FULL RESEARCH ARTICLES

Modelling technical efficiency of horticulture farming in Kosovo: An application of data envelopment analysis

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Appendices

To complete bootstrapping for DEA approach output orientation we used the algorithm of Simar and Wilson (1998) described in following six steps.

For each (x_k, y_k) k = 1,….n compute by the linear program

- Using smoothing bootstrap of §4, generates a random sample of size *n* from θ_i, *i* = 1,…, *n* providing θ^*_{1b},…, θ^*_{nb}.
- Computing X^*_b= { $(x^*_{ib}$, $y_i)$ *i*=1,…,*n)* where $x^*_{ib} = (\frac{\theta_i}{\theta^*_{1b}})x_i$,*i* = 1,…, *n*.
- Computing bootstrap estimate $\theta^*_{k,b}$ of θ_k for *k* = 1,…, *n* by solving
- $\theta^*_{k,b}$ = min $\{\theta \backslash y_k \leq \sum_{k=1}^{n} y_i y_i \, , \theta x_k \geq \sum_{k=1}^{n} y_i x^*_{kb} \, ; \, \theta > 0 \, ; \sum_{k=1}^{n} y_i = 1 \, ; \, y_i \geq 0, i = 1, \ldots, n \}$.

Repeating steps 2-4 B (=2000 times) to provide for *k* = 1,…, *n*a set pf estimates$\{\theta^*_{k,b}$, *b* = 1,…,*B*}

Table 2. Descriptive Statistics

Year/ 2015/ nr. of farms 139	mean	sd	min	max
Labour (AWU)	2.32	2.32	0.14	21.67
Utilized agricultural land (ha)	6.46	7.18	0.03	42
Average farm capital (€)	26,187	39,500	0	272,929
Intermediate consumption (€)	7,622	10,173	60	69,613
Output (€)	29,319	50,795	400	550,000
Year /2016/ nr. of farms 150				
Labour (AWU)	2.21	2.28	0.14	21.67
Utilized Agricultural land (ha)	6.94	11.44	0.03	122
Average farm capital (€)	28,425	42,593	0	280,429
intermediate consumption (€)	8,515	16,984	60	179,862
Output (€)	28,404	49,570	570	540,000
Year/ 2017 / nr. of farms 162				
Labour (AWU)	2.74	2.54	0.14	21.67
Utilized agricultural land (ha)	8.51	17	0.23	164
Average farm capital (€)	26,849	36,971	0	237,226
Intermediate consumption (€)	11,234	31,820	235	381,230
Output (€)	29,678	50,068	1,135	551,550
Year/ 2018/ nr. of farms 143				
Labour input (AWU)	2.55	2.02	0.25	18.66
Utilized Agriculture Area (ha)	5.83	7.73	0.1	69
Average farm capital (€)	25,226	66,131	0	742,871
Intermediate consumption (€)	9,203	15,236	47	97,300
Output (€)	26,516	46,716	205	405,000

Year/2019/ nr. of farms 185				
Labour (AWU)	3.14	2.26	0.56	17.5
Utilized Agriculture Area (ha)	5.71	7.86	0.2	90
Average farm capital (€)	21,969	60,508	0	753,613
Intermediate consumption (€)	8,531	11,289	235	101,321
Output (€)	25,550	32,731	600	252,635

Source: Author's composition based FADN database

Table 3. Basic statistics for the data used: Indoor (horticulture)

year/ 2015/ nr. of farms 18	mean	sd	min	max
Total labour input (AWU)	4.1	5.52	0.31	21.67
Total Utilized Agriculture Area (ha)	2.1	1.42	0.03	4.4
Average farm capital €	45,395	50,357	0	171,250
Total intermediate consumption €	10,690	19,024	480	69,613
Total output €	67,765	129,240	400	550,000
year /2016/ nr. of farms 20				
Total labour input (AWU)	3.8	5.33	0.19	21.67
Total Utilized Agriculture Area (ha)	2.3	1.67	0.03	6.6
Average farm capital €	44,905	50,414	0	166,250
Total intermediate consumption €	10,699	19,528	480	69,613
Total output €	58,093	120,151	570	540,000

