Land Economics 94:2, May 2018
"Measuring the Income Elasticity of Water Demand: The Importance of Publication and Endogeneity Biases," by Tomas Havranek, Zuzana Irsova, and Tomas Vlach

APPENDIX

TABLE A1

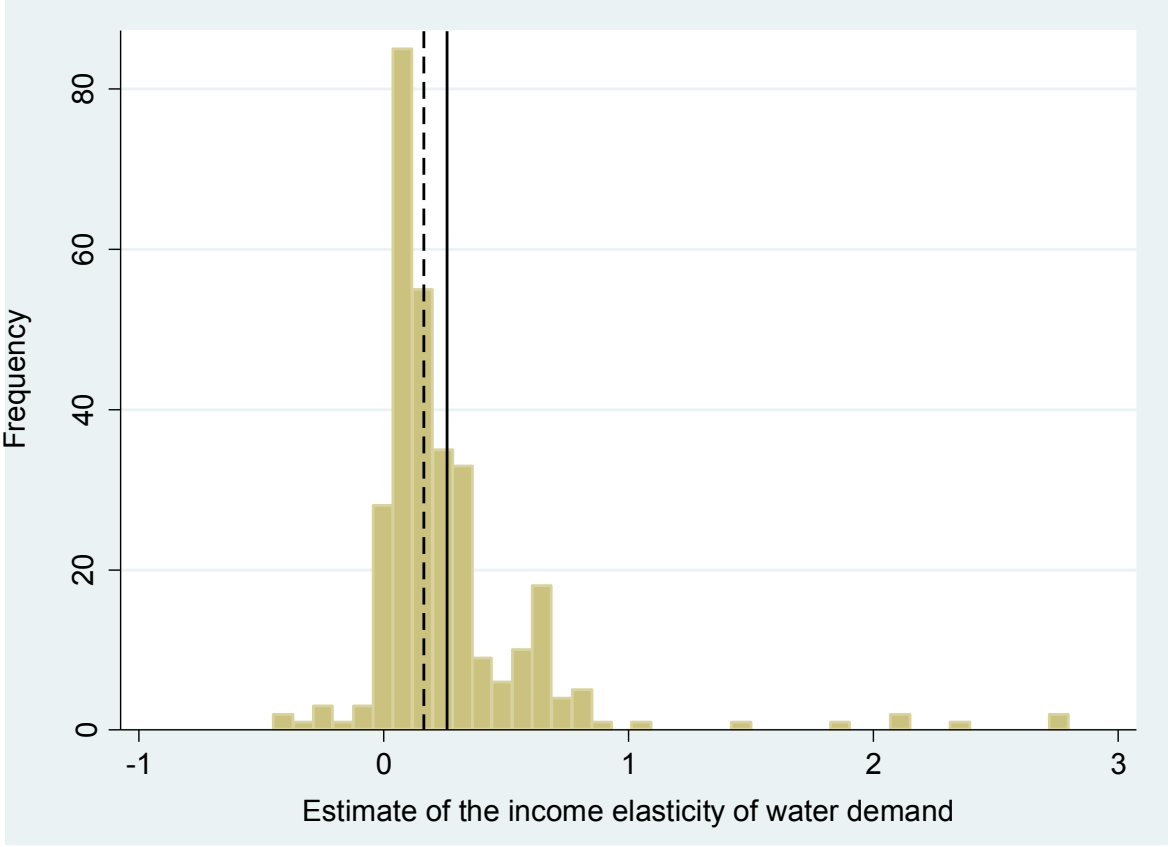
Studies used in the meta-analysis

Agthe and Billings (1980)	Lyman (1992)
Al-Najjar, Al-Karablieh, and Salman (2011)	Mansur and Olmstead (2012)
Al-Qunaibet and Johnston (1985)	Miyawaki, Omori, and Hibiki (2011)
Asci and Borisova (2014)	Monteiro and Roseta-Palma (2011)
Ayadi, Krishnakumar, and Matoussi (2002)	Musolesi and Nosvelli (2007)
Bartczak, Kopanska, and Raczka (2009)	Mylopoulos, Mentes, and Theodossiou (2004)
Basani, Isham, and Reilly (2008)	Nauges and Strand (2007)
Billings (1982)	Nauges and Thomas (2003)
Billings and Agthe (1980)	Nauges and van den Berg (2009)
Binet, Carlevaro, and Paul (2012)	Nieswiadomy (1992)
Binet, Carlevaro, and Paul (2014)	Nieswiadomy and Cobb (1993)
Carter and Milon (2005)	Nieswiadomy and Molina (1991)
Cheesman, Bennett, and Son (2008)	Olmstead (2009)
Dalmas and Reynaud (2004)	Olmstead, Hanemann, and Stavins (2007)
Darr, Feldman, and Kamen (1975)	Piper (2003)
Dharmaratna and Parasnis (2011)	Polycarpou and Zachariadis (2013)
Fenrick and Getachew (2012)	Reynaud, Renzetti, and Villeneuve (2005)
