A) fund #4 .41910739
Fund #6 .2460271
Fund #8 .22738701

B) fund #4 .54137257
Fund #6 .28268096
Fund #5 .24517545

C) Fund #5 1.1058157
Fund #17 .88918966
Fund #3 .85962846

Carhart

```
. reg r1 rmrf smb hml wml
```

Source	SS	df	MS	Number of obs	=	120
				F(4, 115)	=	130.81
Model	1763.719	4	440.92975	Prob > F	=	0.0000
Residual	387.652185	115	3.37088857	R-squared	=	0.8198
				Adj R-squared	=	0.8135
Total	2151.37118	119	18.0787494	Root MSE	=	1.836

r1	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
rmrf	88.37442	4.132204	21.39	0.000	80.18932	96.55952
smb	-30.55523	15.20777	-2.01	0.047	-60.6789	-.4315607
hml	-29.55418	14.55813	-2.03	0.045	-58.39103	-.7173227
wml	-16.89643	11.8509	-1.43	0.157	-40.37078	6.57791
_cons	.7176653	.7344903	0.98	0.331	-.7372186	2.172549

i)Using 0.05 level of significance;

Coefficient of rmrf is very high and statistically significant. That means it is sensitive to the market in a positive direction. If the market is doing good, this mutual would be doing good as well, vice versa.

Coefficient of smb is negative and statistically significant. It has negative exposure to the Small Minus Big factor. Therefore, this fund is doing **bad when small stocks outperform large stocks. This mutual fund probably invests in large stocks**.

Coefficient of hml is negative and statistically significant. It has negative relationship to the High Minus Low factor. Therefore, if value stocks outperform growth stocks, this fund is doing bad. It might primarily invest in **growth stocks.**

Coefficient of wml is negative and statistically significant. This means it has exposure to how the broader market momentum is performing in the opposite direction.

This makes sense because this mutual fund may invest a lot in large stocks, growth stocks, those stocks that are sensitive to the market risk. One example could be tech stocks such as Apple, Facebook, and so on. They are large stocks with very high market cap. Tech stocks also grow fast due to their new technology. Lastly they are usually highly sensitive to the market risk.

ii) F-test shows the significance at 0.05 level of significance since p-value=0.0000
iii) R-square is 81.98% which is considered to be high
iv)T-test

Coefficients of rmrf(p-value=0.000), smb(p-value=0.047), and hml(p-value=0.045) are statistically significant at 95% level of confidence. However, the wml(p-value=0.157) and intercept(p-value=0.331) are not.

D)

Carhart

Autocorrelation

```
. reg r1 rmrf smb hml wml
```

Source	SS	df	MS	Number of obs	=	120
				F(4, 115)	=	130.81
Model	1763.719	4	440.92975	Prob > F	=	0.0000
Residual	387.652185	115	3.37088857	R-squared	=	0.8198
				Adj R-squared	=	0.8135
Total	2151.37118	119	18.0787494	Root MSE	=	1.836

r1	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
rmrf	88.37442	4.132204	21.39	0.000	80.18932	96.55952
smb	-30.55523	15.20777	-2.01	0.047	-60.6789	-.4315607
hml	-29.55418	14.55813	-2.03	0.045	-58.39103	-.7173227
wml	-16.89643	11.8509	-1.43	0.157	-40.37078	6.57791
_cons	.7176653	.7344903	0.98	0.331	-.7372186	2.172549

```
. prais r1 rmrf smb hml wml

Iteration 0:  rho = 0.0000
Iteration 1:  rho = -0.1841
Iteration 2:  rho = -0.1905
Iteration 3:  rho = -0.1906
Iteration 4:  rho = -0.1906
Iteration 5:  rho = -0.1906

Prais-Winsten AR(1) regression -- iterated estimates
```

