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Counterpoint Global Insights

Underestimating the Red Queen

Measuring Growth and Maintenance Investments

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Introduction

Geoffrey West is a theoretical physicist who may be best known for his work in biological systems. A distinguished professor and past president of the Santa Fe Institute, West and his collaborators explained previously unexplained empirical phenomenon.[1]

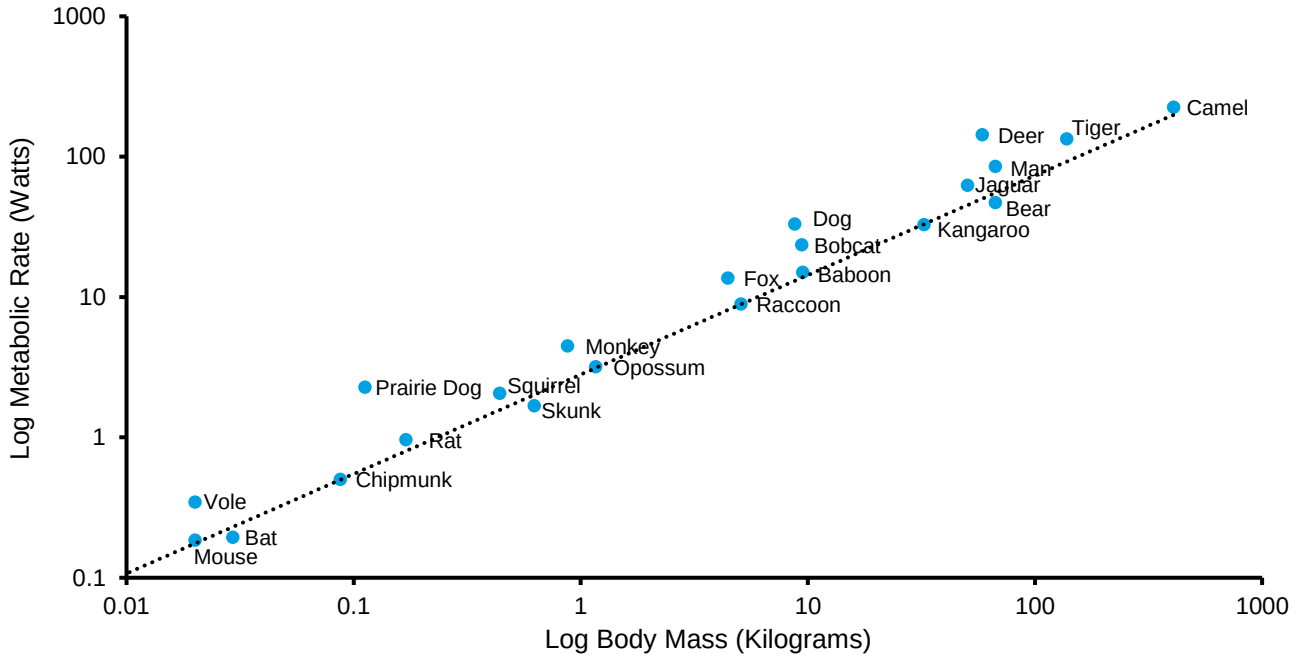
The most famous of these is the eponymous law developed by a biologist named Max Kleiber.[2] In exhibit 1, which depicts the law, the x-axis is an animal's body mass, measured on a logarithmic scale. (Instead of 1, 2, 3, the scale is 1, 10, 100 so that the percentage difference between the points is the same.) The y-axis, also on a logarithmic scale, measures the animal's metabolic rate, or energy used per unit of time. Kleiber's law is the observation that the outcome of the plot is a straight line with a slope, or rise over run, of three-fourths (¾). This is a classic example of a power law. As West explains, "the slope of the graph is just the exponent of the power law."[3]

Simply stated, West and his research partners used math to show that the relationship is the result of how energy is dissipated through a network.[4] Evolution figured out the optimal network structure to feed all of the cells in the body, which applies to a mouse as it does to an elephant. Nature is amazing.

The principles behind these networks explain other features of the systems, including the rate of blood flow, the number of heartbeats, longevity, and growth. Some of these scaling laws apply to social systems as well, including cities and companies.[5]

Our focus is on growth. We are all familiar with physical growth, as we ourselves grew and we watch the growth of others. But have you ever wondered why you stopped growing? Indeed, other living things, including certain trees, fish, and plants, grow until they die. Since you continue to provide your body with energy through nourishment, why did you reach a point of maturity and stop growing taller?

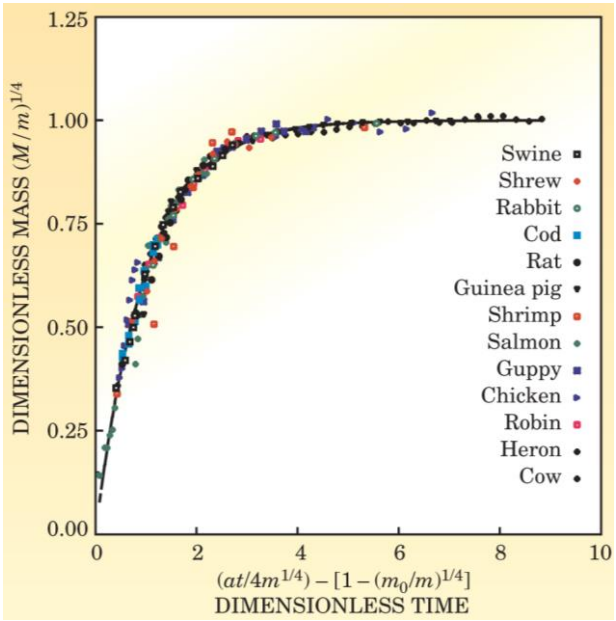
Exhibit 1: Kleiber's Law



Source: Based on Supplementary Material 1: Basal Metabolic Rate, Body Mass & Temperature in Mammals, Data set for Andrew Clarke, Peter Rothery, and Nick J. B. Isaac, "Scaling of basal metabolic rate with body mass and temperature in mammals," Journal of Animal Ecology, *Vol. 79, No. 3, May 2010, 610-619.*

West explains that energy is allocated between the growth of new cells and the maintenance and repair of existing ones. When you are born, your energy can largely be directed toward growth. But after you reach a certain size, all of your energy has to go to maintenance and repair and you stop growing.[6] Scientists have developed equations that predict the relationship between age and size. It turns out the growth curves are the same for all animals when you replace specific units of time and mass with dimensionless units (see exhibit 2).[7]

Exhibit 2: Universal Growth Curve



Source: Geoffrey West.

In this report, we suggest that a similar framework is relevant for understanding corporate growth. Indeed, West and another group of colleagues have derived a universal growth curve for companies.[8] Instead of energy, the input is financial capital. But the allocation between growth and maintenance is the same.

This topic is important because you can anticipate a company's growth only if you understand how much capital the company spends on growth versus maintenance. A company's prospects for growth may be dimmer than you believe if it is spending more on maintenance than you think. In Lewis Carroll's novel, *Through the Looking-Glass*, the Red Queen says, "Now, *here*, you see, it takes all the running *you* can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!"[9] Estimating maintenance capital expenditures provides insight into how fast a company has to run just to stay in place.

