FARM ACCOUNTANCY DATA NETWORK AS A TOOL FOR MEASURING EFFICIENCY OF APPLIED NEW TECHNOLOGIES IN AGRICULTURE

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Abstract

The aim of the paper is to determine potential use of Farm Accountancy Data Network (FADN) as a tool for measuring efficiency of new technologies in agribusiness sector in EU and Serbia.

The paper provides a broader context for understanding the concept of new technologies as a Precision Agriculture and Smart Agriculture. Effective system for measuring results of applied new technologies in agriculture is analyzed in this paper both at the level of individual farms and agrarian policy.

FADN is the accountancy system uniform for all EU countries. As the FADN has same methodology in collecting and processing data for all EU countries, results are comparable for all EU countries and candidate countries. Serbia has started with FADN introduction in 2011 and an efficient system has been established so far.

Results of the paper are showing that FADN can be excellent tool for measuring effects of the new technologies' application. The FADN data as e.g. the used working unit (AWU), fixed capital, variable expense, yields per hectare, profit margin can be used as indicators for effectiveness of the new applied technologies. In this paper there are suggested some new indicators which could be included within the FADN.

Keywords: *Precision Agriculture, Smart Agriculture, FADN, Efficiency of new technologies.*

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Introduction

The Food and Agriculture Organization (FAO) estimates that there will be 9 billion people in the world by 2050. It will be needed 70% increase in food production compared to 2005 level to feed the aforementioned people. Thus we have to grow, harvest, distribute and consume our food more efficiently. Considering the fact that we are not gaining additional resources such as land or water, the only solution lies in introducing new technologies in agriculture (FAO, 2002).

One of the new technologies in agriculture the international scene has paid great attention to is the Precision Agriculture. Applications of precision agriculture include auto-guiding systems and variable-rate technology that allow for precise tillage, seeding, fertilization, irrigation, herbicide and pesticide application, harvesting and animal husbandry. Crop management and aspects of animal rearing are optimized thanks to the use of information collected from sensors mounted on-board agricultural machinery (soil properties, leaf area, animal internal temperature) or derived from high resolution remotely sensed data (plant physiological status). The benefits to be obtained include increased yields and profitability (mainly for arable farmers), increased animal welfare, and improvement of various aspects of environmental management (EU Directorate general for internal policies, 2014).

It is important for all countries to monitor the situation in the field of application of modern technologies in agriculture with aim that subsidies in new technologies be conceived to deliver optimal effects. Measuring of new technologies efficiency beside importance for the agrarian policy is important for farmers in order to measure efficiency of new technologies implemented at the farm level (Vasiljevic et al., 2012).

FADN is an important instrument in measuring the efficacy of new technology in agriculture in the EU and candidate countries with established FADN (Vasiljević, 2012).

The Farm Accountancy Data Network (FADN) is an instrument for evaluating the income of agricultural holdings and the impacts of the Common Agricultural Policy and national agricultural policies. The concept of the FADN was launched in 1965 when Council Regulation 79/65 established the legal basis for the organization of the network. It consists of an annual survey carried out by the Member States of the European Union. The services responsible in the Union for the operation of the FADN collect every year accountancy data from a sample of the agricultural holdings in the European

Union. Derived from national surveys, the FADN is the only source of microeconomic data that is harmonized, i.e. the bookkeeping principles are the same in all countries. Holdings are selected to take part in the survey on the basis of sampling plans established at the level of each region in the Union. The survey does not cover all the agricultural holdings in the Union but only those which due to their size are considered commercial. The applied methodology aims to provide representative data along three dimensions: region, economic size and type of farming. While the European Commission is the primary user of analyses based on FADN data, the aggregated data can be found in the Standard Results database (Regulation (EC) No 1166/2008).

The aim of the network is to gather accountancy data from farms for the determination of incomes and business analysis of agricultural holdings. Currently, the annual sample covers approximately 80,000 holdings. They represent a population of about 5,000,000 farms in the EU, which covers approximately 90% of the total utilized agricultural area (UAA) and account for about 90% of the total agricultural production. The information collected, for each sample farm, concerns approximately 1,000 variables.

It is important to note that the collecting and processing methodology is the same for all EU countries thus the FADN data are comparable between them.