year/ 2017 / nr. of farms 18				
Total labour input (AWU)	4.9	5.38	0.39	21.67
Total Utilized Agriculture Area (ha)	3.4	2.09	0.4	8.2
Average farm capital €	46,014	56,192	600	230,220
Total intermediate consumption €	33,097	88,186	880	381,230
Total output €	75,799	130,072	3,198	551,550
year/ 2018/ nr. of farms 19				
Total labour input (AWU)	2.6	1.92	0.31	7.83
Total Utilized Agriculture Area (ha)	2.4	1.71	0.1	7
Average farm capital €	27,689	47,285	321	210,974
Total intermediate consumption €	3,323	3,960	47	17,364
Total output €	32,264	90,892	205	405,000
year/2019/ nr. of farms 21				
Total labour input (AWU)	3.5	2.1	0.9	9.5
Total Utilized Agriculture Area (ha)	2.5	2.4	0.3	11.1
Average farm capital €	34,247	59,893	3,017	269,622
Total intermediate consumption €	4,056	4,325	282	17,852
Total output €	35,421	60,503	600	252,635

Source: Author's composition

Table 4. Basic statistics for the data used: Vegetable open field

year/ 2015/ nr. Of farms 121	mean	sd	min	max
Total labour input (AWU) (SE010)	2.05	1.15	0.14	6.67
Total Utilized Agriculture Area (ha) (SE025)	7.11	7.46	0.6	42
Average farm capital € (SE510)	23,330	37,034	0	272,929
Total intermediate consumption € (SE275)	7,166	8,131	60	59,196
Total output € (SE131)	23,600	18,608	1,300	87,300
year /2016/ nr. Of farms 130				
Total labour input (AWU) (SE010)	1.96	1.17	0.14	6.67
Total Utilized Agriculture Area (ha) (SE025)	7.64	12.12	0.6	122
Average farm capital € (SE510)	25,889	40,897	0	280,429
Total intermediate consumption € (SE275)	8,179	16,618	60	179,862
Total output € (SE131)	23,836	23,541	1,990	186,500
year/ 2017 / nr. of farms 144				
Total labour input (AWU) (SE010)	2.48	1.79	0.14	8
Total Utilized Agriculture Area (ha) (SE025)	9.14	17.93	0.23	164
Average farm capital € (SE510)	24,454	33,340	0	237,226
Total intermediate consumption € (SE275)	8,501	12,157	235	106,266
Total output € (SE131)	23,913	22,579	1,135	120,880
year/ 2018/ nr. Of farms 124				
Total labour input (AWU) (SE010)	2.54	2.04	0.25	18.66
Total Utilized Agriculture Area (ha) (SE025)	6.38	8.16	0.2	69
Average farm capital € (SE510)	24,848	68,706	0	742,871

Total intermediate consumption € (SE275)	10,104	16,110	300	97,300
Total output € (SE131)	25,635	36,120	1,000	267,500
year/2019/ nr. Of farms 164				
Total labour input (AWU) (SE010)	3.1	2.28	0.56	17.5
Total Utilized Agriculture Area (ha) (SE025)	6.11	8.22	0.2	90
Average farm capital € (SE510)	20,397	60,588	0	753,613
Total intermediate consumption € (SE275)	9,104	11,775	235	101,321
Total output € (SE131)	24,286	27,314	600	172,869

Source: Author's composition

Table 5. Efficiency score based on economic size of farm (2015-2019)