Foster and Beattie (1979)	Rietveld, Rouwendal, and Zwart (1997)
Foster and Beattie (1981)	Schleich and Hillenbrand (2009)
Frondel and Messner (2008)	Sebri (2013)
Garcia and Reynaud (2004)	Statzu and Strazzera (2009)
Gaudin (2005)	Strand and Walker (2005)
Gaudin (2006)	Strong and Smith (2010)
Hanemann and Nauges (2005)	Tabieh et al. (2012)
Hewitt (1993)	Taylor, McKean, and Young (2004)
Hewitt and Hanemann (1995)	Williams (1985)
Hoffmann, Worthington, and Higgs (2006)	Williams and Suh (1986)
Hoglund (1999)	Wong (1972)
Horn (2011)	Yoo (2007)
Hussain, Thrikawala, and Barker (2002)	Younes and Matoussi (2011)
Jia and Bao (2014)	Zapata (2015)

TABLE A2
Studies using other than double-log functional form

Agthe and Billings (1980)	Hoffmann, Worthington, and Higgs (2006)
Al-Qunaibet and Johnston (1985)	Howe and Linaweaver (1967)
Billings (1982)	Jones and Morris (1984)
Chicoine, Deller, and Ramamurthy (1986)	Moncur (1987)
Dalmas and Reynaud (2004)	Nauges and Thomas (2000)
Gibbs (1978)	Nieswiadomy and Molina (1989)
Griffin and Chang (1990)	Schefter and David (1985)
Hanke and de Mare (1982)	

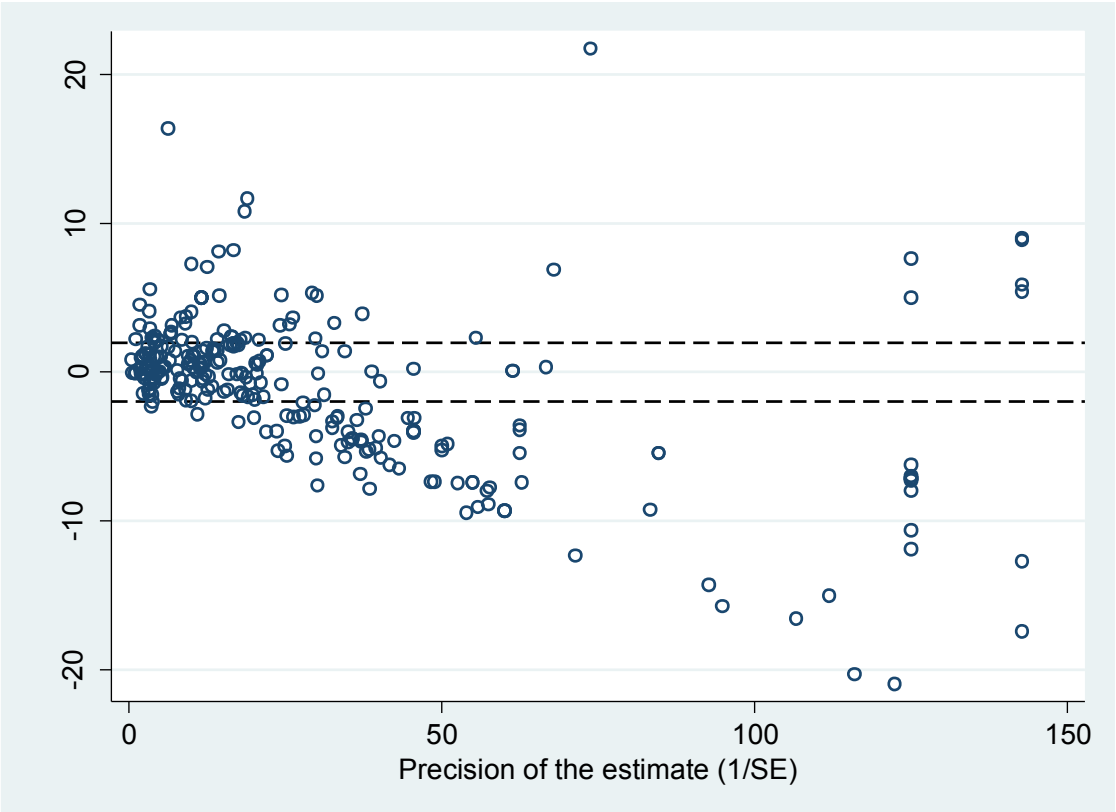
FIGURE A1
The histogram suggests substantial heterogeneity and under-reporting of negative estimates



