Case Study - Amazon (AMZN)
Valuation Parameters Via Linear Regression

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In this white paper we will use a regression analysis of publicly-traded company annual reports to generate estimates for the following valuation model parameters:

Index	Description	Useage
1	Pre-tax revenue margin	Estimating net income (addition to net cash flow)
2	Ratio of assets to revenue	Estimating capital expenditures (subtraction from net cash flow)

Our goal is to use regression analysis and audited public company annual reports to generate estimates of the parameters in the table above. To that end we will work through the following hypothetical problem...

Our Hypothetical Problem

We are tasked with estimating the short-term and long-term values of Amazon's pre-tax return on assets and ratio of assets to revenue. The table below presents results of operatings for Amazon (AMZN) over the years ended 2014 to 2024...

Table 1: Balance Sheet and Income Statement Base Values (Dollars in millions)

Report	Balance Sheet		Income Statement		Revenue	Assets to
Year	Assets	Capital	Revenue	Expense	Margin	Revenue
2014	33,770	7,933	88,988	88,810	0.20%	–
2015	41,877	10,348	107,006	104,773	2.09%	39.14%
2016	53,637	16,486	135,987	131,801	3.08%	39.44%
2017	86,974	14,843	177,866	173,760	2.31%	48.90%
2018	10,6850	30,036	232,887	220,466	5.33%	45.88%
2019	155,473	48,292	280,522	265,981	5.18%	55.42%
2020	221,782	78,567	386,064	363,240	5.91%	57.45%
2021	309,129	124,250	469,822	444,943	5.30%	65.80%
2022	372,361	130,242	513,983	501,735	2.38%	72.45%
2023	418,285	182,126	574,785	537,933	6.41%	72.77%
2024	500,618	262,930	637,959	569,366	10.75%	78.47%

Base value definitions:
Base assets: Total GAAP assets minus cash and securities, goodwill and non operating assets.
Base capital: Total GAAP capital minus goodwill and other equity (unrealized gains and losses).
Base revenue: Sales plus operating investment gain/(loss) plus other operating income.
Base expense: Cost of sales plus R&D expense plus SG&A expense plus other operating expense.

Questions:
1. Estimate Amazon's short-term and long-term pre-tax revenue margins.
2. Estimate Amason's short-term and long-term ratios of assets to revenue.
3. How reliable are the estimates in Questions 1 and 2 above?

Pre-Tax Revenue Margin

We will define the variable R_t to be annualized operating revenue at time t, the variable E_t to be annualized operating expense (excludes income taxes) at time t, and the variable ω_t to be the pre-tax revenue margin. The equation for pre-tax revenue margin at time t is...

$$\omega_t = \frac{R_t - E_t}{R_t} \tag{1}$$

Using Equation (1) above, the regression equation for operating expense as a function of operating revenue is...

$$\text{If... Operating expense} = f(\text{Operating revenue}) \;\; \text{...then...} \;\; E_t = \alpha + \beta\, R_t \tag{2}$$

Using Equations (1) and (2) above, the revised equation for pre-tax revenue margin at time t is...

$$\omega_t = \frac{R_t - E_t}{R_t} = \frac{R_t - \alpha - \beta\, R_t}{R_t} = \frac{R_t\,(1-\beta)}{R_t} - \frac{\alpha}{R_t} = 1 - \beta - \frac{\alpha}{R_t} \tag{3}$$

Using the data in Table 1 above, the tables below present operating revenue and operating expense for the reporting periods 2014 to 2024, and regression estimated operating expense and residuals over those reporting periods...

Table 2: Operating Revenue and Expense (dollars in billions)

Report Year	X Revenue	Y Expense	X Squared	Y Squared	Product X Y
2014	88.99	88.81	7,919	7,887	7,903
2015	107.01	104.77	11,450	10,977	11,211
2016	135.99	131.80	18,492	17,372	17,923
2017	177.87	173.76	31,636	30,193	30,906
2018	232.89	220.47	54,236	48,605	51,344
2019	280.52	265.98	78,693	70,746	74,614
2020	386.06	363.24	149,045	131,943	140,234
2021	469.82	444.94	220,733	197,974	209,044
2022	513.98	501.74	264,179	251,738	257,883
2023	574.79	537.93	330,378	289,372	309,196
2024	637.96	569.37	406,992	324,178	363,232
Total	3,605.87	3,402.81	1,573,753	1,380,985	1,473,490

Table 3: Regression Estimates

Expense Estimate	Squared Residuals SSE	SST
91.07	5.12	48,636.21
107.54	7.66	41,850.19
134.03	4.96	31,522.29
172.30	2.12	18,383.61
222.59	4.52	7,899.69
266.13	0.02	1,880.54
362.59	0.42	2,904.54
439.14	33.62	18,386.50
479.51	494.08	37,013.46
535.08	8.15	52,251.93
592.82	549.99	67,610.31
–	1,110.66	328,339.26

Note: In the tables above, the variable X is the independent variable (revenue), the variable Y is the dependent variable (expense), the variable SSE is the sum of squared errors (actual - estimate squared), and the variable SST to be the sum of squared errors using the mean vs the estimate (actual - mean squared).

