

Distance from the New Esquilino Market [km]	0.76	0.46	0-500m	169
			501m-1000m	115
			1001m-1500m	80
			1501m-2000m	36
Distance from the Polyclinic Umberto I [km]	1.90	0.43	0-500m	0
			501m-1000m	16
			1001m-1500m	56
			1501m-2000m	178
			2001m-2400m	142
			2401m-2800m	8
Distance from the San Giovanni Addolorata Hospital [km]	1.73	0.61	0-500m	0
			501m-1000m	46
			1001m-1500m	136
			1501m-2000m	124
			2001m-2400m	24
			2401m-3200m	70
Distance from the Sapienza University of Rome Campus [km]	1.81	0.33	0-500m	0
			501m-1000m	15
			1001m-1500m	56
			1501m-2000m	217
			2001m-2500m	112
Distance from the Science of Education Department – University of Rome 3 (entrance on Via Principe Amedeo) [km]	0.73	0.45	0-500m	178
			501m-1000m	111
			1001m-1500m	84
			1501m-1900m	27
Distance from the Science of Education Department – University of Rome 3 (entrance on Via del Castro Pretorio) [km]	1.16	0.44	0-500m	30
			501m-1000m	138
			1001m-1500m	141
			1501m-2000m	82
Distance from the Department of Computer, Automatic, and Management Engineering - Sapienza University of Rome [km]	1.02	0.60	2001m-2200m	9
			0-500m	87
			501m-1000m	176
			1001m-1500m	46
			1501m-2000m	50
Distance from the Colosseum [km]	1.68	0.37	2001m-2500m	41
			0-500m	0
			501m-1000m	2
			1001m-1500m	153
			1501m-2000m	158
Distance from the Museum of the	1.24	0.66	2001m-2600m	87
			0-500m	30

Liberation [km]			501m-1000m	177
			1001m-1500m	84
			1501m-2000m	33
			2001m-2400m	59
			2401m-2700m	17
Distance from the Biblioteca Nazionale [km]			0-500m	4
1.68	0.53		501m-1000m	65
			1001m-1500m	66
			1501m-2000m	158
			2001m-2400m	96
			2401m-2700m	11
Distance from the Terme di Diocleziano [km]			0-500m	45
1.15	0.54		501m-1000m	154
			1001m-1500m	89
			1501m-2000m	84
			2001m-2600m	28
Distance from the Park of the Oppian Hill [km]			0-500m	2
1.28	0.42		501m-1000m	127
			1001m-1500m	159
			1501m-2000m	97
			2001m-2300m	15
Distance from the Teatro dell'Opera [km]			0-500m	31
1.10	0.43		501m-1000m	180
			1001m-1500m	136
			1501m-2000m	39
			2001m-2500m	14
Distance from the Teatro Brancaccio [km]			0-500m	86
0.90	0.47		501m-1000m	186
			1001m-1500m	70
			1501m-2100m	57
Distance from the Teatro Ambra Jovinelli [km]			0-500m	129
0.79	0.45		501m-1000m	156
			1001m-1500m	82
			1501m-1900m	33
distance from the Basilica of San Giovanni in Laterano [km]			0-500m	5
1.56	0.66		501m-1000m	103
			1001m-1500m	105
			1501m-2000m	94
			2001m-2500m	41
			2501m-3100m	52
1.55	0.66		0-500m	19