Notes: The figure depicts a histogram of the estimates of the income elasticities of water demand reported by individual studies. The dashed vertical line denotes the sample median; the solid vertical line denotes the sample mean.

FIGURE A2

Galbraith plot suggests publication bias



Notes: The horizontal dashed lines form the boundary of the (−1.96, 1.96) interval, which should not be surpassed in more than 95% of cases if there is no publication bias related to statistical significance and no heterogeneity.

TABLE A3

Description and summary statistics of regression variables

Variable	Description	Mean	SD	WM
Income elasticity	The estimate of the income elasticity of water demand.	0.261	0.377	0.270
Standard error	The standard error of the estimate of the income elasticity of water demand.	0.123	0.232	0.130
SE · No endog. control	Interaction term between the standard error and the estimation methods not addressing price endogeneity.	0.071	0.178	0.053
Water demand specification				
Household size	= 1 if the demand equation controls for household size (usually defined as a number of persons living in a household).	0.518	0.500	0.533
Population density	= 1 if the demand equation controls for population density (which often serves as a proxy for lawn size).	0.107	0.310	0.099
Temperature	= 1 if the demand equation controls for temperature.	0.489	0.501	0.427
Rainfall	= 1 if the demand equation controls for rainfall.	0.632	0.483	0.535
Evaporation	= 1 if the demand equation controls for evaporation.	0.130	0.337	0.161
Difference variable	= 1 if the demand equation contains the variable accounting for the difference between the water bill priced at actual rates and the water bill priced at marginal prices (Dalhuisen et al., 2003).	0.156	0.364	0.218
Lagged dep. variable	= 1 if the demand equation contains the lagged dependent variable.	0.085	0.279	0.124
Discrete-continuous	= 1 if the demand equation is based on the discrete-continuous model.	0.107	0.310	0.125
Price specification				
Marginal price	= 1 if marginal price computed as the price of the last cubic meter of water is used for estimation (reference category for this group of dummy variables: average price computed as the total bill divided by total consumption).	0.401	0.491	0.462
Other price	= 1 if a price other than marginal or average is used for estimation (such as the Shin price deployed by Shin, 1985).	0.130	0.337	0.198
Data characteristics				
Long-run elasticity	= 1 if the estimated elasticity is the long-term instead of short-term elasticity.	0.296	0.457	0.237

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TABLE A3
Description and summary statistics of regression variables *(continued)*

Variable	Description	Mean	SD	WM
Household data	= 1 if residential data are used for the estimation instead of data aggregated at the municipal level (including residential, industrial, and commercial water demand).	0.632	0.483	0.597
Daily data	= 1 if the frequency of data used for estimation is daily instead of quarterly, monthly, or annual.	0.189	0.392	0.161
Monthly data	= 1 if the frequency of data used for estimation is monthly instead of daily, monthly, or annual.	0.394	0.489	0.483
Annual data	= 1 if the frequency of data used for estimation is annual instead of daily, monthly, or quarterly.	0.235	0.424	0.242
Cross-section	= 1 if cross-sectional data are used for estimation instead of time-series or panel data.	0.293	0.456	0.334
Time-series	= 1 if time series data are used for estimation instead of cross-section or panel data.	0.029	0.029	0.086
Estimation technique				
No endogeneity control	= 1 if the estimation method does not account for price endogeneity; typically ordinary least squares (reference category for this group of dummy variables is the use of instrumental variables).	0.463	0.499	0.411
Panel technique	= 1 if a fixed effects panel technique is employed for estimation.	0.244	0.430	0.212
Other estimator	= 1 if an estimation method accounting for endogeneity other than instrumental variables and panel fixed effects is employed for estimation.	0.111	0.314	0.208
Tariff structure				
Flat tariff	= 1 if a flat tariff structure is used for estimation (reference category for this group of dummy variables is the situation in which the tariff structure employed is not available).	0.078	0.269	0.121
Increasing tariff	= 1 if an increasing tariff structure is used for estimation.	0.485	0.501	0.526
Decreasing tariff	= 1 if a decreasing tariff structure is used for estimation.	0.023	0.150	0.031