	2019				2018				2017				2016				2015			
Economic size	no of farm	VRS	CRS	SE	no of farm	VRS	CRS	SE	no of farm	VRS	CRS	SE	no of farm	VRS	CRS	SE	no of farm	VRS	CRS	SE
1(2,000 - < 4,000)	4	1.00	0.37	0.37	2	0.57	0.13	0.54	1	1.00	0.80	0.80	-	-	-	-	-	-	-	-
2 (4,000 - < 8,000)	8	0.61	0.40	0.66	7	0.24	0.18	0.34	6	0.68	0.59	0.90	4	0.35	0.28	0.84	1	0.38	0.25	0.66
3 (8,000 - <25,000)	32	0.48	0.40	0.83	24	0.39	0.36	0.95	30	0.41	0.40	0.96	30	0.39	0.35	0.92	28	0.38	0.36	0.94
4 (25,000 - <50,000)	37	0.29	0.28	0.97	36	0.36	0.33	0.97	36	0.42	0.41	0.95	31	0.26	0.24	0.92	28	0.23	0.22	0.92
5 (50,000 - < 100,000)	66	0.42	0.38	0.90	45	0.36	0.32	0.95	48	0.50	0.48	0.96	53	0.51	0.42	0.82	53	0.48	0.42	0.86
6 (100,000 - < 500,000)	38	0.57	0.48	0.84	29	0.34	0.31	0.92	41	0.58	0.52	0.90	32	0.50	0.37	0.72	29	0.49	0.40	0.79
Total	185				143				162				150				139			

Source: Author's composition

Table 6. Descriptive statistics of efficiency results

	Indoor (greenhouses)					Indoor & Outdoor					Outdoor – open field vegetables				
2015	Mean	SD	Min	max	no of farms	Mean	SD	Min	max	no of farms	Mean	SD	Min	max	no of farms
PTE(VRS)	0.59	0.39	0.07	1.00		0.41	0.28	0.03	1.00		0.52	0.28	0.11	1.00	
GTE(CRS)	0.55	0.38	0.03	1.00	18	0.36	0.27	0.02	1.00	139	0.36	0.24	0.10	1.00	121
SE	0.88	0.18	0.35	1.00		0.87	0.13	0.44	1.00		0.74	0.21	0.10	1.00	
2016															
PTE(VRS)	0.63	0.37	0.03	1.00		0.43	0.27	0.02	1.00		0.49	0.27	0.13	1.00	
GTE(CRS)	0.55	0.36	0.02	1.00	20	0.35	0.26	0.01	1.00	150	0.36	0.23	0.12	1.00	130
SE	0.86	0.22	0.26	1.00		0.84	0.16	0.20	1.00		0.77	0.21	0.28	1.00	
2017															
PTE(VRS)	0.72	0.33	0.11	1.00		0.50	0.25	0.09	1.00		0.56	0.26	0.13	1.00	
GTE(CRS)	0.67	0.34	0.11	1.00	18	0.46	0.25	0.09	1.00	162	0.51	0.24	0.12	1.00	144
SE	0.92	0.15	0.38	1.00		0.94	0.10	0.36	1.00		0.91	0.14	0.31	1.00	
2018															
PTE(VRS)	0.45	0.39	0.04	1.00		0.36	0.27	0.04	1.00		0.46	0.28	0.13	1.00	
GTE(CRS)	0.39	0.37	0.04	1.00	19	0.32	0.24	0.03	1.00	143	0.39	0.24	0.10	1.00	124
SE	0.90	0.18	0.23	1.00		0.94	0.16	0.13	1.00		0.87	0.19	0.21	1.00	
2019															
PTE(VRS)	0.71	0.34	0.01	1.00		0.46	0.28	0.01	1.00		0.48	0.28	0.14	1.00	
GTE(CRS)	0.52	0.31	0.01	1.00	21	0.39	0.24	0.01	1.00	185	0.42	0.24	0.12	1.00	164
SE	0.77	0.24	0.16	1.00		0.88	0.17	0.06	1.00		0.89	0.16	0.17	1.00	