			501m-1000m	78
			1001m-1500m	114
Distance from the Basilica of Santa Croce in Gerusalemme [km]			1501m-2000m	92
			2001m-2500m	59
			2501m-2900m	38
			0-500m	91
Distance from the Basilica of Santa Maria Maggiore [km]	0.87	0.38	501m-1000m	180
			1001m-1500m	112
			1501m-2000m	17
			0-500m	121
Distance from the Secret Service Office [km]	0.90	0.60	501m-1000m	159
			1001m-1500m	31
			1501m-2000m	67
			2001m-2400m	22
			0-500m	127
Distance from the Polygraph and Mint Institute [km]	0.82	0.47	501m-1000m	159
			1001m-1500m	68
			1501m-2000m	46
			0-500m	22
Distance from the Ministry of Defence [km]	1.52	0.52	501m-1000m	47
			1001m-1500m	152
			1501m-2000m	124
			2001m-2500m	41
			2500m-3000m	14
			0-500m	34
Distance from the Ministry of the Interior [km]	1.17	0.45	501m-1000m	134
			1001m-1500m	136
			1501m-2000m	88
			2001m-2200m	8
			0-500m	41
Distance from the Revenue Agency Office [km]	1.50	0.68	501m-1000m	77
			1001m-1500m	101
			1501m-2000m	90
			2001m-2500m	65
			2501m-3100m	26
			0-500m	84
Distance from the Finance Ministry [km]	0.9	0.48	501m-1000m	190
			1001m-1500m	68
			1501m-2000m	57
			2001m-2100m	1
Distance from the Manzoni	1.05	0.65	0-500m	93

metro station [km]			501m-1000m	158
			1001m-1500m	53
			1501m-2000m	53
			2001m-2500m	43
Distance from the Vittorio Emanuele metro station [km]	0.69	0.47	0-500m	198
			501m-1000m	95
			1001m-1500m	79
			1501m-2000m	27
			2001m-2600m	1
Distance from the Repubblica metro station [km]	1.18	0.50	0-500m	36
			501m-1000m	154
			1001m-1500m	126
			1501m-2000m	65
			2001m-2500m	19
Distance from the Castro Pretorio metro station [km]	1.44	0.55	0-500m	42
			501m-1000m	35
			1001m-1500m	146
			1501m-2000m	117
			2001m-2500m	60
Number of buildings whose facades are characterized by an excellent state of conservation [n.]			0-100m	2653
			101m-300m	12946
			301m-500m	17088
Number of buildings whose facades are characterized by a good state of conservation [n.]			0-100m	5625
			101m-300m	28212
			301m-500m	37247
Number of buildings whose facades are characterized by a bad state of conservation [n.]			0-100m	1203
			101m-300m	5302
			301m-500m	5381

Table S1. Descriptive statistics of the variables considered in the analysis

Methodology

The Evolutionary Polynomial Regression (EPR) econometric technique uses multi-objective genetic algorithms to identify the model that, at the same time, maximizes the data accuracy and the parsimony of the mathematical expressions. The methodology performs a multivariable analysis, i.e. considers a set of factors (intrinsic and extrinsic) that are ordinarily influential on the selling prices, and selects those that - for the properties collected in the study sample - have the most significant impacts. Starting from the different intrinsic and extrinsic variables that mainly characterize the bargaining phases, the EPR technique allows to firstly identify those most influencing in the property prices formation processes and, then, to verify the functional correlation between each independent variable and the dependent one (the selling prices).

A set of polynomial functions, named models, are generated and each term included in the expression consists of a numerical parameter and an input variable or a combination of variables, possibly raised through opportune numerical exponents.

According to the range of candidate real numbers among which the technique selects the exponents and to the maximum terms number, both preliminarily fixed by the user, the generated models are characterized by a different mathematical complexity level.

The generic symbolic expression returned by EPR application is shown in Eq.(S1)

$$Y = \sum_{i=1}^l [a_i \cdot (X_n)^{(i,n)} \cdot \dots \cdot (X_j)^{(i,j)} \cdot f((X_n)^{(i,j+n)} \cdot \dots \cdot (X_j)^{(i,2j)})] + a_0 \quad (S1)$$

With l that is the number of model additive terms, a_i are numerical parameters, X_i are candidate input variables among those initially considered in the analysis, (i, n) - with $n = (1, \dots, 2j)$ - is the exponent of the n -th explanatory variable within the i -th term preliminarily chosen by the user, a_0 is the equation constant term, f is a function selected by the user between a set of different mathematical expressions (the *no function* option is included).