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TABLE A3
Description and summary statistics of regression variables *(continued)*

Variable	Description	Mean	SD	WM
Countries examined				
Europe	= 1 if the income elasticity of water demand is estimated for a location in Europe, instead of the US or other countries.	0.166	0.373	0.226
Other location	= 1 if the income elasticity of water demand is estimated for other location than Europe or the US.	0.391	0.489	0.355
Developed countries	= 1 if the income elasticity of water demand is estimated for a developed country instead of developing country.	0.655	0.476	0.693
Publication characteristics				
Publication year	The publication year of the study (the base year is the sample minimum: 1972).	30.29	11.36	30.02
Citations	The average yearly number of citations the study received in Google Scholar since its appearance there.	4.494	6.724	4.385
Impact factor	RePEc recursive discounted impact factor for journals.	0.106	0.199	0.088
Published	= 1 if the study is published in a peer-reviewed journal.	0.799	0.416	0.839

Notes: SD = standard deviation, SE = standard error, WM = mean weighted by the inverse of the number of estimates reported per study.

TABLE A4
Study fixed effects and division by study age

Response variable:	Fixed effects			Older datasets			Newer datasets		
Income elasticity	Post. mean	Post. SD	PIP	Post. mean	Post. SD	PIP	Post. mean	Post. SD	PIP
Constant	0.000	NA	1.000	0.123	NA	1.000	0.102	NA	1.000
Standard error	0.614	0.116	1.000	0.397	0.085	1.000	2.475	0.305	1.000
SE x No endog. control	-0.089	0.154	0.313	-0.016	0.066	0.095	-0.001	0.084	0.036
Water demand specification									
Household size				-0.001	0.024	0.071	-0.077	0.099	0.452
Population density	-0.012	0.083	0.064	0.156	0.176	0.519	-0.881	0.202	1.000
Temperature	-0.001	0.025	0.052	-0.037	0.079	0.236	0.140	0.114	0.692
Rainfall	0.003	0.032	0.056	0.023	0.063	0.170	-0.001	0.042	0.089
Evaporation				0.528	0.160	0.983	-0.012	0.055	0.098
Difference variable	0.000	0.081	0.051	-0.362	0.208	0.853	0.002	0.021	0.053
Lagged variable	-0.017	0.104	0.070	-0.008	0.048	0.083	0.069	0.114	0.335
Discrete-continuous	0.001	0.040	0.051	0.004	0.048	0.061	0.043	0.092	0.239
Price specification									
Marginal price	0.008	0.029	0.107	0.024	0.050	0.244	-0.005	0.028	0.078
Other price	-0.004	0.048	0.056	0.210	0.195	0.626	-0.006	0.032	0.072
Data characteristics									
Long-run elasticity	0.026	0.076	0.148	-0.007	0.033	0.099	-0.001	0.020	0.052
Household data				0.040	0.088	0.233	0.004	0.027	0.069
Daily data				-0.017	0.087	0.129	-0.085	0.142	0.354
Monthly data				0.371	0.124	0.989	-0.002	0.022	0.056
Annual data				0.131	0.231	0.324	-0.004	0.033	0.064
Cross-section	0.022	0.097	0.092	-0.140	0.135	0.612	0.002	0.036	0.086
Time series				-0.269	0.193	0.741			
Estimation technique									
No endog. control	0.006	0.026	0.098	0.001	0.015	0.046	0.004	0.021	0.065
Panel technique	0.001	0.014	0.055	0.008	0.032	0.099	-0.001	0.021	0.057
Other estimator	-0.004	0.029	0.061	-0.010	0.044	0.097	-0.161	0.134	0.692
Tariff structure									
Flat tariff	0.350	0.272	0.707	0.011	0.061	0.099	0.179	0.146	0.690
Increasing tariff	-0.004	0.047	0.065	-0.121	0.120	0.621	0.002	0.020	0.055
Decreasing tariff				-0.011	0.067	0.070	-0.004	0.039	0.046
Countries examined									
Europe				-0.091	0.184	0.263	-0.047	0.087	0.291
Other location				-0.017	0.070	0.121	0.014	0.050	0.128
Developed countries							-0.009	0.040	0.103
Publication characteristics									
Publication year				0.000	0.001	0.069	0.004	0.008	0.230
Citations				0.000	0.002	0.062	0.003	0.007	0.232
Impact factor				-0.566	0.148	0.997	-0.035	0.184	0.103
Published				-0.009	0.060	0.111	-0.225	0.122	0.872
Studies	62			31			31		
Observations	307			169			138		