The distinction between growth and maintenance spending is complicated by the role of inflation and technological obsolescence. When prices are rising, capital expenditures will exceed depreciation even when the business is stable because new capital expenditures reflect inflation while depreciation is based on historical costs. In the case of falling prices, or deflation, capital expenditures get cheaper over time and depreciation can overstate maintenance costs. Think of products that have benefitted from Moore's Law, which suggests the cost of computing declines over time. Sometimes first movers have to spend more than followers do.[10]

Technological obsolescence creates the risk that a company overestimates an asset's useful life. For example, the costs for companies in certain industries addressing climate change, or for automobile manufacturers migrating from internal combustion engines to electric vehicles, are potentially massive. These costs are necessary to maintain market position, sales, and competitiveness.

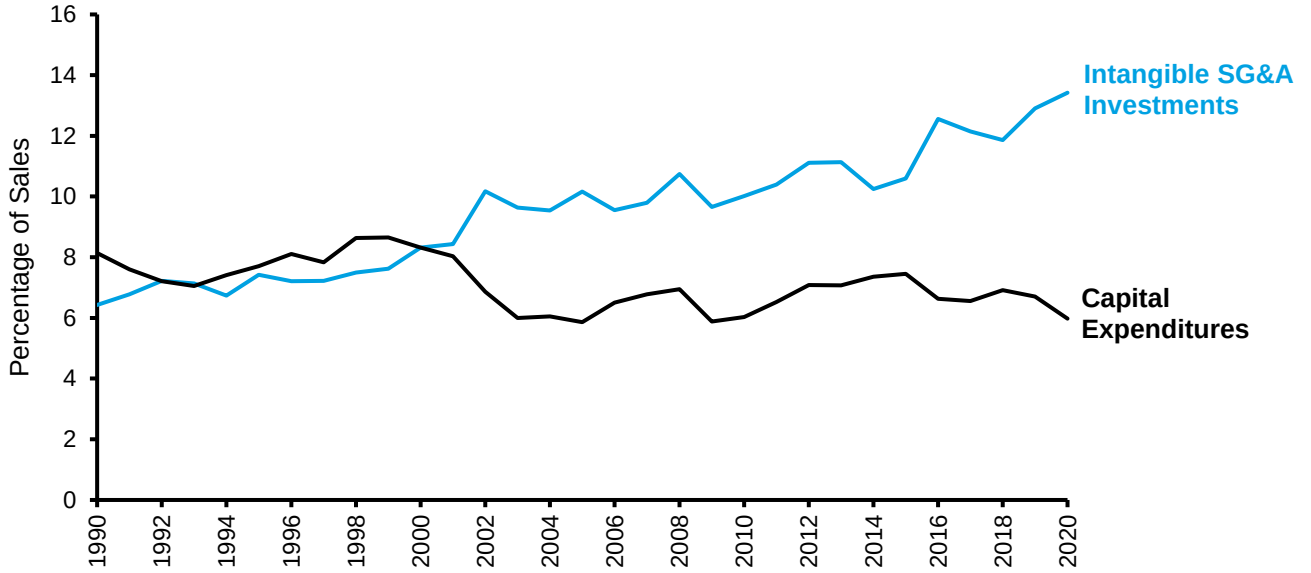
In the cases of inflation or obsolescence, less investment will go toward growth and more will be required to maintain current operations.

Investment spending for growth is not limited to tangible assets but also includes non-physical intangible assets. Today, total intangible investments exceed tangible ones and accounting for them is very challenging. For example, a young company's sales and marketing budget is often dedicated primarily to acquiring new customers, but as the business matures that expense is split between growth spending to acquire new customers and maintenance spending to retain customers.

The data suggest two stories of growth. For tangible assets, depreciation tends to understate maintenance capital expenditures. The tangible part of the economy is on average mature, with capital expenditures as a percentage of sales flat to down for the last three decades. This is important because recent research shows that firms that underestimate their maintenance investments "experience future write-offs and negative future earnings" and are associated with "significantly negative future abnormal stock returns."[11]

The intangible part of the economy appears to be younger. Intangible selling, general, and administrative (SG&A) investments as a percentage of sales have risen steadily over the last three decades, with some acceleration in growth since the turn of the century (see exhibit 3). This is relevant because firms with high intangibles grow faster, on average, than firms with low intangibles but also have a higher standard deviation of growth.[12] Academics studying this issue found that buying firms with high intangibles and shorting those with low intangibles generated an average annual return of 4.6 percentage points from June 1989 to November 2020.[13]

Exhibit 3: Intangible SG&A Investments and Capital Expenditures, 1990-2020



Source: Intangible SG&A investments is based on Luminita Enache and Anup Srivastava, "Should Intangible Investments Be Reported Separately or Commingled with Operating Expenses? New Evidence," Management Science*, Vol. 64, No. 7, July 2018, 3446-3468. Data extended through 2018 by Anup Srivastava. Includes Counterpoint Global estimates. FactSet. Note: Intangible SG&A investments and capital expenditures reflect the Russell 3000 excluding the financial and real estate sectors; Intangible investments=R&D + Advertising + Investment Main SG&A.*

Accounting for Growth

Let's start with a simple case before we introduce complexity.[14] Assume a company needs four machines with a useful life of four years each to run its operations. The sales for the company are in a steady state, the ages of the machines are staggered (new, one-year old, etc.), the machines have no salvage value, and the company uses straight-line depreciation. At the end of each year, the company spends $80,000 to replace the machine at the end of its life and there is no inflation. Capital expenditures and the depreciation for each year are $80,000.

Free cash flow, the number we project and discount in a discounted-cash flow model, is typically defined as net operating profit after taxes (NOPAT) minus investment in future growth (I). Investment in future growth captures changes in net working capital, as companies often need to increase their working capital as they grow, and capital expenditures net of depreciation. The simplifying assumption is that depreciation is a reasonable proxy for maintenance capital spending and that investment in excess of depreciation is allocated to growth.

The analytical issue we need to address is whether depreciation is in fact a decent proxy for maintenance capital expenditures and the ramifications if it misses the mark. Appendix A examines whether companies themselves know the level of maintenance capital spending.