Source	SS	df	MS	Number of obs	=	120
				F(4, 115)	=	140.13
Model	1822.22336	4	455.55584	Prob > F	=	0.0000
Residual	373.860714	115	3.25096273	R-squared	=	0.8298
				Adj R-squared	=	0.8238
Total	2196.08408	119	18.454488	Root MSE	=	1.803

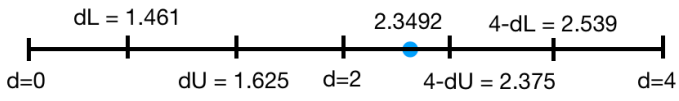
r1	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
rmrf	88.00825	4.020373	21.89	0.000	80.04467	95.97184
smb	-30.10393	14.73095	-2.04	0.043	-59.28311	-.9247424
hml	-27.98348	14.1509	-1.98	0.050	-56.01369	.0467322
wml	-14.65331	9.937354	-1.47	0.143	-34.33729	5.030679
_cons	.5898874	.6149215	0.96	0.339	-.6281537	1.807929
rho	-.1906287					

```
Durbin-Watson statistic (original)    2.349188
Durbin-Watson statistic (transformed) 2.014291
```

Ho : No Autocorrelation vs H1 : Autocorrelation

Durbin-Watson stat = 2.3492

Obtaining dL and dU from Durbin-Watson table, we get dL = 1.461, dU = 1.625. (α = 0.01)



Ho is not rejected. Therefore, there is no autocorrelation.

Multicollinearity

We have significant F-test but but intercept's and wml's coefficients are not significant at 0.05 significance level. Therefore, there might be multicollinearity.
The correlation between hml and smb is -0.9514 which is considered to be very high.
Therefore, there is multicollinearity problem.

Carhart or FF should be employed?

Carhart

From last question, autocorrelation does not exist.

After performing white test, it shows that heteroskedaticity doesn't exist.

```
White's test for Ho: homoskedasticity
         against Ha: unrestricted heteroskedasticity

         chi2(14)     =     18.06
         Prob > chi2  =    0.2039

Cameron & Trivedi's decomposition of IM-test
```

Source	chi2	df	p
Heteroskedasticity	18.06	14	0.2039
Skewness	9.01	4	0.0607
Kurtosis	0.15	1	0.7007
Total	27.22	19	0.0995

Prob>chi2 = 0.2039 > 0.05 Therefore, Ho is not rejected. We have homoskedasticity.

FF

```
. reg r1 rmrf smb hml
```

Source	SS	df	MS		
				Number of obs	= 120
				F(3, 116)	= 172.20
Model	1756.86676	3	585.622255	Prob > F	= 0.0000
Residual	394.504419	116	3.40090016	R-squared	= 0.8166
				Adj R-squared	= 0.8119
Total	2151.37118	119	18.0787494	Root MSE	= 1.8442

r1	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
rmrf	88.45839	4.150136	21.31	0.000	80.23852	96.67826
smb	-30.48331	15.27524	-2.00	0.048	-60.73783	-.2287763
hml	-29.65203	14.62263	-2.03	0.045	-58.61399	-.6900658
_cons	-.300368	.1729078	-1.74	0.085	-.6428337	.0420977

- Using 0.05 level of significant;

Coefficient of rmrf is very high and statistically significant. That means it is sensitive to the market in a positive direction. If the market is doing good, this mutual would be doing good as well, vice versa.

Coefficient of smb is negative and statistically significant. It has negative exposure to the Small Minus Big factor. Therefore, this fund is doing bad when small stocks outperform large stocks. This mutual fund probably invests in large stocks.

Coefficient of hml is negative and statistically significant. It has negative relationship to the High Minus Low factor. Therefore, if value stocks outperform growth stocks, this fund is doing bad. It might primarily invest in growth stocks.

This makes sense because this mutual fund may invest a lot in large stocks, growth stocks, those stocks that are sensitive to the market risk. One example could be tech stocks such as Apple, Facebook, and so on. They are large stocks with very high market cap. Tech stocks also grow fast due to their new technology. Lastly they are usually highly sensitive to the market risk.