Source: Author's composition

Table 7. Summary of exogenous variables

Variable	Description
Age	Years of the holder
Agricultural training of the manager/holder	8 = only practical agricultural experience 9 = basic agricultural training 10 = full agricultural training (specialized)
Gender	Gender: 1= female, 2= male
Irrigation system	Codes describing the main irrigation system used on the farm: 35= not applicable (when no irrigation on the farm) 36 = surface 37 = sprinkler 38 = drip 39 = other
Altitude	31 = below 300 meters 32 = from 300 to 600 33 = above 600 m; 34 = data not available
Area constrains	27 = In the normal zone/area 28 = less favoured area, not mountainous 29 = less favoured area mountainous 30 = No land
Output P	Production expressed in physical units

CULC/LAND	Cultivation costs per hectare of land
CAP/LAND	Capital per hectare of land
OUTPUT/LAND (€)	Output per hectare of land expressed in monetary units
OUTPUT/LAB (€)	Output, in monetary units, per labour unit
Total subsidies on crops	Total subsidies on crops The share of total subsidies crops in the total output (%)
Rented U.A.A. (ha)	U.A.A rented by the holder under a tenancy agreement for a period of at least one year (remuneration in cash or in kind); in hectares. / The share of rented area, into Total U.A.A (%)
Paid Labour to AWU	Share of hired labour to Total labour (%)
Total OGA output to TO	Total output coming from other gainful activities (OGA) directly related to the holding such as processing of farm products both, animal's and crop's, receipts from contract work, agritourist, production of renewable energy, forestry and other OGA The share of total OGA in total Output (%)
Machinery and equipment (€)	Tractors, motor cultivators, lorries, vans, cars, major and minor farming equipment. (€)

Source: Author's composition

Table 8. Determinants of inefficiency

Determinant	VRS	CRS	SE
Age	-0.00002	-0.00004	-0.00031
	(-0.03)	(-0.08)	(-0.68)
education (full agri)	0.02810	0.09390	0.10100***
	(0.44)	(1.24)	(3.37)
Education x large farmsize	-0.65048*	-0.70100*	-0.17500**
	(-2.23)	(-2.58)	(-2.59)
open field	-0.00561	0.00114	0.00083
	(-0.14)	(0.03)	(0.03)
form of irrigation (drip)	0.04190*	0.03830*	-0.00253
	(2.04)	(2.01)	(-0.20)
altitude - below 300	-0.07110	0.00363	0.11400***
	(-1.46)	(0.08)	(4.07)
altitude - fr300to600	-0.08720*	-0.02760	0.09510***
	(-2.50)	(-0.86)	(4.60)
altitude - above600m	-0.05680	0.0108	0.10800***
	(-1.45)	(0.31)	(5.89)
area constrains normalzone	-0.06140*	-0.0610*	-0.00402
	(-2.29)	(-2.40)	(-0.26)
dukagjini plain	-0.05650	-0.17400	-0.11400**
	(-0.65)	(-1.74)	(-2.60)
kosovo plain x male	-0.05600	-0.18400	-0.14200**
	(-0.55)	(-1.84)	(-3.23)
large farm	-0.07560	-0.04940	-0.01140

	(-0.83)	(-57)	(-0.26)
male x large farm	-0.03530	0.04740	0.07640
	(-0.43)	(0.59)	(1.65)
male x medium farm	-0.10800*	0.02040	0.14400***
	(-2.2.6)	(0.55)	(3.50)
Output P kg	0.00000***	0.00000***	-0.00000
	(4.47)	(3.71)	(-1.96)
Culc/land	-0.00000	-0.00000	-0.00000
	(-0.43)	(-0.46)	(-0.02)
cap/land	-0.00000	-0.00000	-0.00000
	(-1.76)	(-1.82)	(-0.90)
output/land	0.00000***	0.00000***	0.00000
	(4.09)	(4.51)	(1.90)
output/awu	0.00000***	0.00000***	0.00000
	(5.83)	(6.05)	(1.47)
Subsidies/TO	-0.38300***	-0.38500***	-0.10100
	(-3.54)	(-3.36)	(-1.23)
Rented/UAA	-0.03160	-0.01460	0.021800
	(-1.27)	(-0.66)	(1.49)
Paid labour/AWU	0.06980	0.08220*	0.01210
	(1.63)	(2.23)	(0.37)
OGA/TO	-0.26500*	-0.28600**	-0.11800
	(-2.38)	(-3.19)	(-1.65)
OGA x large farm	0.20000	0.30900**	0.24600**
	(1.52)	(2.74)	(2.92)