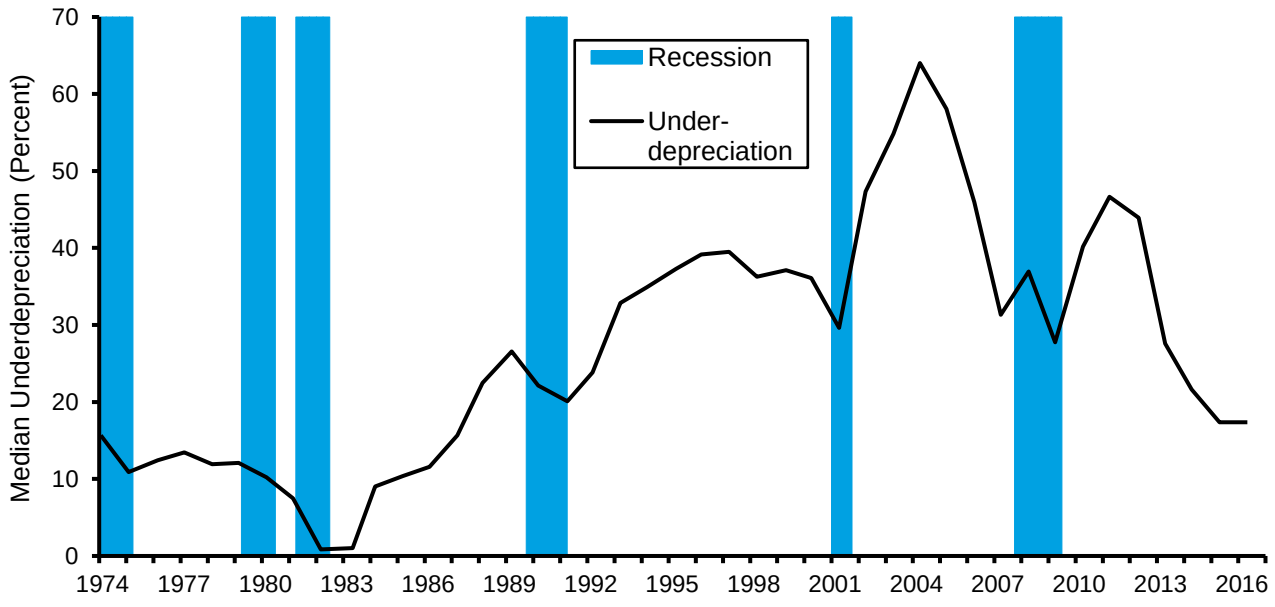
How do we know if a company's depreciation understates its maintenance capital spending? Venkat Peddireddy, an assistant professor of accounting at China Europe International Business School, created a method to do this. He calculates "cumulative capacity cost," a measure of maintenance spending, as the sum of depreciation and amortization (D&A), asset write-downs, loss on the sale of assets, goodwill impairment, and intangible asset impairments over a five-year period. This calculation considers both normal wear and tear via depreciation as well as write-downs or losses that might be related to technological obsolescence.

He then divides the cumulative capacity cost by the cumulative sales over the same period. That ratio provides an estimate of the cost of assets required to generate a dollar's worth of sales. Multiplying that ratio by current year sales yields a measure of maintenance capital expenditures.

Peddireddy tests this on all companies of a sufficient size from 1974 through 2016 and includes nearly all industries. These companies follow U.S. generally accepted accounting principles. He finds that in the aggregate, maintenance capital expenditures exceed D&A by about 20 percent (see exhibit 4). Appendix B shows that there is substantial variance in this percentage by industry, and you can infer that there are additional differences for individual companies within the industries.

That maintenance capital expenditures surpass D&A means that less capital is going toward investment than many investors think. He attributes this understatement of D&A to technological obsolescence. Inflation has the same effect and deflation has the opposite effect.[15]

Exhibit 4: Amount That Maintenance Capital Expenditures Exceed D&A, 1974-2016



Source: Venkat Ramana Reddy Peddireddy, "Estimating Maintenance CapEx," PhD Thesis—Columbia University, *2021.*

Here's a simple example of how this might work. Let's say a company bought a machine and assumed a useful life of four years. But after three years the company realizes, as the result of technological obsolescence, that the machine no longer has value. The company will take an asset write-down to reflect that reality, and it is clear that the depreciation understated the asset's useful life and hence maintenance capital spending.

Sorting growth versus maintenance spending is essential and Peddireddy's analysis provides a framework for considering the issues. It also shows that the breakdown between growth and maintenance matters for total shareholder returns. But his approach fails to capture a few issues that are relevant to the overall results and important for investors.

Limitations of the Approach

The first limitation is a potential asymmetry in what the data capture. Companies that overstate the useful lives of their assets will need to write them down. But this analysis won't reflect situations when companies understate the useful lives of their assets. In effect, these companies get the free use of an asset after it has been depreciated fully.

To be clear, companies that understate the useful lives of assets are much rarer than those that overstate them, if for no other reason than a longer assumed asset life leads to higher short-term earnings. But it is nonetheless a consideration.

For example, Amazon, Alphabet (the parent company of Google), and Microsoft all recently changed their estimates of the useful life of their servers from three to four years. Here's the paragraph from Amazon's Form 10-K for the year ended December 31, 2020 that describes the change:[16]

> "We review the useful lives of equipment on an ongoing basis, and effective January 1, 2020 we changed our estimate of the useful life for our servers from three years to four years. The longer useful life is due to continuous improvements in our hardware, software, and data center designs. The effect of this change . . . was a reduction in depreciation and amortization expense of $2.7 billion and an increase in net income of $2.0 billion."

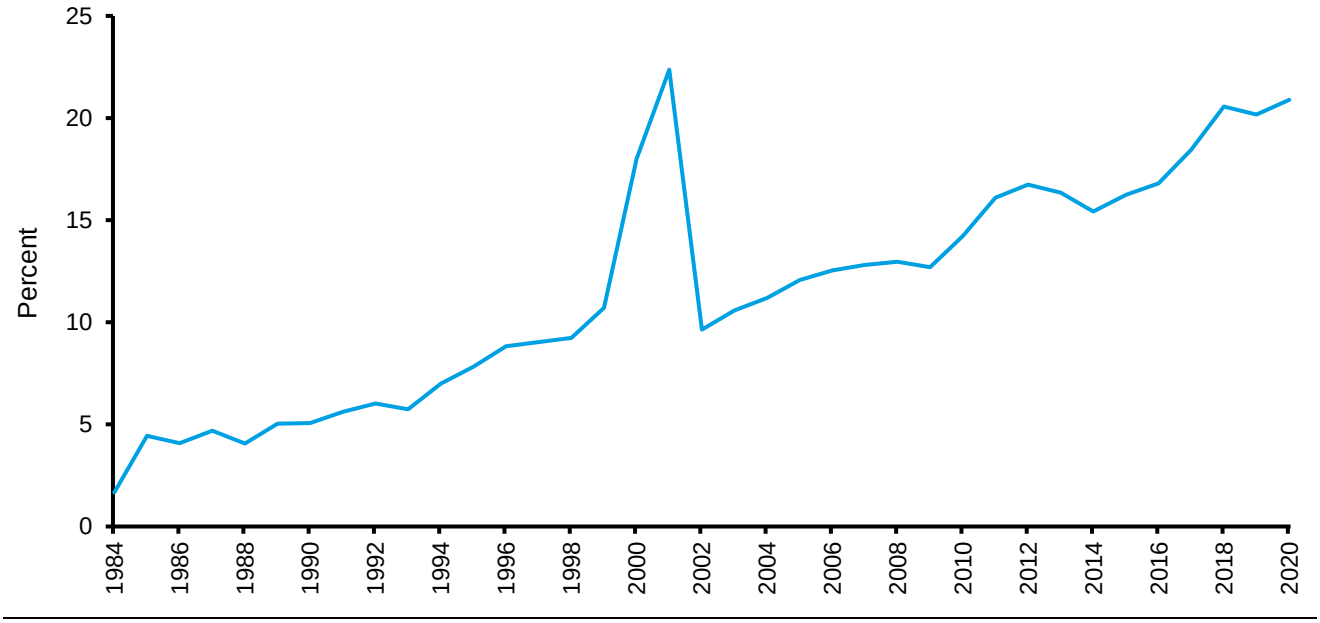
To put this in context, Amazon's net income was $21.3 billion in 2020. That means we can attribute just under 10 percent of the company's earnings to this accounting change. The adjustment boosted Alphabet's and Microsoft's earnings by more than $2 billion each in fiscal 2021.[17]

This approach also struggles to capture how the evolution of accounting rules, especially those related to mergers and acquisitions (M&A), can affect the numbers. Peddireddy's analysis covers more than four decades, and during that period there have been a lot of changes in how companies can account for M&A. For example, prior to 2001 companies could use either the purchase or pooling-of-interests method. With purchase accounting, any premium to book value was recorded as goodwill and then amortized over a period of up to 40 years. With pooling, the two companies simply combined their balance sheets.