FADN data can be used for monitoring of the situation in the fields of modern technologies in agriculture, as well as the effects of agricultural policy at the macro level. The farmers included in the FADN sample can use FADN Feedback form to monitor the effects of the applied new technologies on the farm.

FADN as a tool for measuring efficiency of applied new technologies in agriculture – macro level

At the macro level, the FADN allows EU member states to compare results of applied new technologies in agriculture. At the national level it measures the efficiency of agricultural policy (primarily subsidies) in the field of new technologies in agricultural production.

In this part of the paper there are presented indicators that have been already available within the FADN, as well as indicators that can be calculated from existing data.

Table 1: ***Labor data as indicators of new technologies efficiency - FADN 2013***

Country	Labor input (SE011*)	Total Utilized Ag. Area (SE025)	Labor input in hours/ha	L (Labor input/avg labor input)	$K_{\text{Labor input}}$
Belgium	4962.52	49.3	100.66	0.65	34.99%
Bulgaria	4575.53	35.22	129.91	0.84	16.10%
Cyprus	2935.91	9.12	321.92	2.08	-107.90%
Czech Republic	13597.69	232.93	58.38	0.38	62.30%
Denmark	3399.23	96.84	35.10	0.23	77.33%
Germany	4942.63	86.63	57.05	0.37	63.15%
Greece	2539.51	9.31	272.77	1.76	-76.16%
Spain	2615.21	39.31	66.53	0.43	57.03%
Estonia	4393.76	128.27	34.25	0.22	77.88%
France	3300.64	85.87	38.44	0.25	75.18%
Croatia	3354.27	14.59	229.90	1.48	-48.48%
Hungary	3426.51	45.02	76.11	0.49	50.85%
Ireland	2576.97	51.36	50.17	0.32	67.60%
Italy	2685.14	15.55	172.68	1.12	-11.52%
Lithuania	3945.71	50.31	78.43	0.51	49.35%
Luxembourg	3899.02	78.5	49.67	0.32	67.92%
Latvia	4037.04	69.16	58.37	0.38	62.30%
Malta	3135.4	2.57	1,220.00	7.88	-687.91%
Netherlands	5842.43	34.61	168.81	1.09	-9.02%
Austria	3264.55	32.39	100.79	0.65	34.91%
Poland	3831.58	19.11	200.50	1.29	-29.49%
Portugal	3022.15	25.53	118.38	0.76	23.55%
Romania	3097.14	9.9	312.84	2.02	-102.04%
Finland	2595.9	55.53	46.75	0.30	69.81%
Sweden	3049.2	102.45	29.76	0.19	80.78%
Slovakia	27758.5	594.82	46.67	0.30	69.86%
Slovenia	2611.27	11.38	229.46	1.48	-48.19%
United Kingdom	5180.02	166.15	31.18	0.20	79.87%

Source: *FADN, Labor input in hours/ha, L (Labor input/avg labor input) and* $K_{\textit{Labor input}}$ *author's calculation based on FADN data.*

*Additional information on SE data can be found on FADN web page: http://ec.europa.eu/agriculture/rica/concept_en.cfm.

Information related to labor can be used as an indicator for new technologies application with assumption that new technologies will have lower labor input[4].

First it is calculated Labor input in hours/ha, than for each country average labor input compared to EU. $K_{Labor\ input}$ is calculated as:

$K_{Labor\ input}$ = (1- Labor input/avg labor input)*100%

According to the table 1 more efficient technologies and lower labor hours/ha has Denmark with only 29.76 hours/ha, Labor input/avg labor input 0.19 (almost five times lower use of labor hours/ha compared to EU average) and $K_{Labor\ input}$ 80.78%. Malta has most hours/ha and more extensive production with 1,220 labor hours/ha.

