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Markowitz’s (1952) theory of Portfolio Diversification has been instrumental in

paving the way for modern asset pricing models to measure risks associated with

equity returns. Subsequently, Capital Asset Pricing Model (CAPM) has been

developed by Sharpe (1964), Linter (1965) and Mossin (1966). The Arbitrage Pricing

Theory (APT) proposed by Ross (1976, 1977), has come as an alternative to CAPM

measure of risk-return. The progress of models especially the APT appears to be

influenced by the macroeconomic factors that intuitively affect capital investment.

Whether the APT stands empirical viability has been tested widely time and again

hence there exists a dense literature e.g. Shanken (1982), Brown and Weinstein

(1983), Chen (1983), Cho, Elton and Gruber (1984), Chen, Roll, and Ross (1986),

Connor and Korajczk (1986), Burmeister and McElroy (1988), Lehman and Modest

(1988), to mention but a few.

However, the literature is rather limited in that these theories especially the

APT have been tested in large developed stock markets now and then. Though it is

noted that the APT has already been tested in a few emerging markets e.g. in

Pakistan, Turkey and Indonesia (among others) yet in the context of frontier stock

markets, defined as less advanced and very small capital markets, the evidence is

nonexistent.

It is noteworthy that CRR results suffer from robustness

Del **Multicollinearity**

http://www.nature.com/bdj/journal/v199/n7/full/4812743a.html

**Multicollinearity**

In a multiple regression model with *k* covariates (*k*>2), ie:*y*=*b*0+*b*1*x*1+*b*2*x*2+...+*b*k*x*k, the problem of multicollinearity is more complex and more difficult to detect, because multicollinearity does not necessarily require high bivariate correlations between covariates. For instance, if *x*1, *x*2 and *x*3 are independent, the bivariate correlations between each pair are zero. However, if a new variable *x*4 is derived from *x*1, *x*2, and *x*3, such that *x*4=*x*1+*x*2+*x*3, there is perfect multicollinearity amongst the four variables, since each *xi* (*i*=1 to 4) can be expressed as a combination of the other three such as: *x*3=*x*4-*x*1-*x*2. Each pair of correlations between *x*4 and the remaining three covariates may be relatively modest, but multicollinearity is still a serious problem due to the fact that the information provided by the four variables as a whole is overlapped. Unless one of the four covariates is removed from the regression model, computer software cannot proceed with mathematical computation for the regression model.

**Diagnosis of multicollinearity**

One of the diagnostic methods for multicollinearity is to perform auxiliary regressions, to regress one covariate on the remaining covariates.[7,](http://www.nature.com/bdj/journal/v199/n7/full/4812743a.html#B7)[8](http://www.nature.com/bdj/journal/v199/n7/full/4812743a.html#B8) For instance, *x*4 is used as the outcome and is regressed on *x*1, *x*2, and *x*3, the *R*2 for this auxiliary regression is a measure of the degree of multicollinearity for *x*4. The variance inflation factor (*VIF*), defined as *VIF*=1/(1-R2i) where *R*2i is the *R*2 for a covariate *xi* regressed on the remaining covariates in a auxiliary regression, is the most commonly used regression diagnostic for multicollinearity within standard statistical software.[7,](http://www.nature.com/bdj/journal/v199/n7/full/4812743a.html#B7)[8,](http://www.nature.com/bdj/journal/v199/n7/full/4812743a.html#B8)[9,](http://www.nature.com/bdj/journal/v199/n7/full/4812743a.html#B9)[10,](http://www.nature.com/bdj/journal/v199/n7/full/4812743a.html#B10)[11](http://www.nature.com/bdj/journal/v199/n7/full/4812743a.html#B11)

Another diagnostic tool for multicollinearity is the *condition index*, which is more complicated but provides very similar information as the *VIF*.[8,](http://www.nature.com/bdj/journal/v199/n7/full/4812743a.html#B8)[14](http://www.nature.com/bdj/journal/v199/n7/full/4812743a.html#B14) Detailed explanations of these diagnostics can be found in the cited references.[7,](http://www.nature.com/bdj/journal/v199/n7/full/4812743a.html#B7)[8,](http://www.nature.com/bdj/journal/v199/n7/full/4812743a.html#B8)[9,](http://www.nature.com/bdj/journal/v199/n7/full/4812743a.html#B9)[10,](http://www.nature.com/bdj/journal/v199/n7/full/4812743a.html#B10)[11](http://www.nature.com/bdj/journal/v199/n7/full/4812743a.html#B11) In general, standard errors of regression coefficients are inflated when the *VIF*is large (eg when *VIF*>10, multicollinearity is usually considered a problem, though this is an arbitrary threshold).

In summary, when there are more than two covariates in a regression model, correlations amongst covariates are informative but should not be the only criterion used to judge whether or not multicollinearity is a problem. Other diagnostic tools, such as the *VIF* and *condition index* should also be used and reported. Moreover, even when there is a problem of multicollinearity, the collinear covariates may remain statistically significant, though the sign of regression coefficient might be contrary to expectation — this is another indication of potential problems due to multicollinearity.[7,](http://www.nature.com/bdj/journal/v199/n7/full/4812743a.html#B7)[8,](http://www.nature.com/bdj/journal/v199/n7/full/4812743a.html#B8)[9,](http://www.nature.com/bdj/journal/v199/n7/full/4812743a.html#B9)[10](http://www.nature.com/bdj/journal/v199/n7/full/4812743a.html#B10)

In the next sections, we use three examples within dental research to illustrate how to detect the problem of collinearity. It should be noted that these examples were selected as they exhibit good quality in the reporting of their regression analyses, thereby providing sufficient information to the reader to evaluate whether or not collinearity is a potential problem. This is frequently not the case in current clinical research publications.

 Asset returns are explained by systematic factors.

 Investors can build a portfolio of assets where [specific risk](http://www.investopedia.com/terms/s/specificrisk.asp) is eliminated through diversification.

 No arbitrage opportunity exists among well-diversified portfolios. If any arbitrage opportunities do exist, they will be exploited away by investors. (This how the theory got its name.)  
  
 [Investopedia]( Investopedia) <http://www.investopedia.com/articles/active-trading/082415/arbitrage-pricing-theory-its-not-just-fancy-math.asp#ixzz4LrCTF5N4> 