In 2001, the Financial Accounting Standards Board (FASB) issued Accounting Standards No. 141, which got rid of pooling-of-interests. It also replaced the amortization of goodwill with an annual goodwill impairment test. As a result, amortization as a percentage of depreciation and amortization plummeted from 22 percent in 2001 to about 10 percent in 2002 (see exhibit 5).

This is relevant because it changes the calculation of the cumulative capacity cost. Before the accounting change, a company that made an acquisition using purchase accounting would have to amortize the goodwill it recorded on its balance sheet. After the accounting change, the same company doing the same deal would not have to amortize the goodwill. The cumulative capacity cost, which includes amortization, would therefore be lower assuming no impairment.

Exhibit 5: Amortization as a Percentage of Depreciation and Amortization



Source: FactSet.
Note: Russell 3000 excluding the financial and real estate sectors.

In 2007, the FASB recognized that it needed to tighten its guidelines and released a revised version of No. 141.[18] This provided greater specificity about what the company should record as an intangible asset, which is amortized on the income statement, and goodwill, which is subject only to impairment tests.[19] The result was a rise in intangible assets and the amortization of acquired intangibles. All of this was aided by lots of M&A.

The final limitation is the biggest, by far, and deserves a separate discussion.

The Rise of Intangibles: How Do We Sort Investment from Maintenance Spending?

The global economy has shifted from one relying primarily on tangible investments to one that is based on intangible assets. As recently as the 1970s, tangible investments in the U.S. were twice as large as intangible investments. Today, that ratio has flipped. For example, we estimate that companies in the Russell 3000 expensed $1.8 trillion for intangible investments in 2020, more than double their capital expenditures of $800 billion. These and the following figures exclude the financial and real estate sectors.

The formula for growth is the same as for tangible assets. Companies spend on intangible assets and the money is allocated between growth and maintenance.[20] A simple but important case in point is spending on research and development (R&D). Many academics and practitioners assume that R&D is a discretionary investment, which means that it is all about growth and has nothing to do with maintenance.

But professors who examined the issue carefully concluded that a meaningful percentage of R&D spending, especially for large digital technology companies, is in fact necessary just to maintain the current operations.[21] Understanding this ratio for R&D as well as for other categories of intangible investment is essential to assessing a company's prospects.

While Peddireddy's analysis is solid for tangible assets, the task is a lot more difficult for intangible assets because of the inconsistent way they are treated by accountants. Specifically, organic intangible investment and maintenance spending are expensed on the income statement. Acquired intangible assets are recorded on the

balance sheet following a deal, but the ongoing spending to maintain the value of those intangible assets is again expensed.

To solidify these ideas, pretend that Company A acquires Company B at a premium to book value. The assets of Company B are a number of machines with specified useful lives and a list of customers who subscribe to a service.

Company A records the machines as property, plant, and equipment (PP&E) on its balance sheet and depreciates the assets on the income statement over their useful lives. Future growth and maintenance spending are also capitalized. Depreciation is a solid proxy for maintenance capital spending if it matches the useful lives of the machines. If, on the other hand, technological obsolescence means that the useful lives are less than the depreciation schedule suggests, Company A will eventually have to write down the assets. Peddireddy's approach provides valuable insight for physical assets.

But things are different for the customer list. Company A posts the acquired list as an intangible asset on the balance sheet and amortizes it over its estimated useful life. But it expenses the money it spends to maintain and grow the list on the income statement within SG&A. This is why we use earnings before interest, taxes, and amortization of acquired intangibles (EBITA), rather than earnings before interest and taxes (EBIT), when we calculate NOPAT. The appearance of the customer list on the balance sheet is a one-time event as a result of the acquisition, and spending for future maintenance and growth reverts to the income statement.

Exhibit 6 shines a spotlight on these issues by providing some estimates for the Russell 3000 in 2020. The columns are tangible and intangible assets and the rows are where on the income statement and balance sheet the accounting for these investments appears.

Exhibit 6: Accounting for Growth and Maintenance

	Tangible Asset	Intangible Asset
Income Statement	• Depreciation Expense $700 Billion	• Intangible Selling, General, and Administrative $1,830 Billion • Amortization of Acquired Intangibles $190 Billion
Balance Sheet	• Net Property, Plant, and Equipment $6,700 Billion	• Intangible Assets (Acquired Only) $1,150 Billion

Source: Counterpoint Global and FactSet.
Note: Russell 3000 excluding the financial and real estate sectors.

Let's start with tangible assets. These assets show up on the income statement in the form of depreciation expense (upper left quadrant). Depreciation is the result of the matching principle in accounting that requires sales and related expenses to be matched during a period.

Companies commonly report their results using straight-line depreciation, which spreads the expense of an asset evenly over its useful life. For example, a company that spends $500 to buy a machine with a useful life of 5 years would recognize a depreciation expense of $100 per year for 5 years. Total depreciation for companies in the Russell 3000 was about $700 billion in 2020.

Capital expenditures are added to gross PP&E on the balance sheet and are then depreciated over time (lower left quadrant). Net PP&E is gross PP&E minus accumulated depreciation. Total net PP&E for companies in the Russell 3000 was $6.7 trillion in 2020.

We now turn to intangible assets. We estimate that for companies in the Russell 3000, $1.8 trillion of total SG&A expense was in the form of intangible investments in 2020 (upper right quadrant). Further, the amortization of acquired intangibles was almost $200 billion. Acquired intangibles are amortized in the same fashion that capital expenditures are depreciated.

