

**1. Estimate Autoregressive Integrated Moving Average (ARIMA(p,d,q)) model for spot return (rspot) and future return (rfuture) – determine the most appropriated order for p, d, and q using SBIC given the maximum lag equals 5**

For Spot Series,

Variable	arimars101	arimars102	arimars103	arimars104	arimars105
rspot					
_cons	.00002358	.00002358	.00002358	.00002357	.0000236
ARMA					
ar					
L1.	-.39222121***	.42866768***	.65121793**	-.4419119	.19422255
ma					
L1.	.44515732***	-.38284317***	-.60570251**	.48782136	-.14853288
L2.		-.06805288***	-.0785457***	-.02952572	-.0578027**
L3.			.01541405	-.04117649	-.00879285
L4.				-.00216661	.00427518
L5.					-.02212732*
sigma					
_cons	.00178634***	.00178491***	.00178487***	.00178491***	.00178452***
Statistics					
N	7683	7683	7683	7683	7683
ll	37713.142	37719.292	37719.478	37719.305	37720.958
chi2	119.51861	100.14226	108.29283	133.22283	101.26927
aic	-75418.284	-75428.583	-75426.956	-75424.609	-75425.916
bic	-75390.497	<b>-75393.85</b>	-75385.276	-75375.982	-75370.342

legend: \* p<.1; \*\* p<.05; \*\*\* p<.01

Variable	arimars201	arimars202	arimars203	arimars204	arimars205
rspot					
_cons	.00002357	.00002358	.00002357	.00002358	.00002356
ARMA					
ar					
L1.	.38018903***	.4428634***	-.29668626	.20852054	.63265257***
L2.	-.06525664***	.06485063	.18525538	.37775134	-.9173871***
ma					
L1.	-.33467542**	-.39715673***	.3426502	-.16262337	-.58712918***
L2.		-.13338401	-.22062902	-.43686733	.83973716***
L3.			-.0455461	-.02892213	.05477111***
L4.				.02144947	-.0340934***
L5.					-.03011077***
sigma					
_cons	.00178498***	.00178489***	.00178489***	.00178475***	.00178388***
Statistics					
N	7683	7683	7683	7683	7683
ll	37719.008	37719.388	37719.394	37719.987	37723.723
chi2	97.508642	100.31373	120.1281	104.89138	709.67885
aic	-75428.017	-75426.777	-75424.788	-75423.974	-75429.446
bic	<b>-75393.283</b>	-75385.096	-75376.161	-75368.4	-75366.925

legend: \* p<.1; \*\* p<.05; \*\*\* p<.01

Variable	arimars301	arimars302	arimars303	arimars304	arimars305
rspot					

	_cons	.00002358	.00002358	.00002358	.00002358	.00002358
-----						
ARMA						
ar						
L1.		.77437319***	.75391093	-.00931271	.11656704	.17034276
L2.		-.08500113***	-.07142142	.14076076	-.77534242***	-.75360361***
L3.		.02486609	.02349348	.27348399*	.50688547***	.56054909*
ma						
L1.		-.72875825***	-.70829213	.05444554	-.07069015	-.12455802
L2.			-.0126675	-.19087608	.72188937***	.69747322***
L3.				-.29968133**	-.48361496***	-.53438921*
L4.					-.06737523***	-.06848303***
L5.						.00394329
-----						
sigma						
_cons		.00178484***	.00178484***	.00178455***	.00178409***	.00178409***
-----						
Statistics						
N		7683	7683	7683	7683	7683
ll		37719.588	37719.589	37720.837	37722.792	37722.804
chi2		116.99403	115.5826	113.25114	10209.973	10000.556
aic		-75427.175	-75425.178	-75425.675	-75427.585	-75425.609
bic		<b>-75385.495</b>	-75376.55	-75370.101	-75365.064	-75356.141