Table 2: ***Production data as indicators of new technologies efficiency - FADN 2013***

Country	Yield of wheat (SE110)	D_{wheat}	Yield of maize (SE115)	D_{corn}	Milk yield (SE125)	D_{milk}
Belgium	90.38	71.14%	128.21	55.58%	6998.21	7.74%
Bulgaria	42.75	-19.05%	68.86	-16.44%	3160.46	-51.34%
Cyprus	3.97	-92.48%	67.7	-17.85%	7481.36	15.18%
Czech Republic	57.62	9.11%	72.21	-12.38%	7348.07	13.13%
Denmark	72.59	37.46%	79.52	-3.51%	8858.33	36.38%
Germany	78.25	48.17%	81.25	-1.41%	7696.43	18.49%
Greece	31.13	-41.05%	123.88	50.32%	6043.39	-6.96%
Spain	33.92	-35.77%	116.08	40.86%	7073.13	8.89%
Estonia	35.66	-32.47%	/	/	7961.83	22.58%
France	73.45	39.08%	81.15	-1.53%	6890.09	6.08%
Croatia	48.05	-9.01%	69.34	-15.86%	4051.33	-37.63%
Hungary	47.49	-10.07%	57.43	-30.31%	6496.71	0.02%
Ireland	85.65	62.19%	/	/	5362.06	-17.45%
Italy	54.53	3.26%	97.08	17.80%	5797.92	-10.74%
Lithuania	47.02	-10.96%	/	/	5561.06	-14.39%
Luxembourg	63.64	20.51%	58.81	-28.64%	7025.11	8.15%
Latvia	38.89	-26.36%	/		5713.18	-12.04%
Malta	/	/	/		6516.82	0.33%
Netherlands	88.11	66.84%	117.76	42.90%	7901.28	21.64%

[4] Information on labor hours/ha and K coefficient should be analyzed with data from the table 3 output/ha.

Austria	51.35	-2.76%	93.65	13.64%	6493.81	-0.03%
Poland	52.74	-0.13%	79.78	-3.19%	5107.38	-21.37%
Portugal	20.86	-60.50%	77.2	-6.32%	7044.79	8.46%
Romania	39.14	-25.89%	51.39	-37.64%	3357.34	-48.31%
Finland	40.35	-23.59%	/	/	8665.06	33.40%
Sweden	57.87	9.58%	65.01	-21.11%	8560.02	31.78%
Slovakia	46.4	-12.14%	54.49	-33.88%	6260.45	-3.62%
Slovenia	47.19	-10.64%	73.01	-11.41%	5122.35	-21.14%
U. Kingdom	76.99	45.79%	99.3	20.50%	7324.62	12.77%
EU Average	52.81		82.41		6495.45	

Source: *FADN, D_{wheat}, D_{corn}, D_{milk}, author's calculation based on FADN data*.

Assumption is that new technologies will lead to higher yield[5]. D_{wheat}, D_{corn}, D_{milk} are calculated:

D_{yield} = (Country yield/EU average yield-1)*100%

According to the table 2 the highest efficiency in applied technologies has Belgium for wheat and corn, while Denmark has the highest D coefficient for milk - 36.38%, and best technologies in milk production. Bulgaria and Romania are countries with the lowest D coefficients and the lowest technologies applied in agricultural production.

Table 3: ***Production output as an indicator of new technologies efficiency - FADN 2013***

Country	Total output (SE131)	Total output/ha	Total output / Total input (SE132)	Total crops output / ha (SE136)	Total livestock output / LU (SE207)
Belgium	265975	5395.03	1.15	2008.89	1175.98
Bulgaria	38872	1103.69	0.96	782.4	927.14
Cyprus	40769	4470.28	1.18	1713.24	1773.62
Czech Republic	344709	1479.88	0.89	830.5	1230.44
Denmark	484484	5002.93	1.06	1526.62	1678.69
Germany	266707	3078.69	1.06	1261.14	1530.15

[5] This indicator has to be followed with analysis on climate, soil fertility and water supply in compared countries.

Greece	21783	2339.74	1.27	1697.27	1022.16
Spain	52181	1327.42	1.3	874.74	866.66
Estonia	111296	867.66	0.9	460.57	1296.95
France	195887	2281.20	1.01	1247.46	1107.24
Croatia	23200	1590.13	1.06	913.53	904.23
Hungary	65507	1455.06	1.02	925.2	1157.25
Ireland	69754	1358.13	1.05	252.79	930.58
Italy	52951	3405.20	1.41	2450.03	1085.53
Lithuania	42555	845.85	1.08	499.75	1205.48
Luxembourg	192653	2454.17	0.93	572.94	1182.49
Latvia	56694	819.75	0.94	463.06	1047.94
Malta	39675	15437.74	1.25	6640.77	1627.18
Netherlands	490248	14164.92	1.12	5931.48	1768.38
Austria	75255	2323.40	1.1	642.31	1506.46
Poland	31390	1642.59	1.15	828.75	1127.12
Portugal	29499	1155.46	1.24	801.51	800.97
Romania	12967	1309.79	1.49	754.35	796.86
Finland	106543	1918.65	0.77	945.75	1740.2
Sweden	199885	1951.04	0.89	905.75	1302.46
Slovakia	609681	1024.98	0.78	621.55	865.1
Slovenia	25047	2200.96	0.9	1039.37	826.05
United Kingdom	257008	1546.84	1.02	685.09	1035.18