Machinery(equipment)	-0.00000	-0.00000***	-0.00000***
	(-1.38)	(-3.79)	(-6.52)
2015.years	0	0	0
	(.)	(.)	(.)
2016.years	0.06020*	0.03610	-0.02280
	(2.05)	(1.35)	(-1.77)
2017.years	0.11500***	0.13400***	0.07280***
	(4.98)	(6.12)	(5.86)
2018.years	-0.03990	-0.03220	0.05710**
	(-1.25)	(-1.10)	(2.96)
2019.years	0.09070*	0.06310*	0.03520
	(2.55)	(1.99)	(0.14)
_cons	0.57100***	0.47600***	0.81500***
	(4.67)	(4.01)	(19.04)
N	779	779	779

t statistics in parentheses * p<0.05, ** p<0.01, *** p<0.001 / Source: Author's composition

Figure 1. Box plot for differences between bias corrected score and efficiency score

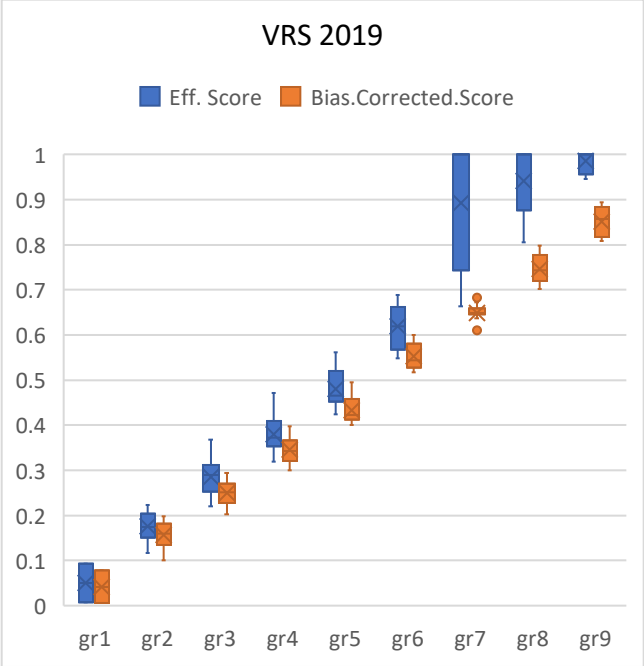

Figure 2. Box plot for differences between bias corrected score and efficiency score

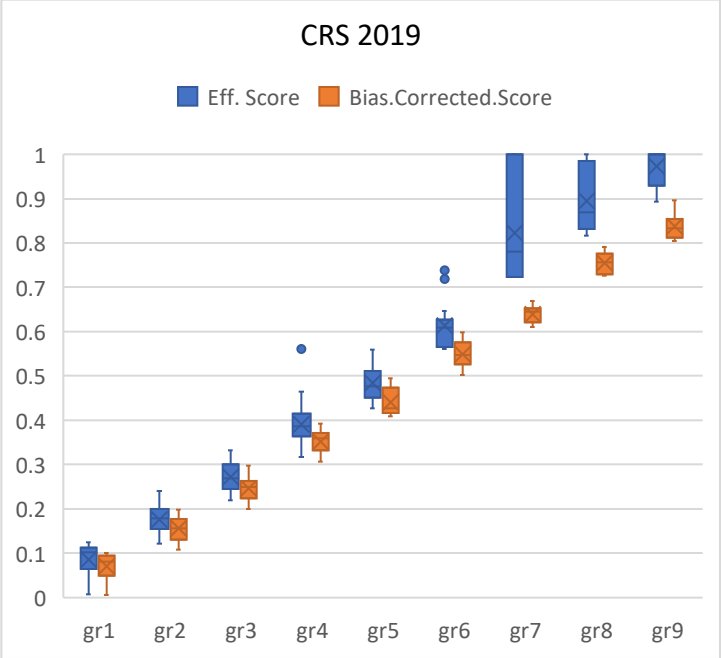

Figure 3. Box plot for differences between bias corrected score and efficiency score