legend: \* p<.1; \*\* p<.05; \*\*\* p<.01

Variable	arimars401	arimars402	arimars403	arimars404	arimars405	
-----						
rspot						
_cons		.00002358	.00002358	.00002358	.00002358	.00002358
-----						
ARMA						
ar						
L1.		.7666053*	.19158964	.11523364	.1151415	-.5504427
L2.		-.0847024***	.40155116	-.84406727***	-.75782372***	-.78379155***
L3.		.02504525	-.03039789	.47709053***	.51318794***	-.04809472
L4.		-.00097078	.02217215	-.06670122***	.01762523	.25343204
ma						
L1.		-.72097599*	-.14607877	-.06957553	-.06931375	.59650556
L2.			-.45952184	.79160824***	.70434889***	.76129286***
L3.				-.45340835***	-.49005879***	.03653616
L4.					-.08488067	-.30545878
L5.						-.04497466
-----						
sigma						
_cons		.00178484***	.0017848***	.00178413***	.00178409***	.00178406***
-----						
Statistics						
N		7683	7683	7683	7683	7683
ll		37719.59	37719.787	37722.647	37722.799	37722.91
chi2		116.13751	103.18568	9964.4835	10386.995	10614.78
aic		-75425.181	-75423.574	-75427.294	-75425.598	-75423.821
bic		<b>-75376.553</b>	-75368	-75364.773	-75356.131	-75347.406

legend: \* p<.1; \*\* p<.05; \*\*\* p<.01

Variable	arimars501	arimars502	arimars503	arimars504	arimars505	
-----						
rspot						
_cons		.00002358	.00002357	.00002356	.00002359	.00002357
-----						
ARMA						
ar						
L1.		.16545423	.27864543	.40276891	.4522115	.65322307
L2.		-.05696613**	-.38380203	-.8125169**	-.79741755***	-.84851364
L3.		-.00729372	.0132755	-.23274748	.79847751	.135421
L4.		.00131373	-.01409715	-.01688907	-.14253218	-.03798813

L5.		-.02387488**	-.027723**	-.03803901	.02403776	.2119602
ma						
L1.		-.11967988	-.23291974	-.35713416	-.40636659	-.60798872
L2.			.32183897	.74598779**	.7276743***	.77021616
L3.				.27304521	-.75638256	-.08258281
L4.					.06689307	.00478413
L5.						-.24346584
-----						
sigma						
_cons		.0017845***	.00178443***	.00178393***	.00178407***	.00178371***
-----						
Statistics						
N		7683	7683	7683	7683	7683
ll		37721.078	37721.395	37723.49	37722.895	37724.453
chi2		102.58864	114.46132	754.49844	7095.4758	2756.6385
aic		-75426.156	-75424.789	-75426.981	-75423.79	-75424.907
bic		<b>-75370.582</b>	-75362.269	-75357.513	-75347.376	-75341.546
-----						
legend: * p<.1; ** p<.05; *** p<.01						

The model ARIMA(1,0,2) has the lowest BIC(-75393.85). Therefore, the most appropriated model for spot return is ARIMA(1,0,2).

### For Future Series,

Variable	arimaf101	arimaf102	arimaf103	arimaf104	arimaf105	
rfuture						
_cons		.00002616	.00002615	.00002616	.00002616	.00002616
-----						
ARMA						
ar						
L1.		.57862596***	.1646139	-.99197396***	.7969672	-.18361821
ma						
L1.		-.61250239***	-.19269514	.96410749***	-.82504953	.15556594
L2.			-.03060977**	-.06340384***	-.01284081	-.04031228
L3.				-.03781399***	.02240475	-.01199443
L4.					.00290008	-.00091534
L5.						-.00688194
-----						
sigma						
_cons		.00205937***	.00205903***	.00205869***	.00205901***	.00205897***
-----						
Statistics						
N		7683	7683	7683	7683	7683
ll		36620.387	36621.683	36622.888	36621.711	36621.87
chi2		81.753207	31.061825	22845.807	196.93459	20.219307
aic		-73232.774	-73233.366	-73233.777	-73229.421	-73227.74
bic		<b>-73204.987</b>	-73198.632	-73192.096	-73180.794	-73172.166
-----						
legend: * p<.1; ** p<.05; *** p<.01						

Variable	arimaf201	arimaf202	arimaf203	arimaf204	
rfuture					
_cons		.00002615	.00002616	.00002615	.00002616
-----					
ARMA					
ar					
L1.		.1969293	.15226368	-.89486565***	-.21249116
L2.		-.02961053**	.01296947	.09649512	.77335544
ma					
L1.		-.22502128	-.18034762	.86712136***	.18471269
L2.			-.04390959	-.15696342	-.814853