Source: *FADN, Total output/ha is author's calculation based on FADN data*.

It is assumed that efficient new technologies will lead to the high Total output/ha, Total crops output / ha, and Total livestock output / LU. According to the table 3 Malta and Netherlands have the highest level of applied new efficient technologies with 15,437.74 and 14,164.92 €/ha, while Netherlands and Denmark are leading countries in applied new technologies in livestock production.

Table 4: ***Production inputs as indicators of new technologies efficiency -FADN 2013***

Country	Total Utilized Agricultural Area (SE025)	Total Inputs (SE270)	Total inputs/ha
Belgium	49.3	231400	4693.71
Bulgaria	35.22	40647	1154.09
Cyprus	9.12	34576	3791.23

Czech Republic	232.93	387348	1662.94
Denmark	96.84	458104	4730.52
Germany	86.63	250848	2895.63
Greece	9.31	17171	1844.36
Spain	39.31	40213	1022.97
Estonia	128.27	123493	962.76
France	85.87	193424	2252.52
Croatia	14.59	21969	1505.76
Hungary	45.02	64056	1422.83
Ireland	51.36	66417	1293.17
Italy	15.55	37524	2413.12
Lithuania	50.31	39554	786.21
Luxembourg	78.5	206081	2625.24
Latvia	69.16	60233	870.92
Malta	2.57	31767	12360.70
Netherlands	34.61	436823	12621.29
Austria	32.39	68585	2117.47
Poland	19.11	27207	1423.70
Portugal	25.53	23860	934.59
Romania	9.9	8698	878.59
Finland	55.53	139104	2505.02
Sweden	102.45	223814	2184.62
Slovakia	594.82	780671	1312.45
Slovenia	11.38	27813	2444.02
United Kingdom	166.15	253070	1523.14

Source: *FADN.*

The highest output with higher level of technologies applied is followed by higher inputs.

Modern technologies are characterized by higher fixed costs and lover variable costs per production area.

According to the table 4, Malta and Netherlands have the highest implemented technologies with the highest inputs/ha, due to the large percentage of indoor production in these two countries.

Table 5: ***Farm value and income as indicators of new technologies efficiency - FADN 2013***

Country	Gross Farm Income (SE410)	Gross Farm Income/ha	Farm Net Value Added (SE415)	Farm Net Value Added (SE415)	Farm Net Income (SE420)	Farm Net Income/ha
Belgium	119795	2429.92	86559	1755.76	57678	1169.94
Bulgaria	24353	691.45	19483	553.18	8866	251.73
Cyprus	19462	2133.99	15876	1740.79	11248	1233.33
Czech R.	178006	764.20	138603	595.04	53979	231.74
Denmark	205377	2120.79	162003	1672.89	59011	609.37
Germany	127625	1473.22	95768	1105.48	49958	576.68
Greece	16413	1762.94	12811	1376.05	10487	1126.42
Spain	32019	814.53	28623	728.14	22059	561.15
Estonia	48373	377.12	32218	251.17	16716	130.32
France	95917	1117.00	62665	729.77	31580	367.77
Croatia	11436	783.82	7212	494.31	4702	322.28
Hungary	34911	775.46	28848	640.78	17083	379.45
Ireland	37256	725.39	28281	550.64	22172	431.70
Italy	33638	2163.22	26707	1717.49	20757	1334.86
Lithuania	24230	481.61	16404	326.06	14081	279.88
Luxembourg	120485	1534.84	65291	831.73	44908	572.08
Latvia	25630	370.59	16725	241.83	9861	142.58
Malta	15490	6027.24	12947	5037.74	11140	4334.63
Netherlands	199540	5765.39	147865	4272.32	66820	1930.66
Austria	47556	1468.23	30012	926.58	25402	784.25
Poland	16678	872.74	11951	625.38	9835	514.65
Portugal	19457	762.12	15765	617.51	13432	526.13
Romania	8564	865.05	7293	736.67	6133	619.49
Finland	55510	999.64	31387	565.23	17857	321.57
Sweden	79532	776.30	52615	513.57	16286	158.97
Slovakia	268247	450.97	176076	296.02	-8683	-14.60
Slovenia	13863	1218.19	5905	518.89	5711	501.85
United K.	116256	699.71	83846	504.64	46465	279.66