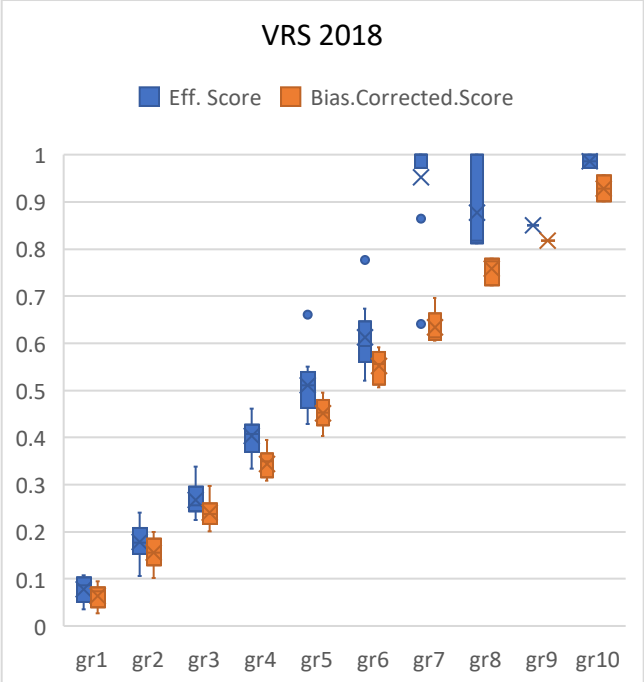

Figure 4. Box plot for differences between bias corrected score and efficiency score

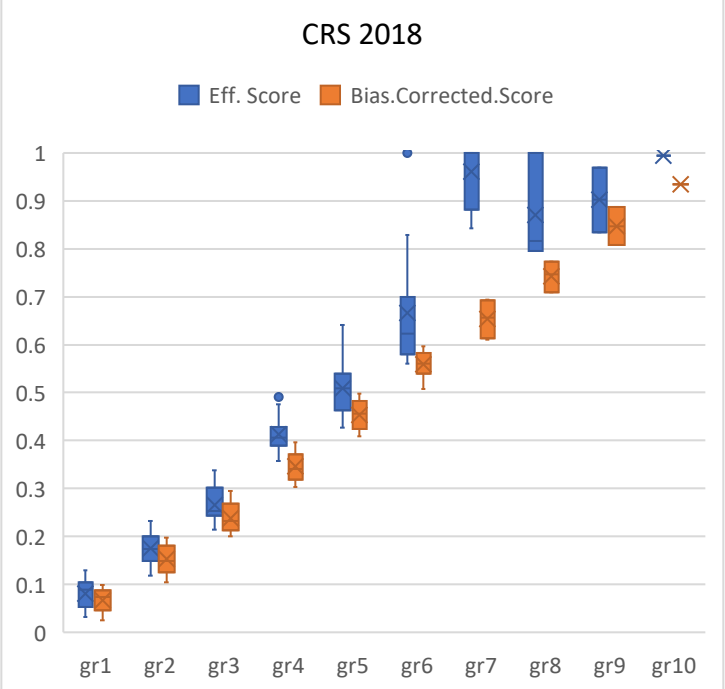

Figure 5. Box plot for differences between bias corrected score and efficiency score