L3.				-.03516964***	.00871263
L4.					.0264409
-----					
sigma					
_cons		.00205903***	.00205902***	.00205869***	.00205868***
-----					
Statistics					
N		7683	7683	7683	7683
ll		36621.673	36621.684	36622.933	36622.979
chi2		31.861358	30.829039	19166.908	7241.8566
aic		-73233.346	-73231.368	-73231.866	-73229.957
bic		<b>-73198.612</b>	-73189.687	-73183.239	-73174.383

legend: \* p<.1; \*\* p<.05; \*\*\* p<.01

Variable		arimaf301	arimaf302	arimaf303	arimaf304
-----					
rfuture					
_cons		.00002615	.00002616	.00002616	.00002616
-----					
ARMA					
ar					
L1.		.43723766	-.85962639***	-.52740176***	-.83422394***
L2.		-.02300598	.09722315	-.40401367**	-.75316796***
L3.		.00949808	-.03403703***	.51718986***	.2296664
ma					
L1.		-.46532123	.83183829***	.49699427***	.80715267***
L2.			-.15647239	.36085732**	.6960639***
L3.				-.55339935***	-.2860842
L4.					-.02533183*
-----					
sigma					
_cons		.00205901***	.00205869***	.00205829***	.00205707***
-----					
Statistics					
N		7683	7683	7683	7683
ll		36621.693	36622.898	36624.395	36628.568
chi2		52.844319	16992.278	3952.7769	1327865.3
aic		-73231.387	-73231.797	-73232.791	-73239.135
bic		<b>-73189.706</b>	-73183.17	-73177.217	-73176.615

legend: \* p<.1; \*\* p<.05; \*\*\* p<.01

Variable		arimaf401	arimaf402	arimaf403	arimaf404
-----					
rfuture					
_cons		.00002616	.00002616	.00002619	.00002616
-----					
ARMA					
ar					
L1.		.76071201	-.25409204	-.18936941**	-1.0431113
L2.		-.01390611	.71291982	-.93574833***	-.7992043**
L3.		.02102091	.0057631	.21211369**	.17869513
L4.		.00316275	.0246218	-.02826146**	.13931101
ma					
L1.		-.78880185	.2263405	.16146457	1.015465
L2.			-.75552764	.8962194	.73534439*
L3.				-.25137844	-.24363018
L4.					-.16703558
-----					
sigma					
_cons		.00205902***	.00205867***	.00205766**	.00205817***
-----					
Statistics					
N		7683	7683	7683	7683
ll		36621.713	36622.973	36624.996	36624.797
chi2		166.90558	7243.9202	5.226e+08	6824.9136

```

aic | -73229.427      -73229.946      -73231.992      -73229.594
bic | -73180.799    -73174.372      -73169.471      -73160.126

```

-----  
legend: \* p<.1; \*\* p<.05; \*\*\* p<.01

Variable	arima501	arima504	arima505
-----			
Y			
_cons	.00002616*	.00002615*	.00002616*
-----			
ARMA			
ar			
L1.	-.17881777	-1.2088095***	-.79758143***
L2.	-.04028792*	-1.1649322***	-1.5288687***
L3.	-.01301738	-.75929455**	-.09243149
L4.	-.00282876	.15079556	-.23653186*
L5.	-.00826276*	-.03135393**	.52788065***
ma			
L1.	.15074717	1.1813416***	.76659346***
L2.		1.0976641***	1.4784826***
L3.		.6778281**	.01626756
L4.		-.21960633*	.1865648*
L5.			-.56308807***
-----			
sigma			
_cons	.00205896***	.00205707***	.00205767***
-----			
Statistics			
N	7683	7683	7683
ll	36621.909	36626.203	36626.651
chi2	20.150745	1.266e+08	200769.26
aic	-73227.818	-73230.405	-73229.302
bic	<b>-73172.244</b>	-73153.991	-73145.941