Finally, intangible assets are reflected on the balance sheet following an acquisition (lower right quadrant). Accountants identify an item as an intangible asset if it meets one of two criteria. The first is that it arises from contractual or other legal rights. The second is that it can be separated or divided from the company.[22] Acquired intangible assets have averaged about one-third of M&A deal value in recent years.[23]

Assets acquired that don't meet those criteria are recorded as goodwill, which is effectively the purchase price of the deal minus the fair value of tangible assets and identifiable intangible assets net of liabilities. Goodwill represents future economic benefits from acquired assets that are not individually identified and separately recognized. We estimate that acquired intangible assets with definite lives were $1.15 trillion for companies in the Russell 3000 at year-end 2020, and that acquired intangible assets with indefinite lives were about the same amount. Goodwill was $3.8 trillion.[24]

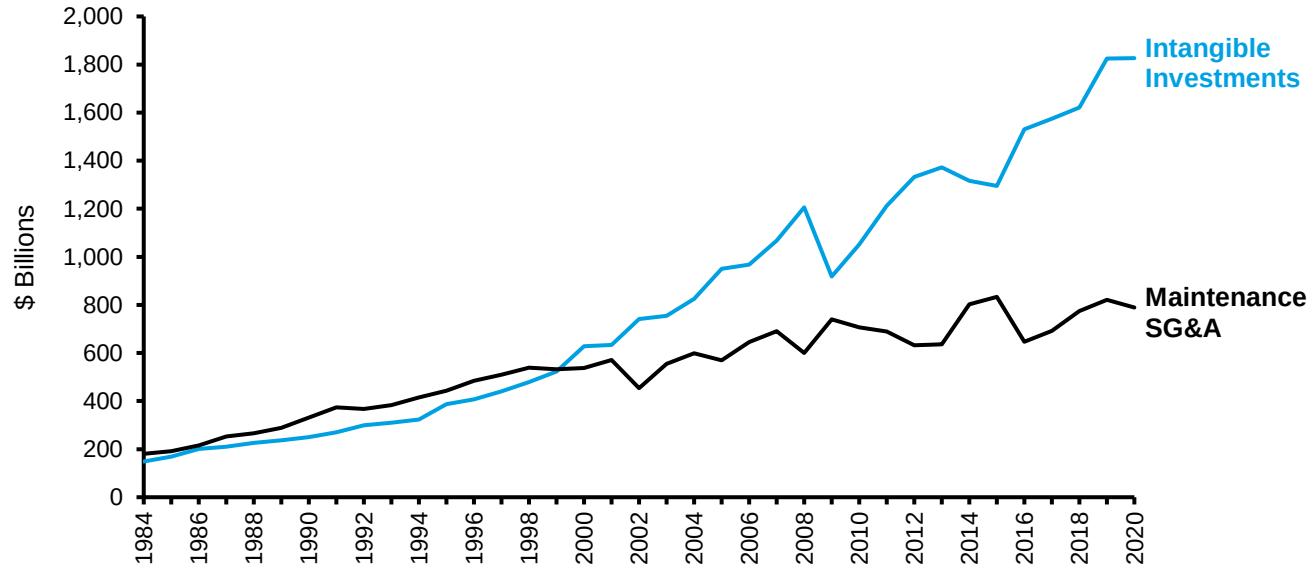
Just as an investor must think about growth and maintenance capital expenditures, he or she must also assess investment versus maintenance SG&A expense. This difficult challenge was addressed by two professors of accounting, Luminita Enache and Anup Srivastava, in their appropriately-named paper, "Should Intangible Investments Be Reported Separately or Commingled with Operating Expenses? New Evidence."[25] The answer is, "Yes, intangible investments should be reported separately," and the authors provide a method to do so.

They start by separating SG&A into two parts: the sum of research and development (R&D) and advertising, which are deemed to be intangible investments, and what they call "Main SG&A." In turn, they split Main SG&A into "Maintenance Main SG&A" and "Investment Main SG&A." Maintenance Main SG&A expenses support existing operations and are calculated by matching them with current revenues. Examples include rent for offices and distribution centers, delivery costs, and sales commissions.

What's left over is called "Investment Main SG&A," and is considered discretionary spending that is the source of future earnings. Maintenance Main SG&A is what a company has to spend to stay in place and Investment Main SG&A is what the company spends to pursue value-creating growth.

Exhibit 7 provides our estimates, guided by Enache and Srivastava's approach, for companies in the Russell 3000 from 1984 through 2020. Intangible investments are the sum of R&D, advertising, and Investment Main SG&A. Maintenance SG&A is simply Maintenance Main SG&A. In Appendix C we show how to estimate growth and maintenance spending for a specific company using a related approach. Microsoft is our case study.

Exhibit 7: Components of SG&A Costs, 1984-2020



Source: Analysis for Russell 3000 excluding the financial and real estate sectors based on Luminita Enache and Anup Srivastava, "Should Intangible Investments Be Reported Separately or Commingled with Operating Expenses? New Evidence," Management Science*, Vol. 64, No. 7, July 2018, 3446-3468. Data extended through 2018 by Anup Srivastava. Includes Counterpoint Global estimates. FactSet.*
Note: Intangible investments=R&D + Advertising + Investment Main SG&A; Maintenance SG&A=Maintenance Main SG&A.

Investment and maintenance SG&A grew roughly in lockstep until the turn of the century, when intangible investments took off. The slope of the growth trajectory for intangible investments steepened following the financial crisis of 2008-2009. In 2020, we estimate that R&D was about one-quarter of total intangible investment. Maintenance SG&A was $800 billion in the same year.

The contrast between tangible and intangible investments is instructive. As companies age, capital spending tends to shift from growth to maintenance. Peddireddy's work suggests that depreciation expense understates maintenance capital spending, which means there is less money left over to support growth. It also implies that earnings are overstated.

But companies appear young based on the sharp rise in intangible investment. A substantial and growing fraction of SG&A spending is going to support growth. We see this in the aggregate data as well.[26] The exercise of capitalizing intangible investments and amortizing them suggests that reported earnings are understated.[27]

Conclusion

Boiled down to the basics, a business invests money with the expectation of earning a satisfactory return on investment. Accounting is the language of business and provides information about a company's profits, financial position, and cash flows. All stakeholders, including executives, shareholders, and lenders, rely to some degree on accounting figures to understand a business and to get a sense of its prospects.

The key is that SG&A and capital expenditures have an investment component that drives future earnings growth and a maintenance component that is necessary to sustain the current operations. Work by Geoffrey West and his colleagues shows that many organisms, including mammals, follow a trajectory called "determinate" growth.

With age, the allocation of resources shifts from growth to maintenance. Growth stops at the point that maintenance needs consume all of the incoming energy. Companies appear to follow a similar pattern.

Getting a handle on growth versus maintenance spending is essential for executives and investors. But the truth is few actually have a clear sense of the figures. Shivaram Rajgopal, a professor of accounting at Columbia Business School, ponders, "I wonder how many [chief financial officers] CFOs even know their maintenance capex number. Asking that question, especially for intangibles such as R&D and certain aspects of SG&A, is even trickier."[28] He is right.

We believe that there are two big steps in the correct direction. The first is to get a better fix on maintenance capital expenditures. Recent work by Peddireddy and others suggests that depreciation understates maintenance capital expenditures, although the mismatch is different by industry and company.

The second is an estimate of what part of SG&A is an investment and what is required to sustain current operations. The task is complicated by the fact that most intangible assets are reflected on the balance sheet only following M&A. And even in cases where intangible assets do appear on the balance sheet, the spending to maintain the value of those assets is again part of the SG&A expense.

The data suggest a noteworthy difference between tangible and intangible investment. Tangible investment, as measured as a percentage of sales, has been flat to down in recent decades, and depreciation often understates maintenance capital spending. One of Peddireddy's important results is that the understatement of maintenance capital spending is linked to future write-offs and poor relative stock price returns.

Intangible investment has been up sharply in recent decades. The maintenance component of intangible investment has risen as well. For example, you should deem a reasonable percentage of R&D spending for large technology companies to be maintenance spending. But on balance more intangible investment is funding growth. Intangible-intensive companies grow faster on average and generate higher shareholder returns than tangible-intensive companies.