Source: *FADN, Gross Farm Income/ha ad Farm Net Income/ha is author's calculation based on FADN data*;

Farm value and income can be indicators of new technologies efficiency. As the new modern technologies are costly higher, the farm value will indicate higher level of applied technologies. Income indicators are important in measuring new technologies efficiency as it is expected that applied technologies will lead to the higher farm income. According to the Gross Farm Income/ha indicator, Malta and Netherlands have the highest level and efficiency of implemented new technologies with 6,027.24 and 5,765.39 €/ha.

Table 6: ***Assets as indicators of new technologies efficiency - FADN 2013***

Country	Total fixed ets (SE441)	Total fixed assets/ha	Machinery (SE455)	Worth of Machinery/ha
Belgium	631212	12803.49	75305	1527.48
Bulgaria	46593	1322.91	20265	575.38
Cyprus	144176	15808.77	16734	1834.87
Czech Republic	742030	3185.64	258559	1110.03
Denmark	2125149	21944.95	192081	1983.49
Germany	748454	8639.66	119312	1377.26
Greece	103258	11091.08	21978	2360.69
Spain	199955	5086.62	16116	409.97
Estonia	193372	1507.54	69636	542.89
France	260265	3030.92	84340	982.18
Croatia	141972	9730.77	19639	1346.06
Hungary	105732	2348.56	28650	636.38
Ireland	866954	16879.95	34403	669.84
Italy	281063	18074.79	24829	1596.72
Lithuania	78835	1566.98	36274	721.01
Luxembourg	976202	12435.69	212516	2707.21
Latvia	98350	1422.06	30757	444.72
Malta	180331	70167.70	25439	9898.44
Netherlands	1976903	57119.42	151498	4377.29
Austria	357816	11047.11	78046	2409.57
Poland	145669	7622.66	25372	1327.68
Portugal	81982	3211.20	14917	584.29
Romania	29546	2984.44	5555	561.11
Finland	358794	6461.26	70872	1276.28
Sweden	704736	6878.83	135415	1321.77
Slovakia	576034	968.42	136476	229.44
Slovenia	185353	16287.61	32132	2823.55
United Kingdom	1635705	9844.75	122426	736.84

Source: *FADN, Total fixed assets/ha and Worth of Machinery/ha is author's calculation based on FADN data.*

Data on average farm assets as indicators of new technologies efficiency are based on the fact that new technology is costly and higher value of asset is indicator of higher level of technologies applied. Higher worth of machinery is indicating higher level of technologies on farms. According

to the Worth of machinery, Malta has the highest level of applied technology and it is followed by Netherlands.

Table 7: ***Investments as indicators of new technologies efficiency - FADN2013***

Country	Net worth (SE501)	Change in net worth (SE506)	Gross Investment (SE516)	Net Investment (SE521)
Belgium	530896	39163	47048	13812
Bulgaria	61353	6116	9304	4434
Cyprus	170636	-12951	1199	-2387
Czech Republic	763875	56140	68257	28855
Denmark	1053465	19517	72751	29376
Germany	708037	13165	49729	17871
Greece	107616	-3084	581	-3021
Spain	254967	-905	2099	-1297
Estonia	179773	9000	37300	21145
France	266556	1065	30805	-2447
Croatia	150990	-597	1644	-2580
Hungary	143837	8395	7791	1729
Ireland	903112	28628	13432	4457
Italy	387049	21408	3030	-3902
Lithuania	103859	4573	12015	4188
Luxembourg	883727	25083	98160	42967
Latvia	103032	8622	18182	9277
Malta	187048	-763	1977	-566
Netherlands	1512948	72781	69777	18102
Austria	402305	1534	23615	6070
Poland	156299	1697	4073	-653
Portugal	104417	3551	5665	1972
Romania	38989	2426	697	-574
Finland	319519	7235	26498	2376
Sweden	597376	-44693	33952	7035
Slovakia	898147	-60500	106346	14174
Slovenia	195437	3112	8953	996
United Kingdom	1629095	91813	47303	14894
EU Average	272905	8147	9838	677