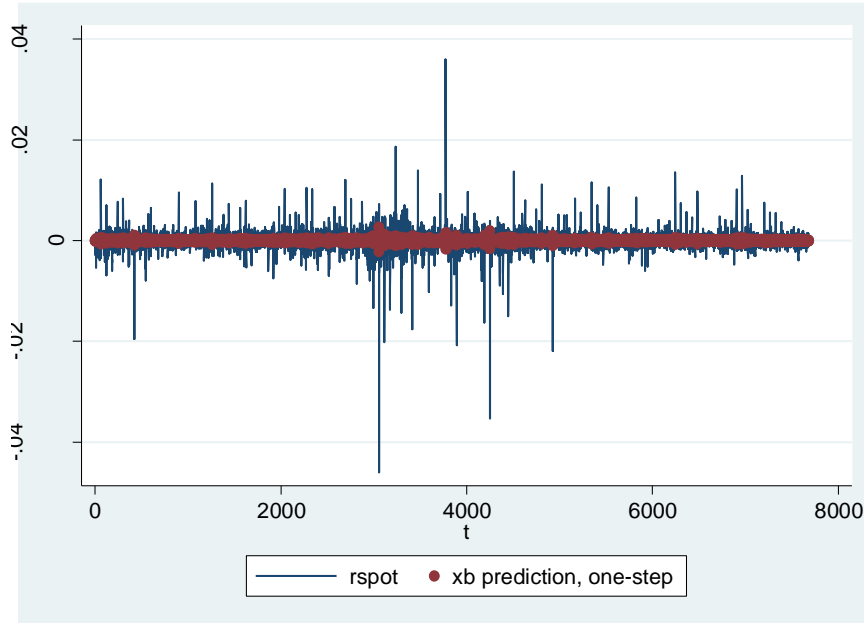
-----  
legend: \* p<.1; \*\* p<.05; \*\*\* p<.01

The model ARIMA(1,0,1) has the lowest BIC(-73204.987). Therefore, the most appropriated model for future return is ARIMA(1,0,1).

**2. Perform in-sample (both static and dynamic) forecast of the two series (spot return (rspot) and future return (rfuture), then, compute RMSE of each forecast**