Using Table 2 above, the table below presents the regression statistics that we will need to calculate our regression model parameters where alpha is the constant and beta is the indepent variable multiple...

Table 4: Reported Revenue and Expense Statistics

Description	Symbol	Value	Calculation
Number of observations	N	11	2014 to 2024
Mean of X	$\bar{X}$	328	$\frac{1}{N} \times 3,605.87$
Mean of Y	$\bar{Y}$	309	$\frac{1}{N} \times 3,402.81$
Variance of X	σ_x^2	35,612	$\frac{1}{N} \times 1,573,753 - \bar{X}^2$
Variance of Y	σ_y^2	29,849	$\frac{1}{N} \times 1,380,985 - \bar{Y}^2$
Covariance of X and Y	Cov(x,y)	32,548	$\frac{1}{N} \times 1,473,490 - (\bar{X} \times \bar{Y})$

Using Table 4 above, the table below presents our regression model parameters...

Table 5: Regression Model Parameters

Description	Value	Calculation
Correlation of X and Y	0.9983	$Cov(x,y)/(\sigma_x\,\sigma_y)$
Beta (β)	0.9140	$Cov(x,y)/\sigma_x^2$
Alpha (α)	9.7396	$\bar{Y}-\beta\,\bar{X}$
R-Squared (Goodness of fit)	0.9966	$(SST-SSE)/SST$
SSE	1,111	from Table 3
SST	328,339	from Table 3
Standard error of estimate	11.11	$SQRT(SSE)/(N-2)$

Using Equation (3) above and the tables above, our estimated pre-tax revenue margin at time zero is...

$$\text{Short-term margin} = \omega_0 = 1-\beta-\frac{\alpha}{R_0} = 1-0.9140-\frac{9.7396}{637.96} = 7.08\% \tag{4}$$

Using Equation (3) above and the tables above, our estimated pre-tax revenue margin at time infinity is...

$$\text{Long-term margin} = \omega_\infty = \lim_{t\to\infty}\left[1-\beta-\frac{\alpha}{R_t}\right] = 1-\beta = 8.60\% \tag{5}$$

Note that Equation (5) above assumes that the secular revenue growth rate is greater than zero. If the variable μ is the revenue growth rate then the equation for operating revenue at time t is...

$$R_t = R_0\,\text{Exp}\left\{\mu\,t\right\} \;\text{...where...}\; \mu > 0 \tag{6}$$

Ratio of Assets to Revenue

We will define the variable A_t to be operating assets at time t and the variable ϕ_t to be the ratio of operating assets to operating revenue at time t. The equation for this ratio at time t is...

$$\phi_t = \frac{A_t}{R_t} \tag{7}$$

Using Equation (7) above, the regression equation for the ratio of operating assets to operating revenue at time t is...

$$\text{If... Operating assets} = f(\text{Operating revenue}) \;\text{...then...}\; A_t = \alpha+\beta\,R_t \tag{8}$$

Using Equations (7) and (8) above, the revised equation for the ratio of operating assets to operating revenue at time t is...

$$\phi_t = \frac{A_t}{R_t} = \frac{\alpha+\beta\,R_t}{R_t} = \frac{\alpha}{R_t}+\beta \tag{9}$$

Using the data in Table 1 above, the tables below present operating revenue and operating assets for the reporting periods 2014 to 2024, and regression estimated operating assets and residuals over those reporting periods...