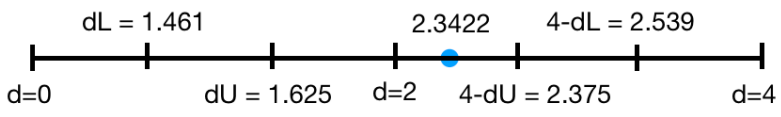
- F-test shows the significance
- R-square is 81.66% which is considered to be high.
- T-test

Coefficients of rmrf, smb, hml, and wml are statistically significant at 95% level of confidence. However, the intercept is not.

- Check Autocorrelation

```
. prais r1 rmrf smb hml

Iteration 0:  rho = 0.0000
Iteration 1:  rho = -0.1818
Iteration 2:  rho = -0.1865
Iteration 3:  rho = -0.1866
Iteration 4:  rho = -0.1866
Iteration 5:  rho = -0.1866

Prais-Winsten AR(1) regression -- iterated estimates

      Source |       SS           df       MS      Number of obs   =       120
-------------+----------------------------------   F(3, 116)       =    183.99
       Model |  1812.60106         3  604.200353   Prob > F        =    0.0000
    Residual |  380.932528       116   3.2839011   R-squared       =    0.8263
-------------+----------------------------------   Adj R-squared   =    0.8218
       Total |  2193.53359       119  18.4330554   Root MSE        =    1.8122

------------------------------------------------------------------------------
          r1 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        rmrf |     87.9912   4.042849    21.76   0.000     79.98383    95.99857
         smb |    -29.90446   14.81425    -2.02   0.046    -59.24596   -.5629738
         hml |     -27.9857   14.23062    -1.97   0.052    -56.17122    .1998326
       _cons |    -.2919542   .1447353    -2.02   0.046    -.5786208   -.0052876
-------------+----------------------------------------------------------------
         rho |    -.1865977
------------------------------------------------------------------------------
Durbin-Watson statistic (original)    2.342202
Durbin-Watson statistic (transformed) 2.007510
```

Ho : No Autocorrelation vs H1 : Autocorrelation
Durbin-Watson stat = 2.3422
Obtaining dL and dU from Durbin-Watson table, we get dL = 1.461, dU = 1.625.
(α = 0.01)



Ho is not rejected. Therefore, there is no autocorrelation.

Check Heteroskedaticity

```
White's test for Ho: homoskedasticity
         against Ha: unrestricted heteroskedasticity

         chi2(9)      =     14.54
         Prob > chi2  =    0.1044

Cameron & Trivedi's decomposition of IM-test
```

Source	chi2	df	p
Heteroskedasticity	**14.54**	**9**	**0.1044**
Skewness	**6.32**	**3**	**0.0969**
Kurtosis	**0.00**	**1**	**0.9580**
Total	**20.87**	**13**	**0.0756**

Prob>chi2= 0.1044 > 0.05 Therefore, Ho is not rejected. We have homoskedasticity.

After looking at all criteria, the 2 models are very similar. To compare the 2 models, we can look at the adjusted R-square. Adjusted R-square of Carhart is 81.35% while FF is 81.19%. R-square of Carhart model is only slightly higher. However, wml is not significant in Carhart model. (T-test)($\sqrt{VIF}$) = 0.15(1) < 2. Therefore, it can be dropped. Hence, FF model might be better.

E) Based on a), b), c), I think FF model might be the most appropriated. Since mutual funds are managed by financial managers and they should be relatively safe. Therefore, the return shouldn't negative in the most cases like the result from Carhart. (T-test)($\sqrt{VIF}$) of the other 2 variables(smb and hml) are higher than 2 so there exist multicollinearity. If the 2 variables are dropped, independent variables would correlate with u. This would violate assumption. Hence, CAPM shouldn't be appropriated.