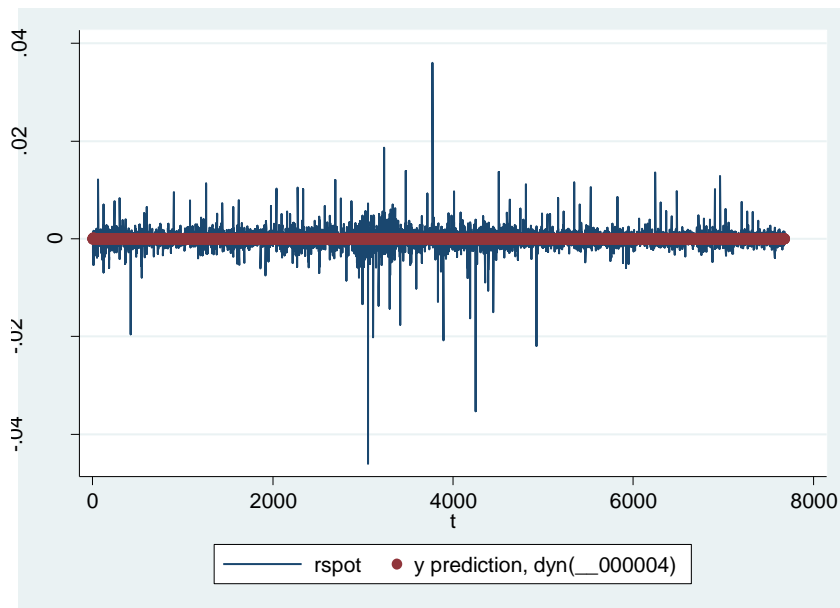
For Spot Series static,

$$RMSE = \sqrt{.0244773/7684} = 0.001785$$



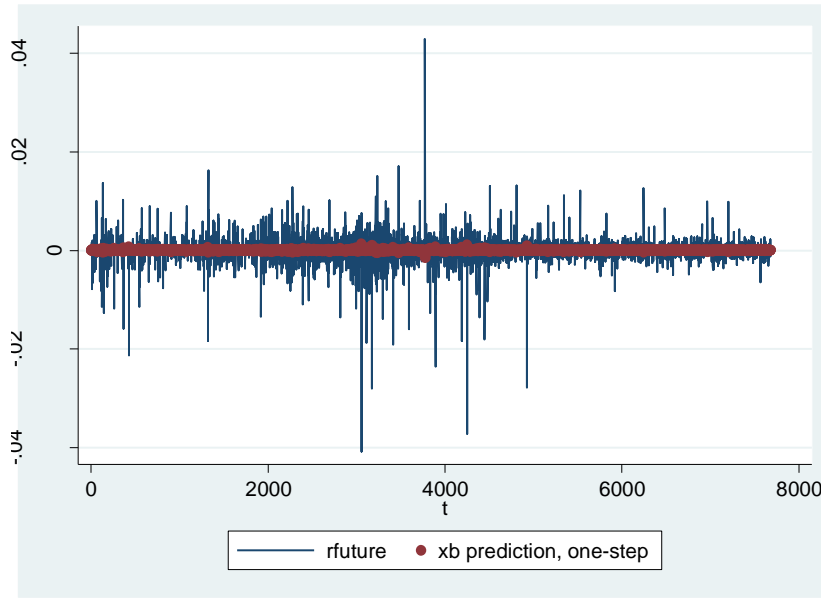
For Spot Series dynamic,

$$\text{RMSE} = \sqrt{.02459747/7684} = 0.001789$$



For Future Series static,

$$\text{RMSE} = \sqrt{.03258357/7684} = 0.002059$$

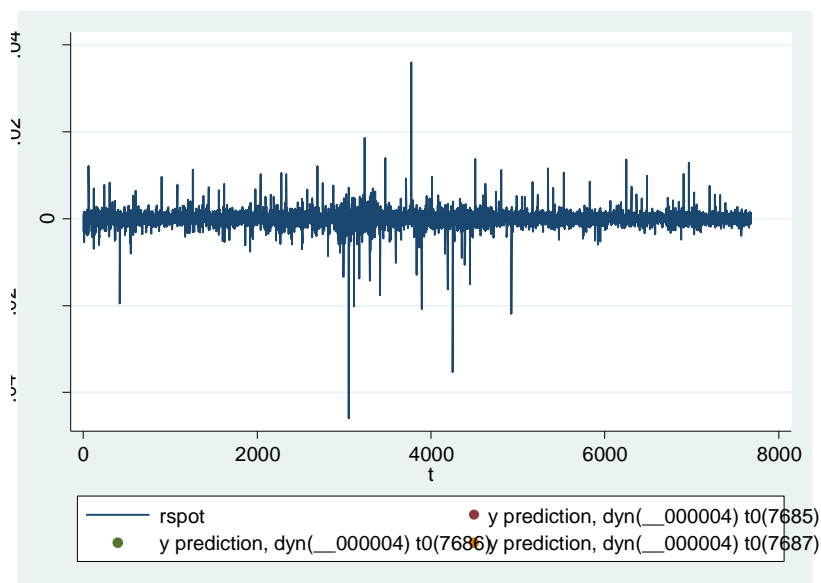


For Future Series dynamic,

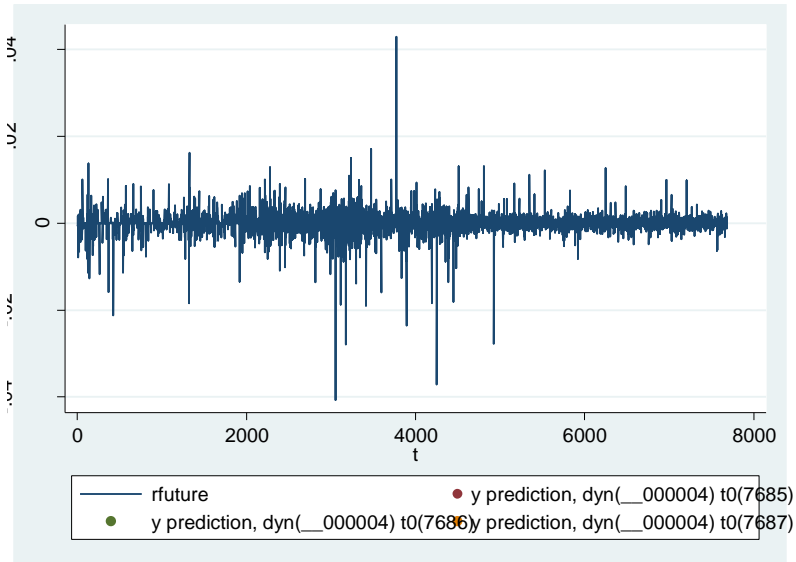
$$\text{RMSE} = \sqrt{.03263977/7684} = 0.002061$$

