

## Profitability

Profitability is composed of six variables: gross profits over assets (*GPOA*), return on equity (*ROE*), return on assets (*ROA*), cash flow over assets (*CFOA*), gross margin (*GMAR*), and low accruals (*ACC*). *GPOA* is calculated as gross profits (*GPROF*, found in tidyincome) over total assets (*TA*, found in tidybalance).

$$GPOA = \frac{GPROF}{TA}$$

*ROE* is calculated as net income (*NI*, found in tidyincome) over book equity (*BE*), which is shareholders' equity (the difference of Total Liabilities and Shareholders' Equity (*TLSE*) with Total Liabilities (*TL*), both found in tidybalance) - preferred stock (the sum of redeemable preferred stock (*RPS*) and non redeemable preferred stock (*NRPS*), both found in tidybalance).

$$ROE = \frac{NI}{BE}$$

*ROA* is calculated as *NI* over *TA*.

$$ROA = \frac{NI}{TA}$$

*CFOA* is calculated as net income + depreciation (*DP.DPL*, found in tidy-cash) - changes in working capital (*CWC*, found in tidycash) - capital expenditures (*CX*, found in tidycash) all over *TA*.

$$CFOA = \frac{NI + DP.DPL - CWC - CX}{TA}$$

*GMAR* is calculated as *GPROF* over total revenue (*TREV*, found in tidy-income).

$$GMAR = \frac{GPROF}{TREV}$$

Finally, *ACC* is calculated as *DP.DPL* - *CWC* all over *TA*.

$$ACC = \frac{DP.DPL - CWC}{TA}$$

We then standardize all components of profitability to z-scores and then standardize all profitability scores into z-scores.

$$Profitability = z(z_{gpoa} + z_{roe} + z_{roa} + z_{cfoa} + z_{gmar} + z_{acc})$$

## Growth

Growth is measured by differences in profitability across a time span of four years. Though AQR recommends measuring growth across a time span of five years, public information that is both consistent and well-organized in 10-K forms is only available for a time span of four years, and it is still too early in the most recent year (2015) for most companies to have submitted a 10-K form. Thus, we measure growth using a time span of four years, which we will update once this year's 10-K form is submitted for each company in the Russell 3000 Index. As of now,

$$Growth = z(z_{\Delta gpoa} + z_{\Delta roe} + z_{\Delta roa} + z_{\Delta cfoa} + z_{\Delta gmar} + z_{\Delta acc})$$

## Safety

Safety is composed of six variables: beta ( $BAB$ ), idiosyncratic volatility ( $IVOL$ ), leverage ( $LEV$ ), Ohlson's O ( $O$ ), Altman's Z ( $Z$ ), and earnings volatility ( $EVOL$ ).  $BAB$  is calculated by scraping publicly available beta scores from Yahoo Finance, which uses the S&P 500 as its benchmark. Idiosyncratic volatility is the standard deviation of daily beta-adjusted excess returns, which is the daily rate of return of the company ( $R$ , found in tidydaily) -  $BAB$ \*(market rate of return( $R_m$ , found in tidydaily)).

$$IVOL = \sigma\left(\sum_{d=n_t-1}^{n_t} R_d - BAB * (R_{md})\right)$$

$d$  is the day,  $n$ , starting at  $t - 1$  (1 year ago), and  $n_t$  is the day before the most recent trading day. Leverage is -(total debts (TD, found in tidybalance) over TA).

$$Leverage = -\frac{TD}{TA}$$

$$O = -(-1.32 - 0.407 * \log(\frac{ADJASSET}{CPI}) + 6.03 * TLTA - 1.43 * WCTA + 0.076 * CLCA - 1.72 * OENEG - 2.37 * NITA - 1.83 * FUTL + 0.285 * INTWO - 0.521 * CHIN)$$