Table 6: Operating Revenue and Assets (dollars in billions)

Report Year	X Revenue	Y Assets	X Squared	Y Squared	Product X Y
2014	88.99	33.77	7,919	1,140	3,005
2015	107.01	41.88	11,450	1,754	4,481
2016	135.99	53.64	18,492	2,877	7,294
2017	177.87	86.97	31,636	7,564	15,470
2018	232.89	106.85	54,236	11,417	24,884
2019	280.52	155.47	78,693	24,172	43,614
2020	386.06	221.78	149,045	49,187	85,622
2021	469.82	309.13	220,733	95,561	145,236
2022	513.98	372.36	264,179	138,653	191,387
2023	574.79	418.29	330,378	174,962	240,424
2024	637.96	500.62	406,992	250,618	319,374
Total	3,605.87	2,300.76	1,573,753	757,906	1,080,790

Table 7: Regression Estimates

Assets Estimate	Squared Residuals SSE	SST
10.05	562.47	30,761.52
25.08	282.29	27,983.48
49.24	19.36	24,187.29
84.15	7.96	14,929.33
130.02	537.04	10,467.26
169.74	203.49	2,882.25
257.73	1,292.25	159.32
327.56	339.71	9,993.87
364.38	63.73	26,634.69
415.07	10.34	43,733.42
467.74	1,081.08	84,947.98
Total	4,399.73	276,680.42

Note: In the tables above, the variable X is the independent variable (revenue), the variable Y is the dependent variable (assets), the variable SSE is the sum of squared errors (actual - estimate squared), and the variable SST to be the sum of squared errors using the mean vs the estimate (actual - mean squared).

Using Table 6 above, the table below presents the regression statistics that we will need to calculate our regression model parameters where alpha is the constant and beta is the indepent variable multiple...

Table 8: Reported Revenue and Assets Statistics

Description	Symbol	Value	Calculation
Number of observations	N	11	2014 to 2024
Mean of X	$\bar{X}$	328	$\frac{1}{N} \times 3,605.87$
Mean of Y	$\bar{Y}$	209	$\frac{1}{N} \times 2,300.76$
Variance of X	σ_x^2	35,612	$\frac{1}{N} \times 1,573,753 - \bar{X}^2$
Variance of Y	σ_y^2	25,153	$\frac{1}{N} \times 757,906 - \bar{Y}^2$
Covariance of X and Y	Cov(x,y)	29,690	$\frac{1}{N} \times 1,080,790 - (\bar{X} \times \bar{Y})$

Using Table 8 above, the table below presents our regression model parameters...

Table 9: Regression Model Parameters

Description	Value	Calculation
Correlation of X and Y	0.9920	$Cov(x,y)/(\sigma_x\,\sigma_y)$
Beta (β)	0.8337	$Cov(x,y)/\sigma_x^2$
Alpha (α)	-64.1369	$\bar{Y} - \beta\,\bar{X}$
R-Squared (Goodness of fit)	0.9841	$(SST - SSE)/SST$
SSE	4,400	from Table 3
SST	276,680	from Table 3
Standard error of estimate	22.11	$SQRT(SSE)/(N-2)$

Using Equation (7) above and the tables above, our estimated ratio of assets to revenue at time zero is...

$$\text{Short-term ratio of assets to revenue} = \phi_0 = \frac{\alpha}{R_t} + \beta = \frac{-64.14}{637.96} + 0.8337 = 73.32\% \tag{10}$$

Using Equation (7) above and the tables above, our estimated pre-tax revenue margin at time infinity is...

$$\text{Long-term ratio of assets to revenue} = \phi_\infty = \lim_{t \to \infty} \left[\frac{\alpha}{R_t} + \beta \right] = \beta = 83.37\% \tag{11}$$

Note that Equation (11) above assumes that the secular revenue growth rate is greater than zero (see Equation (6) above).

Answers To Our Hypothetical Problem

Question 1. Estimate Amazon's short-term and long-term pre-tax revenue margins.

Using Equations (4) and (5) above, our regression estimates of the short-term and long-term pre-tax revenue margins are...

$$\omega_0 = 7.08\% \text{ ...and... } \omega_\infty = 8.60\% \tag{12}$$

Question 2. Estimate Amason's short-term and long-term ratios of assets to revenue.

Using Equations (10) and (11) above, our regression estimates of the short-term and long-term ratios of assets to revenue are...

$$\phi_0 = 73.32\% \text{ ...and... } \phi_\infty = 83.37\% \tag{13}$$

Question 3. How reliable are the estimates in Questions 1 and 2 above?

Using Tables 5 and 9 above, the goodness of fits for those variables are...

$$\text{Revenue margin R-Squared} = 99.66\% \text{ ...and... Assets ratio R-Squared} = 98.41\% \tag{14}$$

For both variable estimates the R-Squared is very high (almost one) so the short-term and long-term estimates should be reliable.

Notes

Support for the regression equations in this white paper can be found in the white paper **Univariate Ordinary Least Squares Estimator, Schurman (2011)**.