The goal of this discussion is to think about how resources translate into growth. In general, companies and investors should think about the split between growth and maintenance spending in the context of a life cycle. Early on, resources are skewed toward growth and they shift to maintenance later on. As a result, larger companies grow more slowly than smaller companies do on average.[29]

Most executives and investors likely underestimate maintenance spending as the result of inflation and technological obsolescence. A company with a competitor that has spent the money to provide a better good or service has little choice but to match the competitor's outlays. Further, technology companies constantly develop new versions of their products, with some of the cost allocated to R&D.

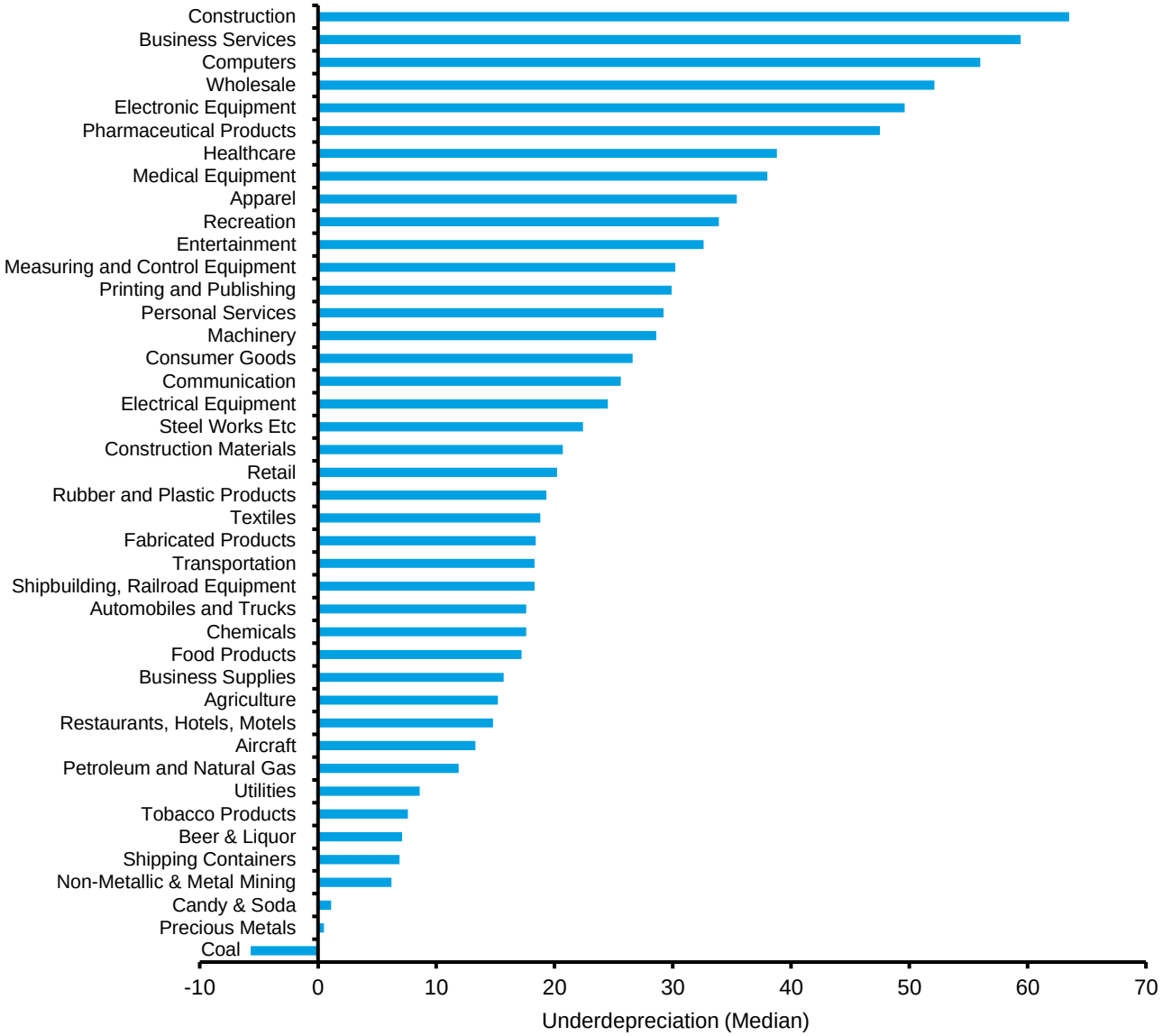
Appendix A: Do Companies Know the Amount of Their Maintenance Capital Expenditures?

Few companies disclose maintenance capital expenditures with the exception of those in the energy industry.[30] Energy companies can estimate maintenance capital expenditures and provide guidance because the basic concepts are reasonably straightforward. An energy company starts the year with a certain amount of reserves, which are deposits of natural resources that are known to exist with some certainty and are recoverable with existing technology. Let's say a company has reserves of 100 barrels of oil.

The company then taps this reserve to produce oil. To continue with the example, let's assume that production during the year was five barrels. The company now needs to acquire five barrels of reserves in order to maintain its position. Companies have a sense of the cost to acquire reserves, either through exploration or acquisition, which is then deemed to be maintenance capital spending.

Note that maintenance spending in the energy industry is pegged to production, not sales. That makes sense because commodity prices bounce around. In many other industries, and at the heart of analysis in this report, maintenance spending is linked to the level of sales.

Appendix B: Difference between Maintenance Capital Expenditures and Depreciation & Amortization (D&A) Expense Divided by D&A, By Industry, 1974-2016



Source: Venkat Ramana Reddy Peddireddy, "Estimating Maintenance CapEx," PhD Thesis—Columbia University, *2021.*

Appendix C: Calculating Investment and Maintenance Spending for Microsoft

A simple way of explaining how Venkat Peddireddy estimates maintenance capital spending is that he starts with depreciation and amortization (D&A). If accurate, D&A allows you to measure the useful lives of assets and hence maintenance capital spending. He then adds write-downs, losses on asset sales, and impairment of goodwill and intangible assets to see if the company correctly specified the lives of its assets. A write-down of a depreciable or amortizable asset indicates that a company spent more on maintenance capital investment than its D&A indicated. It also means that earnings were overstated.

Bruce Greenwald, a professor emeritus of finance and asset management at Columbia Business School, and his co-authors provide another approach to estimate maintenance capital expenditures.[31] Here we explain and expand on the core of his methodology and use Microsoft as a case study.

Greenwald starts by acknowledging that capital expenditures should be separated into growth and maintenance outlays. He follows with the premise that there is a stable relationship between the level of net PP&E and sales. He then calculates the five-year average ratio of net PP&E-to-sales. To illustrate, let's assume that ratio comes out to 30 percent.

Next, he calculates growth capital expenditures by multiplying this ratio of net PP&E-to-sales by the dollar change in sales in the most recent period. To continue with our example, we'll say that sales increased by $200. Growth capital expenditures would be $60 (.30 x $200).

Finally, we solve for maintenance capital expenditures by taking the difference between total capital expenditures and growth capital expenditures. To finish our example, we'll assume that total capital expenditures are $150. Total capital expenditures of $150 minus growth capital expenditures of $60 equals maintenance capital expenditures of $90 ($150 - $60 = $90).