$ADJASSET$  is adjusted total assets, which is  $TA + 0.1 * (\text{market equity } (ME, \text{ calculated as average price per share for the most recent year (using closing price data from tidydaily)}) * \text{total number of shares outstanding } (TCSO, \text{ found in balance sheets})) - BE)$ .

$$ADJASSET = TA + 0.1 * (ME - BE)$$

$CPI$  is assumed to be 100, since we only care about the most recent year.  $TLTA$  is book value of debt ( $BD$ , calculated as  $TD - \text{minority interest } (MI, \text{ found in tidybalance}) - (RPS + NRPS)$ ) over  $ADJASSET$ .

$$TLTA = \frac{BD}{ADJASSET}$$

$WCTA$  is current assets ( $TCA$ , found in tidybalance) - current liabilities ( $TCL$ , found in tidybalance) over  $TA$ .

$$WCTA = \frac{TCA - TCL}{TA}$$

$CLCA$  is  $TCL$  over  $TCA$ .

$$CLCA = \frac{TCL}{TCA}$$

$OENEG$  is a dummy variable that is 1 if total liabilities ( $TL$ , found in tidybalance) is greater than  $TA$ .

$$OENEG = TL > TA$$

$NITA$  is  $NI$  over  $TA$ .

$$NITA = \frac{NI}{TA}$$

$FUTL$  is income before taxes ( $IBT$ , found in tidyincome) over  $TL$ .

$$FUTL = \frac{IBT}{TL}$$

*INTWO* is another dummy variable that is 1 if *NI* for the current year and *NI* for the previous year are both negative.

$$INTWO = MAX(NI_t, NI_{t-1}) < 0$$

*CHIN* is *NI* for the current year - *NI* for the previous year all over the sum of the absolute value of *NI* for the current year and the absolute value of *NI* for the previous year

$$CHIN = \frac{NI_t - NI_{t-1}}{|NI_t| + |NI_{t-1}|}$$

Altman's Z is calculated using weighted averages of working capital (*WC*, calculated as *TCA* - *TCL*), retained earnings (calculated as *NI* - dividends per share (*DIVC*, found in tidyincome) \* *TCSO*), earnings before interest and taxes (*EBIT*, calculated using earnings before interest, taxes, depreciation, and assets (*EBITDA*) from Yahoo Finance - *DP.DPL* - amortization (*AM*, found in tidycash)), *ME*, and *TREV*, all over *TA*.

$$Z = \frac{1.2 * WC + 1.4 * RE + 3.3 * EBIT + 0.6 * ME + TREV}{TA}$$

*EVOL* is calculated as the standard deviation of *ROE* for a four year span. AQR recommends the past five years, but for the same reason stated in the Growth section, we use the a four year span.

$$EVOL = \sigma\left(\sum_{i=t-4}^t ROE_i\right)$$

Likewise, we standardize each variable and then standardize each safety measure, so

$$Safety = z(z_{bab} + z_{ivol} + z_{lev} + z_o + z_z + z_{evol})$$

## Payouts

Payouts is composed of three variables: net equity issuance (*EISS*), net debt issuance (*DISS*), and total net payout over profits (*NPOP*). *EISS* is

calculated as the negative log of the ratio of  $TCSO$  of the most recent year and  $TCSO$  of the previous year.

$$EISS = -\log\left(\frac{TCSO_t}{TCSO_{t-1}}\right)$$

Though AQR uses split-adjusted number of shares, we are currently using  $TCSO$  given available information and will adjust for splits in future iterations of qmj.  $DISS$  is calculated as the negative log of the ratio of  $TD$  of the most recent year and  $TD$  of the previous year.

$$DISS = -\log\left(\frac{TD_t}{TD_{t-1}}\right)$$

$NPOP$  is calculated as  $NI - \Delta BE$  over a four year span all over sum of  $GPROF$  for the past four years (for the same reason as explained in the Growth section).

$$NPOP = \frac{NI - \Delta BE}{\sum_{i=t-4}^t GPROF_i}$$