The EPR technique allows to simultaneously pursue different objective functions, by defining an optimal Pareto frontier of the conflictual objectives, with the aim of maximizing the model statistical accuracy, of maximizing the model parsimony, through the minimization of the number of coefficients (a_i) of the equation, of decreasing the complexity of each model, through the minimization of the number of explanatory variables (X_i) of the final equation.

The Coefficient of Determination (COD) is determined for each equation in order to help the valuer choice related to the best model. This indicator is calculated as shown in Eq. (S2) and it varies from the value 0 (minimum statistical accuracy) to the value 100% (maximum statistical accuracy). In particular, the fitting of each model is higher when the COD is close to 100%, by confirming the model structure suitability to represent the overall observed dataset.

$$CoD = 1 - \frac{N-1}{N} \cdot \frac{\sum_N (y_e - y_d)^2}{\sum_N (y_d - \text{mean}(y_d))^2} \quad (S2)$$

where y_e are the values of the dependent variable assessed by the EPR methodology, y_d are the collected values of the dependent variable, N is the sample size.

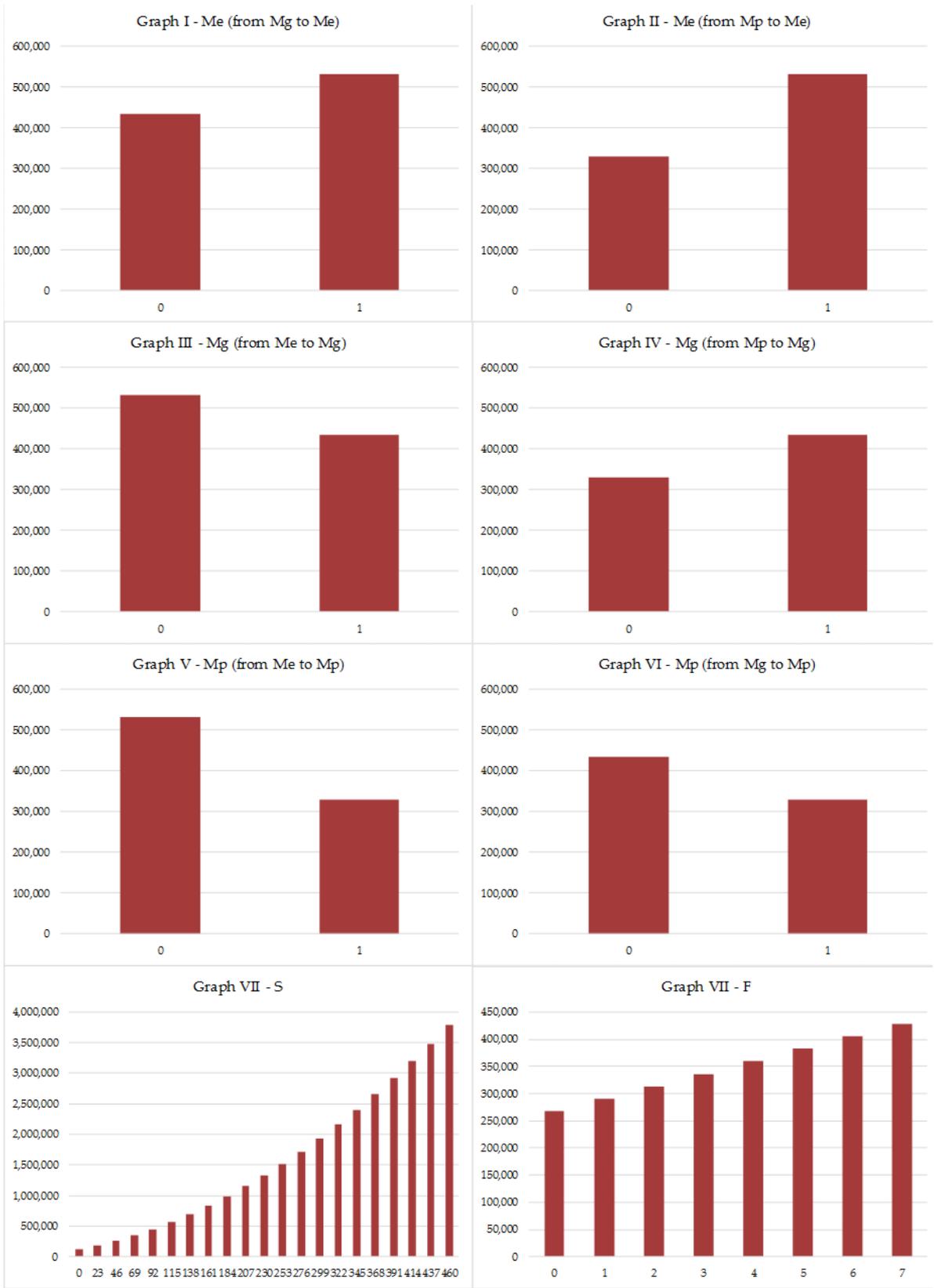
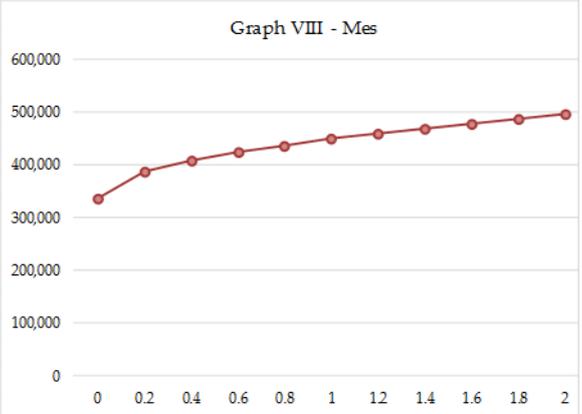
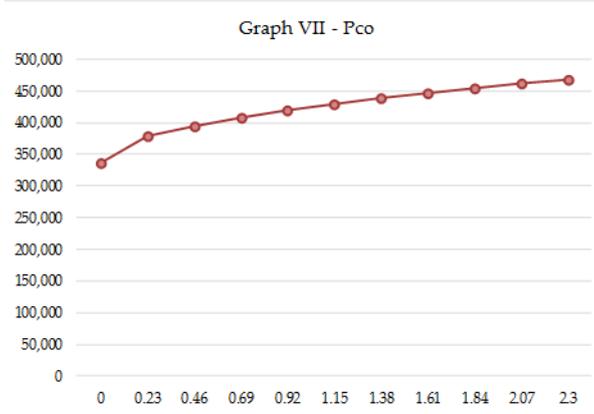
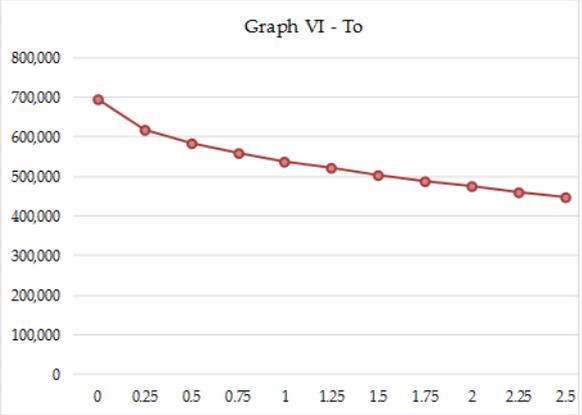
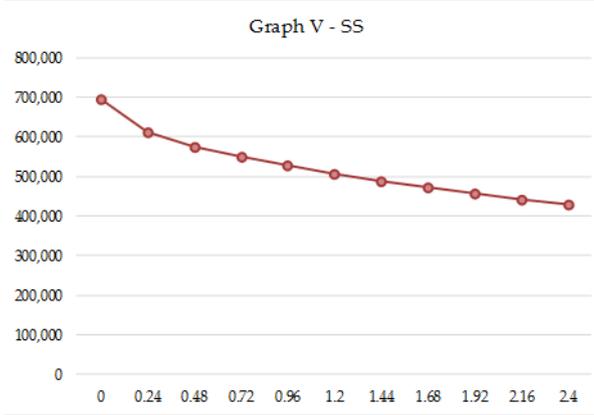
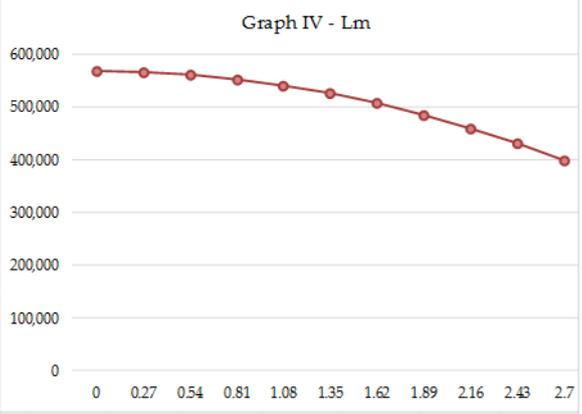
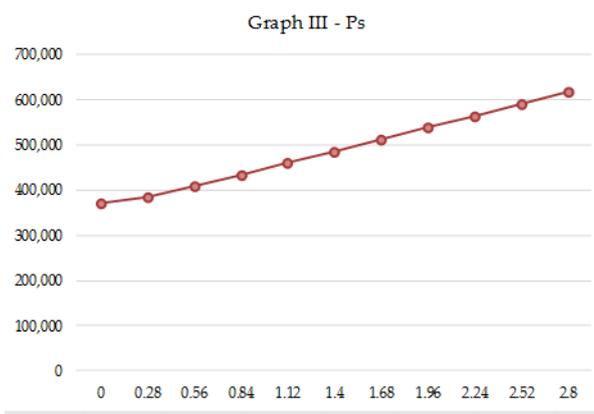
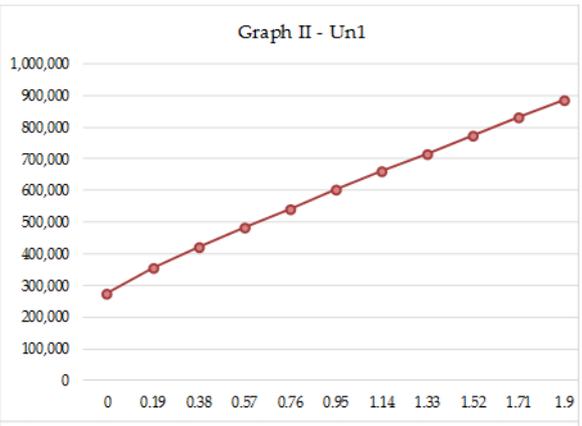
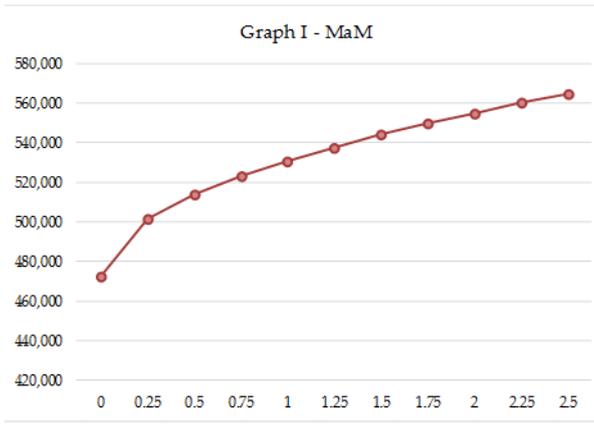