Source: *FADN.*

Investments as indicators of new technologies efficiency are based on the fact that for new technologies investments are needed. Higher investment is needed for the higher level of technologies.

For agrarian policy related to new technologies it is important to analyze gross investment, net investment, net worth, as well as changes related to these indicators.

FADN as a tool for measuring efficiency of applied new technologies in agriculture on farms

Farmers can use FADN in measuring efficiency of applied new technologies on farms. There are two possibilities.

First, farmers included in the FADN are receiving on the annual level FADN Feedback form.

Feedback form contains farmer's data compared with the average data for producers within the same line of production.

Second possibility for farmers not involved in the FADN is to use FADN public reports and compared with their own data.

Feedback form is not conditioned by the EU, thus each EU Member State decides on the Feedback forms.

Farmers not involved within the FADN can use FADN reports and FADN public database and compare their own data with FADN averages.

FADN indicators are giving to the farmers the answers to questions such as:

1. What are the effects of the application of new technologies on the farm?

2. Is there improvement in average operating result after applying the new technology?

3. Is the new technology improving the average operating results on farm compared to all the farmers involved in the same line of work in its own country and compared to other EU countries?

Table 8: ***An example of a Feedback form within the FADN system in Serbia***

		Farm data	Group average
General indicators			
	Total utilised agricultural area (UAA) - ha	70,00	91,00
	of which rented land - ha	50,00	65,00
	Labour input - AWU	2,5	3,3
	of which paid labour input - AWU	1,6	2,1
	Wages of paid labour per hour - RSD/h	45,00	58,50
	UAA per labour - ha/AWU	6,0	7,8
	Yield of wheat - kg/ha	5 678	7 381
	Milk production per cow - kg/cow	6 756	8 783
Financial indicators (RSD)			
+	Total output	7 000	9 100
	Crop production	4 000	5 200
	Livestock production	5 000	6 500
	Other production	2 000	2 600
-	Total intermediate consumption	5 000	6 500
	Specific costs	3 000	3 900
	Farming overheads	2 000	2 600
+	Balance current subsidies & taxes	1 500	1 950
=	Gross Farm Income	3 500	4 550
-	Depreciation	600	780
=	Farm Net Value Added	2 900	3 770
+	Balance subsidies & taxes on investments	200	260
-	Total external factors	1 900	2 470
	Wages paid	1 000	1 300
	Rent paid	400	520
	Interest paid	500	650
=	Family Farm Income	1 200	1 560

Source: *FADN Serbia.*

In addition to the mandatory information required by the European Commission, each national FADN system may include information that is intended for use at national level. So it can be recommended an inclusion in the collection procedure, processing and Feedback form the direct data on application of new modern technologies. For example, it can be recommended to include the following:

- Data on the use of alternative energy sources, solar, wind and biomass;
- Data on irrigation;
- Information about using technologies like sensor automatic irrigation and fertilization, the use of satellite-guided machinery, etc.

Conclusion

According to the survey analyzed in this paper, it could be concluded based on the indicators used, that the highest level of applied technology in agricultural production have Malta and Netherlands, while the lowest level have Bulgaria and Romania (in 2013).

Given the growing importance of increase in average yields and environmental protection caused primarily by constant increase in the number of inhabitants in the world, application of new technologies are getting more and more important.

The tendency of governments is to create incentives aimed at development and application of new technologies. One of the basic conditions for a successful national agricultural policy as well as application of new technologies on the farm is to establish an effective system for monitoring the results of the new technologies' application at the macro and micro level.

Analyses in this paper show that the FADN system can be useful for analyzing the efficiency of application of new technologies on the farm through the Feedback form and/or the public FADN database.

The recommendation could be given to the inclusion of information related to the application of new technologies within the national FADN.

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