This is a good time to pause and reiterate the pattern of growth most companies go through. Young companies grow faster on average than old companies do. Eventually growth flattens out and approaches the level of the overall economy. As growth peters out, the product of beginning year sales and the growth rate yields more modest dollar increases in sales. This means the mix shifts from growth to maintenance spending over time.[32]

One shortcoming of both Peddireddy's and Greenwald's analyses is that they don't properly account for intangible investments.[33] We now do an analysis for tangible and intangible investments and combine them to come up with an aggregate investment figure. We then calculate the ratio of assets-to-sales and estimate growth and maintenance investment spending.

Growth can result from internal investments as well as from external acquisitions. In the aggregate, companies spend more on mergers and acquisitions than they do on either tangible or intangible investments. To reflect this, we include Microsoft's acquisitions and allocate the deal value between tangible and intangible investment based on the company's disclosures.

Let's start with tangible capital. Here we include net PP&E and leases in the asset base, and our tangible investment number includes traditional capital expenditures, assets acquired under capital leases, and tangible assets from M&A.[34] Microsoft's ratio of net tangible assets to sales averaged 36 percent over the last 5 years, but you can see the ratio is increasing as the company commits resources to the cloud business. By this calculation, maintenance tangible investment has averaged a little more than two-thirds of the total tangible investment.

	Net Tangible Assets / Sales			Tangible Investments			
Fiscal Year	Annual	5-Year Average	Change in Sales	Growth	Maintenance	Total	Maintenance Tangible Investments / Sales
2017	32%	19%	11,321	2,195	9,534	11,729	10%
2018	33%	23%	14,159	3,310	10,290	13,600	9%
2019	35%	27%	15,327	4,194	12,849	17,043	10%
2020	37%	32%	17,513	5,533	13,467	19,000	9%
2021	42%	36%	25,073	8,947	15,392	24,339	9%

Source: Microsoft and Counterpoint Global.
Note: Dollar amounts are in millions.

But you can probably see the problem with this analysis: Microsoft's sales increases are not attributable solely to increases in tangible investment. In fact, Microsoft is best known as a software company, which means its investments are mostly intangible. We need to introduce intangible investment.

The challenge is to extract intangible investment from the SG&A expense on the income statement. Judgment is required about which items within SG&A we should treat as an investment as well as the useful lives of those investments. The basic way to think about it is that some percentage of SG&A expense is necessary to maintain the current operations and the rest is discretionary in pursuit of value-creating growth.

Charles Hulten, a professor emeritus of economics at the University of Maryland, wrote a paper about Microsoft that allocates SG&A to investment and offers useful lives for those assets.[35] We use Hulten's figures to capitalize a percentage of Microsoft's SG&A.

This allows us to do a calculation that is similar to that for physical assets. Intangible assets are capitalized on the balance sheet and amortized over time. This leaves us with net capitalized intangibles, which is the intangible equivalent to net PP&E. Note that in fiscal 2021, we estimate that intangible investments were $43 billion versus $24 billion in tangible investments.

Not surprisingly, most of the value is in intangibles. This means that we need to include acquired intangibles and goodwill from the balance sheet to make net intangible investment fully correspond to net PP&E.

After making these adjustments, we can see that the ratio of net capitalized intangibles to sales averaged 96 percent over the last 5 years, although the ratio is decreasing. By this calculation, maintenance intangible investment has averaged about 55 percent of total investment and 20 percent of sales.

	Net Capitalized Intangible Assets / Sales			Intangible Investments			
Fiscal Year	Annual	5-Year Average	Change in Sales	Growth	Maintenance	Total	Maintenance Intangible Investments / Sales
2017	110%	94%	11,321	10,674	38,826	49,501	40%
2018	99%	96%	14,159	13,629	14,276	27,905	13%
2019	96%	97%	15,327	14,823	22,543	37,366	18%
2020	90%	98%	17,513	17,128	16,882	34,010	12%
2021	85%	96%	25,073	24,078	19,178	43,256	11%

Source: Microsoft and Counterpoint Global.
Note: Dollar amounts are in millions.

We still haven't addressed the main problem, which is that growth is the result of all forms of investment. That means we need to examine the relationship between the level of sales and the combination of net tangible and net intangible assets. That ratio averaged 132 percent in the last 5 years.

	(Net Tangible Assets + Net Capitalized Intangible Assets) / Sales			Tangible + Intangible Investments				
Fiscal Year	Annual	5-Year Average	Change in Sales	Growth	Maintenance	Total	Maintenance Investments / Sales	Maintenance Investments / Total Investments
2017	141%	114%	11,321	12,869	48,360	61,230	50%	79%
2018	132%	120%	14,159	16,939	24,566	41,505	22%	59%
2019	131%	124%	15,327	19,017	35,392	54,409	28%	65%
2020	127%	129%	17,513	22,660	30,349	53,010	21%	57%
2021	127%	132%	25,073	33,025	34,571	67,595	21%	51%

Source: Microsoft and Counterpoint Global.
Note: Dollar amounts are in millions.

Following Greenwald's method, we can estimate that on average growth investment was 38 percent of total investment and maintenance was the other 62 percent over the past 5 years. But the trend within the average is also noteworthy, as a higher percentage of investment was earmarked for growth in fiscal 2021 than it was in fiscal 2017.

Percent of Total	Tangible Investments		Intangible Investments		Total Investments
Fiscal Year	Growth	Maintenance	Growth	Maintenance	
2017	4%	16%	17%	63%	100%
2018	8%	25%	33%	34%	100%
2019	8%	24%	27%	41%	100%
2020	10%	25%	32%	32%	100%
2021	13%	23%	36%	28%	100%

Source: Microsoft and Counterpoint Global.
Note: Dollar amounts are in millions.

Let's pause to consider how this analysis extends Greenwald's approach. The first is that it includes intangible as well as tangible investments. The first edition of the book that offered this approach to estimating maintenance capital expenditures was published in 2001. At that time, intangible and tangible investment was about equivalent (see exhibit 7). But the subsequent sharp growth in intangible investment means that failing to include it severely limits the insight the analysis can provide.

Including acquisitions in the estimates is also essential. Many companies rely heavily on acquisitions to sustain or grow their sales, and M&A is a large component of total capital allocation. Companies commonly provide details on how they recorded the tangible and intangible assets on the balance sheet.

Finally, it's worth taking a moment to consider the impact that write-downs have on the estimate of maintenance spending when you use the Greenwald approach. We illustrate the point with net tangible assets but the logic applies to capitalized intangible assets as well. An asset write-down reduces net tangible assets and therefore the ratio of net tangible assets to sales. A lower percentage applied to the change in the dollar amount of sales

therefore attributes less of tangible investments to growth and more to maintenance. Depreciation also drops which means the ratio of maintenance expenditures to depreciation rises.

This analysis underscores that more detailed estimates of growth and maintenance spending can be cumbersome. And note that the issues of inflation and technological obsolescence remain important considerations and concerns.

But it is important to keep the goal in sight. We want to make sure we have a reasonable sense of each, because if we underestimate maintenance spending, and overstate investment, we run the risk of anticipating higher growth than what the company is likely to achieve.