**3. Perform out-sample three-period ahead (dynamic) forecast of the two series (sport return (rspot) and future return (rfuture)).**

For Spot Series dynamic,



For Future Series dynamic,



### Code

```
tsset t

g rspot = (spot/l.spot) - 1
g rfuture = (future/l.future) - 1

*=====

dfuller rspot, trend lag(1) regress
dfuller rfuture, trend lag(1) regress

*===== 1st question rspot

forvalue i=1(1)5 {
    qui arima rspot, arima(1,0,`i') nolog
    est store arimars10`i'
}

forvalue i=1(1)5 {
```

```
    qui arima rspot, arima(2,0,`i') nolog
    est store arimars20`i'
}
forvalue i=1(1)5 {
    qui arima rspot, arima(3,0,`i') nolog
    est store arimars30`i'
}
forvalue i=1(1)5 {
    qui arima rspot, arima(4,0,`i') nolog
    est store arimars40`i'
}
forvalue i=1(1)5 {
    qui arima rspot, arima(5,0,`i') nolog
    est store arimars50`i'
}
forvalue j=1(1)5 {
    est table arimars`j'0*, star(0.1 0.05 0.01) stat(N ll chi2 aic bic)
}
*===== 1st question rfuture
forvalue i=1(1)5 {
    qui arima rfuture, arima(1,0,`i') nolog
    est store arimaf10`i'
}
forvalue i=1(1)5 {
    qui arima rfuture, arima(2,0,`i') nolog
    est store arimaf20`i'
}
forvalue i=1(1)5 {
```

```
    qui arima rfuture, arima(3,0,`i') nolog
    est store arimaf30`i'
}
forvalue i=1(1)4 {
    qui arima rfuture, arima(4,0,`i') nolog
    est store arimaf40`i'
}
forvalue i=1(1)4 {
    qui arima rfuture, arima(5,0,`i') nolog
    est store arimaf50`i'
}
forvalue j=1(1)5 {
    est table arimaf`j'0*, star(0.1 0.05 0.01) stat(N ll chi2 aic bic)
}
*===== 2nd question
**===== 2nd question rspot
static forecast
arima rspot, arima(1,0,2) nolog
predict rspothat_s, xb
tway (line rspothat_s t, sort) (scatter rspot t, sort)
g fe_spot=rspot-rspothat_s
g sfe=fe^2
sum sfe
dis r(sum)
**===== 2nd question rspot
dynamic forecast
arima rspot, arima(1,0,2) nolog
predict rspothat_d, y dynamic(.)
tway (line rspot t, sort) (scatter rspothat_d t, sort)
```

```
g dfe=rspot-rspothat_d if t<7685
g sdfe=dfe^2
sum sdfe
dis r(sum)
**===== 2nd question rfuture
static forecast
arima rfuture, arima(1,0,1) nolog
predict rfuturehat_s, xb
twoway (line rfuture t, sort) (scatter rfuturehat_s t,sort)
g fe_future=rfuture-rfuturehat_s
g sfe_future=fe_future^2
sum sfe_future if t>=2
dis r(sum)
**===== 2nd question rspot
dynamic forecast
arima rfuture, arima(1,0,1) nolog
predict rfuturehat_d, y dynamic(.)
g dfe_future=rfuture-rfuturehat_d
g sdfe_future=dfe_future^2
sum sdfe_future if t<7685
dis r(sum)
*===== 3rd question
**===== 3rd question rspot
dynamic forecast
arima rspot, arima(1,0,2) nolog
predict rspothat, y dynamic(.) t0(7684)
predict rspothat2, y dynamic(.) t0(7685)
predict rspothat3, y dynamic(.) t0(7686)
predict rspothat4, y dynamic(.) t0(7687)
```

```
twoway (line rspot t, sort) (scatter rspothat2 rspothat3 rspothat4 t, sort)

**===== 3rd question rspot
dynamic forecast

arima rfuture, arima(1,0,1) nolog

predict rfuturehat, y dynamic(.) t0(7684)

predict rfuturehat2, y dynamic(.) t0(7685)

predict rfuturehat3, y dynamic(.) t0(7686)

predict rfuturehat4, y dynamic(.) t0(7687)

twoway (line rfuture t, sort) (scatter rfuturehat2 rfuturehat3 rfuturehat4 t,
sort)

*****
```