Figure S1. Functional relationships between the total selling prices and the intrinsic factors selected by the EPR model



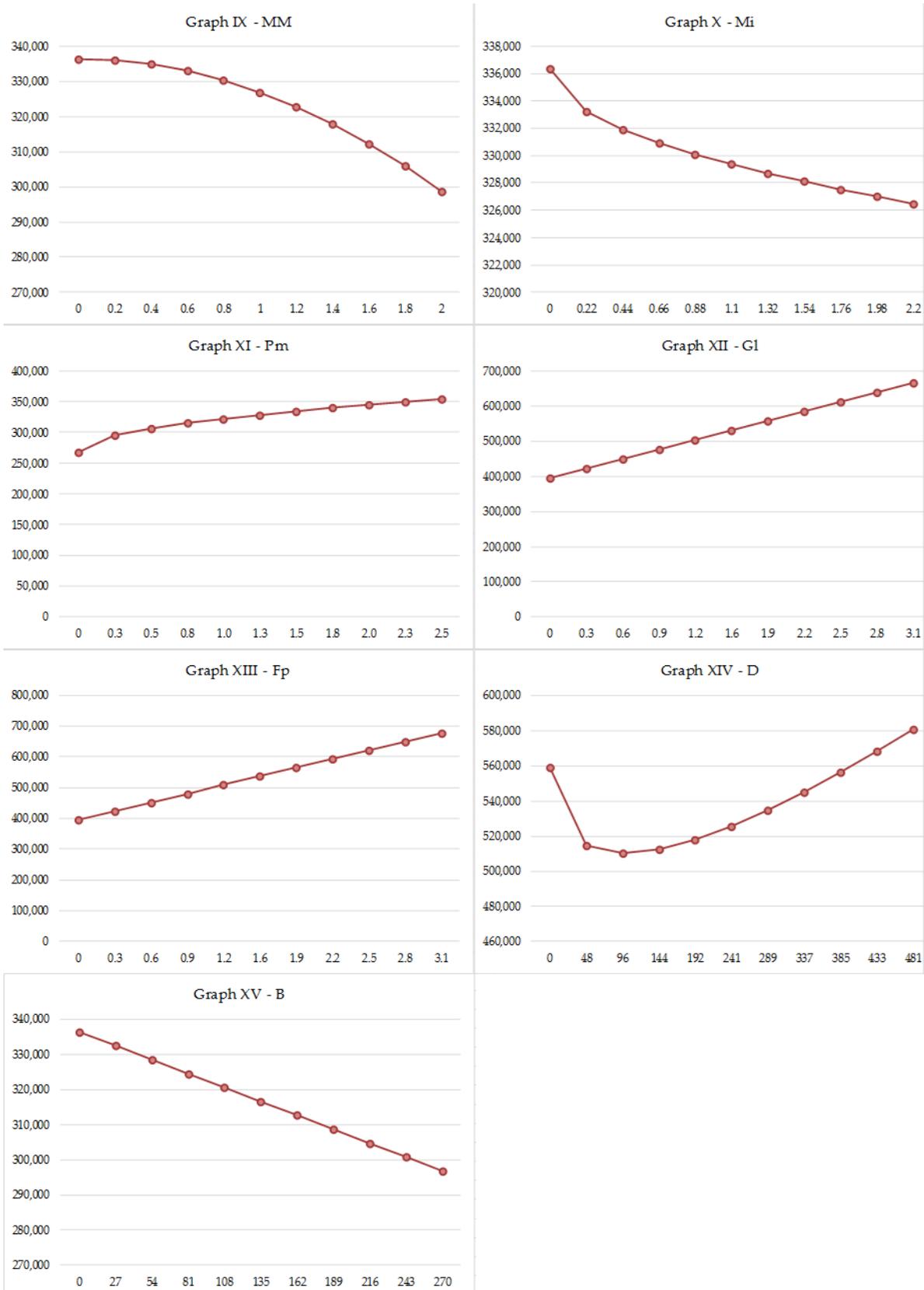


Figure S2. Functional relationships between the total selling prices and the extrinsic factors selected by the EPR model