Endnotes

[1] Geoffrey B. West, James H. Brown and Brian J. Enquist, "A General Model for the Origin of Allometric Scaling Laws in Biology," *Science*, Vol. 276, No. 5309, April 4, 1997, 122-126.
[2] Max Kleiber, "Body Size and Metabolic Rate," *Physiological Reviews*, Vol. 27, No. 4, October 1947, 511-541.
[3] Geoffrey West, *Scale: The Universal Laws of Growth, Innovation, Sustainability, and the Pace of Life in Organisms, Cities, Economies, and Companies* (New York: Penguin Press, 2017), 26.
[4] Key ideas include space filling, the idea that energy has to get to all of the cells, and fractals, which explain the geometry of networks.
[5] Luís M. A. Bettencourt, *Introduction to Urban Science: Evidence and Theory of Cities as Complex Systems* (Cambridge, MA: MIT Press, 2021) and Vaclav Smil, *Growth: From Microorganisms to Megacities* (Cambridge, MA: MIT Press, 2019).
[6] West, *Scale*, 163-173. The ¾ exponent comes back into play here. The number of cells in the mammalian body grow linearly with mass. But as we saw the metabolic rate grows sublinearly (with a ¾ exponent). With a doubling of mass, the metabolic rate grows at $2^{¾}$, or 1.68. The result is that the rate of energy you need for maintenance grows faster than the rate at which you can supply energy, which means that less energy is available for growth until the point where all energy is necessary for maintenance. At that point, you stop growing.
[7] Geoffrey B. West, James H. Brown, and Brian J. Enquist, "A General Model for Ontogenetic Growth," *Nature*, Vol. 413, October 11, 2001, 628-631.
[8] Jiang Zhang, Christopher P. Kempes, Marcus J. Hamilton, Geoffrey B. West, "Scaling Laws and A General Theory for the Growth of Companies," *ArXiv Preprint*, September 23, 2021.
[9] Lewis Carroll and John Tenniel, *Through the Looking-Glass and What Alice Found There* (London: Macmillan and Co., 1872), 42.
[10] Bruce Greenwald and Judd Kahn, *Competition Demystified: A Radically Simplified Approach to Business Strategy* (New York: Portfolio, 2005), 137-159.
[11] Venkat Ramana Reddy Peddireddy, "Estimating Maintenance CapEx," *Columbia University PhD Thesis,* 2021.
[12] Michael J. Mauboussin and Dan Callahan, "The Impact of Intangibles on Base Rates," *Consilient Observer: Counterpoint Global Insights*, June 23, 2021.
[13] Dion Bongaerts, Xiaowei Kang, Mathijs van Dijk, "Intangible Assets and the Cross-Section of Stock Returns," *SSRN Working Paper*, September 2021.
[14] This discussion is based on Bradford Cornell, Richard Gerger, Gregg A. Jarrell, and James L. Canessa, "Inflation, Investment and Valuation," *Journal of Business Valuation and Economic Loss Analysis,* Vol. 16, No. 1, 2021,1-13.
[15] This is the main point of Cornell, Gerger, Jarrell, and Canessa, "Inflation, Investment and Valuation."
[16] Amazon.com, *Form 10-K*, December 31, 2020, 43.
[17] See Alphabet Inc., *Form 10-Q*, March 31, 2021, 8 and Microsoft Corporation, *Form 10-K*, June 30, 2021, 41.
[18] Financial Accounting Standards Board, "Statement of Financial Accounting Standards No. 141 (Revised 2007): Business Combinations," *No. 299-A*, December 2007. Also, see Christine Andrews, Jan Falmer, Jeannette Riley, and Carrie Todd, "SFAS 141(R): Global Convergence and Massive Changes In M&A Accounting," *Journal of Business and Economics Research*, Vol. 7, No. 4, April 2009, 125-136.
[19] An intangible asset is non-physical and is either separable or arises from contractual or other legal rights. Separable means the asset is "capable of being separated or divided from the entity and sold, transferred, licensed, rented, or exchanged, either individually or together with a related contract, identifiable asset, or liability, regardless of whether the entity intends to do so." Contractual or legal rights means that accountants should record the asset "regardless of whether those rights are transferable or separable from the entity or from other rights and obligations."
[20] Luminita Enache and Anup Srivastava, "Should Intangible Investments Be Reported Separately or Commingled with Operating Expenses? New Evidence," *Management Science*, Vol. 64, No. 7, July 2018, 3446-3468.
[21] Vijay Govindarajan, Shivaram Rajgopal, Anup Srivastava, and Luminita Enache, "It's Time to Stop Treating R&D as a Discretionary Expenditure," *Harvard Business Review*, January 29, 2019.

[22] FASB 141.
[23] Wayne Landsman, Alexander Liss, and Sönke Sievers, "The Pricing of Acquired Intangibles," *TRR 266 Accounting for Transparency Working Paper Series*, No. 65, October 2021.
[24] Roger Sinclair and Kevin Lane Keller, "Brand Value, Accounting Standards, and Mergers and Acquisitions: 'The Moribund Effect','' *Journal of Brand Management*, Vol. 24, No. 2, March 2017, 178-192.
[25] Enache and Srivastava, "Should Intangible Investments Be Reported Separately or Commingled with Operating Expenses? New Evidence."
[26] Carol Corrado, Jonathan Haskel, and Cecilia Jona-Lasinio, "Knowledge Spillovers, ICT and Productivity Growth," *Oxford Bulletin of Economics and Statistics*," Vol. 79, No. 4, August 2017, 592-618.
[27] Michael J. Mauboussin and Dan Callahan, "One Job: Expectations and the Role of Intangible Investments," *Consilient Observer: Counterpoint Global Insights*, September 15, 2020.
[28] Shivaram Rajgopal, "The Most Misunderstood Area in Finance: 'What Is Your Company's Maintenance Capex'?" *Forbes.com*, November 13, 2021.
[29] Alex Coad, *The Growth of Firms: A Survey of Theories and Empirical* Evidence (Cheltenham, UK: Edward Elgar, 2009), 40-43.
[30] For example, see U.S. Securities and Exchange Commission filings for Ferrellgas Partners, Marriott International, Sprague Resources, and Vail Resorts.
[31] Bruce C. N. Greenwald, Judd Kahn, Paul D. Sonkin, and Michael van Biema, *Value Investing: From Graham to Buffett and Beyond* (New York: John Wiley & Sons, 2001), 96.
[32] West, *Scale*, 391-393.
[33] Greenwald, Kahn, Sonkin, and van Biema hint at this when they suggest methods to calculate the earnings power of Intel. For instance, they write, "A second method is to estimate a maintenance R&D on the same basis we estimated maintenance capex, by capitalizing R&D into an asset, finding a sales-to-asset ratio, and using that ratio times the dollars of additional sales to arrive at the growth portion of R&D. Maintenance R&D is simply the other portion." (To be consistent with the analysis for capital expenditures, we suspect they meant "asset-to-sales" ratio rather than "sales-to-asset ratio.") See *Value Investing*, 125.
[34] See https://www.microsoft.com/en-us/Investor/earnings/trended/capital-expenditure.aspx.
[35] Charles R. Hulten, "Decoding Microsoft: Intangible Capital as a Source of Company Growth," *NBER Working Paper 15799*, March 2010.

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