Notes: SD = standard deviation. PIP = posterior inclusion probability. Fixed effects = model accounting for within-study heterogeneity. Older datasets = restricted to estimates from studies using data older than the median of our sample. Newer datasets = restricted to estimates from studies using data newer than the median of our sample. All models are estimated using Bayesian model averaging employing priors suggested by Eicher, Papageorgiou, and Raftery (2011).

TABLE A5
Additional variables and estimates of non-constant elasticity

Response variable:	Heterogeneity			Non-constant			Heterogeneity & Non-constant		
Income elasticity	Post. mean	Post. SD	PIP	Post. mean	Post. SD	PIP	Post. mean	Post. SD	PIP
Constant	0.013	NA	1.000	0.137	NA	1.000	-0.155	NA	1.000
Standard error	0.948	0.127	1.000	1.143	0.107	1.000	1.133	0.106	1.000
SE x No endog. control	-0.550	0.175	0.991	-1.066	0.116	1.000	-1.055	0.116	1.000
Water demand specification									
Household size	-0.001	0.010	0.024	-0.069	0.068	0.583	-0.072	0.070	0.585
Population density	0.000	0.010	0.016	-0.007	0.034	0.075	-0.009	0.039	0.080
Temperature	0.115	0.077	0.778	0.074	0.069	0.616	0.068	0.069	0.573
Rainfall	0.010	0.035	0.104	-0.006	0.029	0.077	-0.007	0.031	0.071
Evaporation	0.023	0.071	0.125	0.002	0.026	0.049	0.000	0.023	0.038
Difference variable	0.096	0.095	0.578	0.268	0.058	1.000	0.270	0.056	1.000
Lagged variable	0.055	0.095	0.300	0.001	0.011	0.025	0.000	0.010	0.019
Discrete-continuous	0.004	0.033	0.030	-0.007	0.033	0.068	-0.007	0.033	0.062
Price specification									
Marginal price	0.003	0.018	0.042	0.000	0.008	0.025	0.000	0.007	0.017
Other price	0.136	0.094	0.761	0.184	0.076	0.934	0.179	0.077	0.924
Data characteristics									
Long-run elasticity	-0.005	0.023	0.061	-0.020	0.046	0.206	-0.013	0.038	0.137
Household data	0.024	0.056	0.186	-0.001	0.010	0.033	0.000	0.009	0.024
Daily data	-0.121	0.124	0.568	-0.029	0.061	0.238	-0.031	0.063	0.242
Monthly data	0.004	0.021	0.050	0.004	0.019	0.062	0.002	0.014	0.039
Annual data	0.004	0.026	0.048	0.004	0.021	0.059	0.002	0.015	0.035
Cross-section	-0.001	0.009	0.022	-0.013	0.036	0.149	-0.016	0.041	0.172
Time series	-0.003	0.028	0.026	-0.261	0.130	0.886	-0.255	0.133	0.873
Estimation technique									
No endog. control	0.022	0.046	0.229	0.179	0.048	0.996	0.179	0.047	0.998
Panel technique	0.000	0.009	0.017	0.003	0.018	0.050	0.003	0.017	0.043
Other estimator	-0.008	0.036	0.067	-0.008	0.034	0.083	-0.008	0.033	0.078
Tariff structure									
Flat tariff	-0.003	0.021	0.028	0.001	0.015	0.028	0.001	0.013	0.020
Increasing tariff	-0.071	0.077	0.531	-0.033	0.054	0.325	-0.024	0.049	0.236
Decreasing tariff	-0.128	0.176	0.407	0.000	0.016	0.024	0.000	0.014	0.017
Countries examined									
Europe	-0.004	0.023	0.047	-0.001	0.013	0.030	0.000	0.010	0.022
Other location	-0.074	0.089	0.480	-0.023	0.048	0.236	-0.011	0.035	0.118
Developed countries	0.004	0.040	0.070	0.010	0.033	0.120	0.001	0.035	0.074
Publication characteristics									
Publication year	0.000	0.001	0.024	0.000	0.001	0.067	0.000	0.001	0.045
Citations	0.006	0.006	0.553	0.012	0.006	0.902	0.011	0.006	0.850
Impact factor	-0.233	0.189	0.687	-0.144	0.178	0.464	-0.166	0.188	0.509
Published	-0.122	0.086	0.759	-0.092	0.093	0.572	-0.098	0.093	0.606
Robustness variables									
Non-constant				0.098	0.099	0.566	0.084	0.097	0.493
Preferred estimate	-0.001	0.010	0.025				0.000	0.007	0.018
Survey data	0.017	0.044	0.164				0.001	0.012	0.028
Regional rainfall	0.025	0.033	0.420				0.008	0.019	0.188
Regional temperature	0.006	0.023	0.093				0.003	0.016	0.068
Regional income	0.011	0.024	0.197				0.026	0.033	0.474
Studies	62			72			72		
Observations	307			355			355		