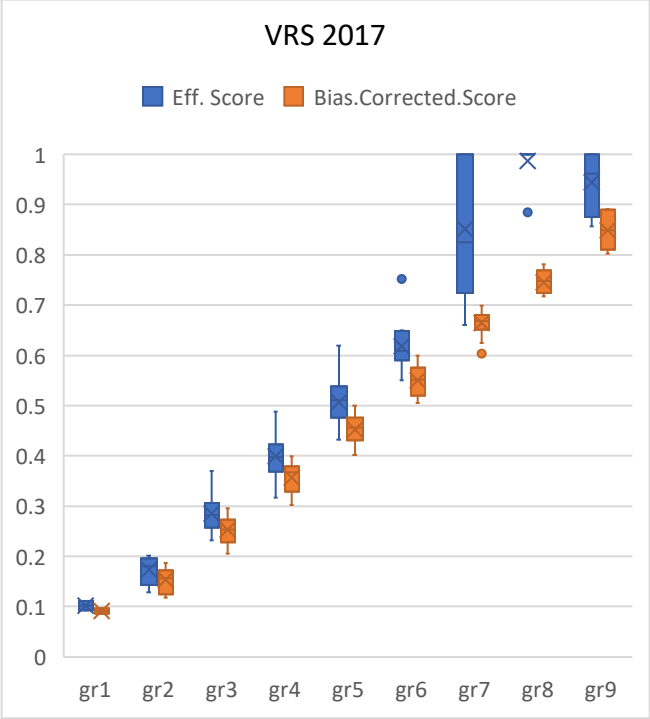

Figure 6. Box plot for differences between bias corrected score and efficiency score

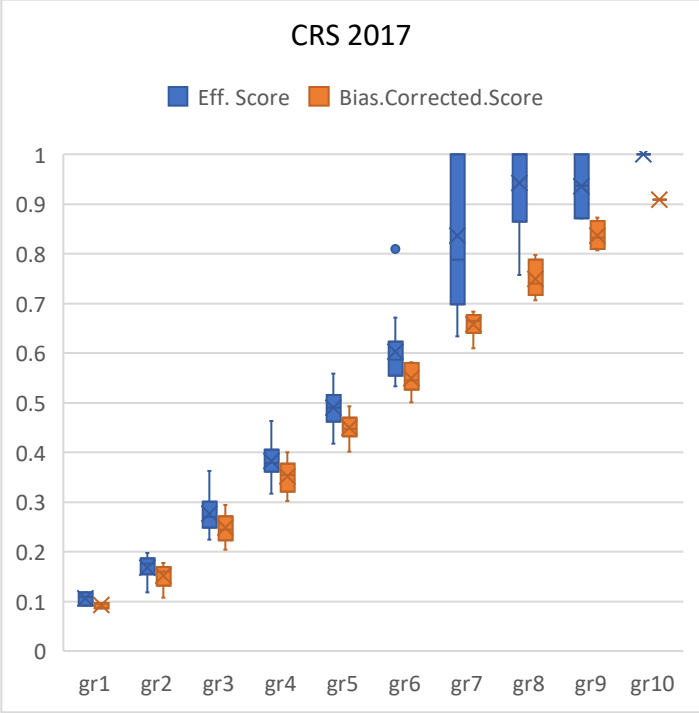

Figure 7. Box plot for differences between bias corrected score and efficiency score