Notes: SD = standard deviation. PIP = posterior inclusion probability. Heterogeneity = the benchmark model with additional explanatory variables capturing if the author prefers the estimate, if the *survey* respondents reported the income themselves, the climate of the researched region, and GDP per capita. Non-constant = the benchmark model estimated on the enlarged data-sample including elasticities recalculated from other than log-linear functional form. All models are estimated using Bayesian model averaging employing priors suggested by Eicher, Papageorgiou, and Raftery (2011).

FIGURE A3
Model size and convergence, BMA with priors according to Eicher, Papageorgiou, and Raftery (2011)

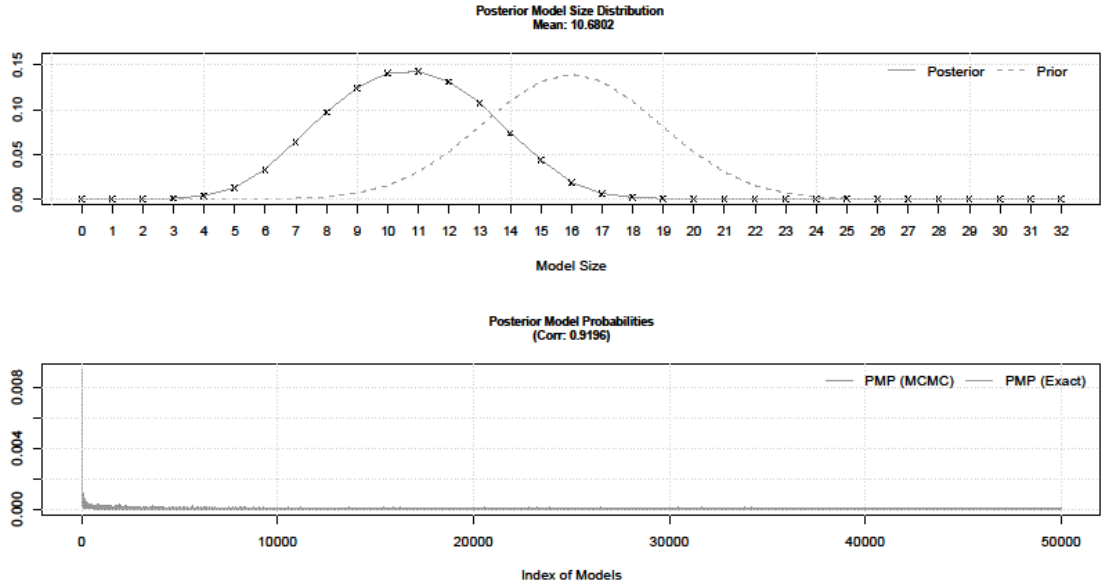

TABLE A6
Summary of BMA estimation: UIP

Mean no. regressors	*Draws*	*Burn-ins*	*Time*	*No. models visited*
12.801	$3 \cdot 10^5$	$1 \cdot 10^5$	2.887989 mins	89,381
Modelspace	*Visited*	*Topmodels*	*Corr PMP*	*No. obs.*
4.30E+09	21.00%	100%	0.9714	307
Model prior	*g-prior*	*Shrinkage-stats*		
Uniform /16	UIP	Av = 0.9968		

Notes: We employ the priors suggested by Eicher, Papageorgiou, and Raftery (2011), who recommend using the uniform model prior (each model has the same prior probability) and the unit information prior (the prior provides the same amount of information as one observation from the data).