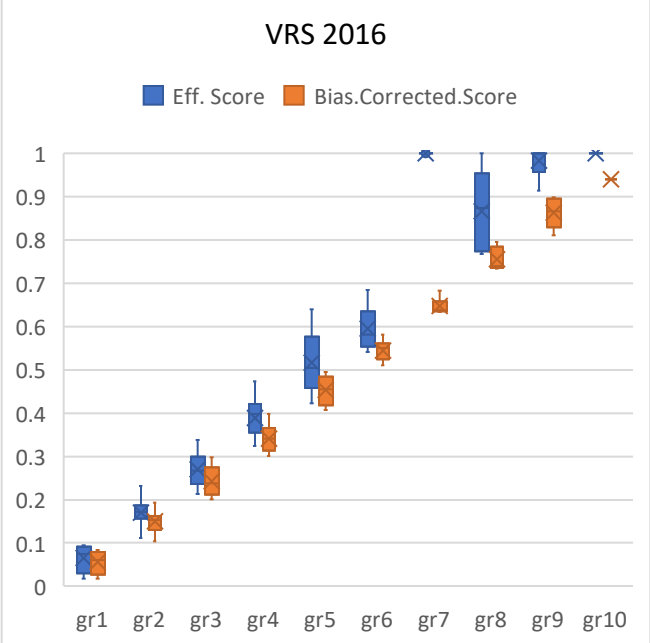

Figure 8. Box plot for differences between bias corrected score and efficiency score

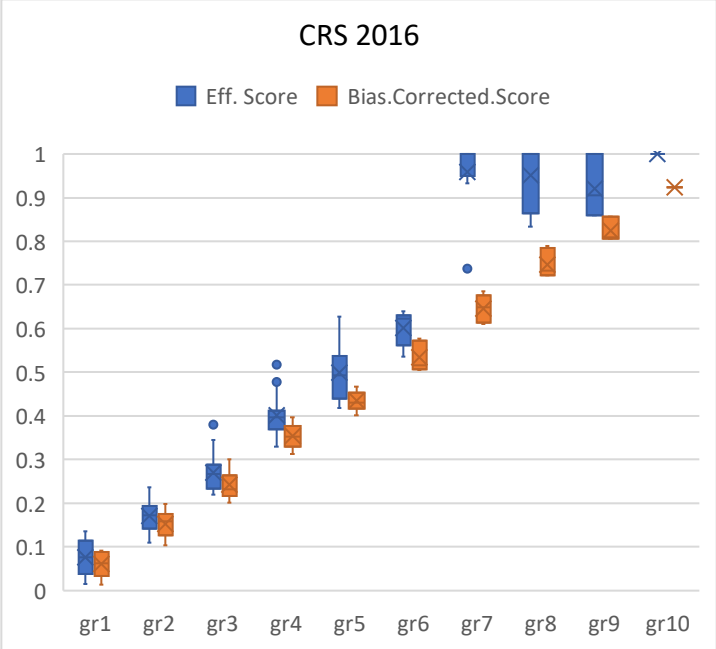

Figure 9. Box plot for differences between bias corrected score and efficiency score

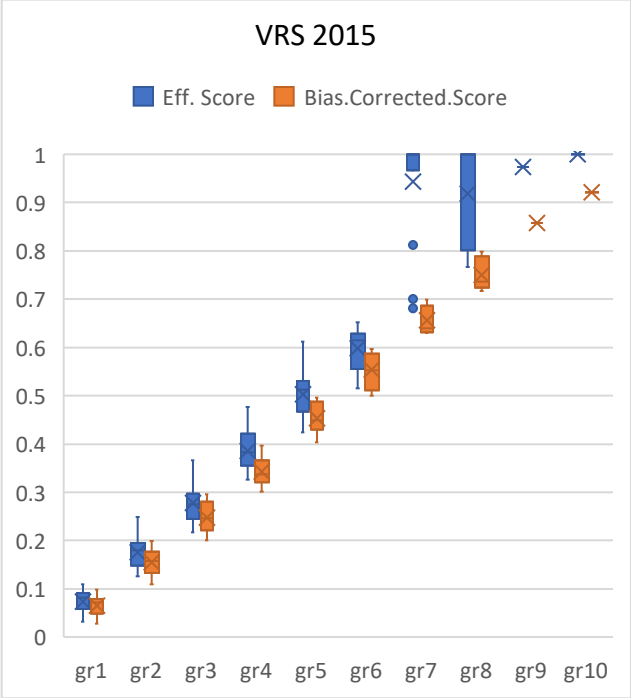

Figure 10. Box plot for differences between bias corrected score and efficiency score