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Enhancing Energy Efficiency Reporting: Using Index Numbers to Report Corporate-Level Measures of Sustainability

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INTRODUCTION

There are increasing pressures for organizations to report on their environmental and social performance (Caritte et al., 2013; Aguinis & Glavas 2012). Motives for reporting vary based on a variety of drivers including retailer and brand pull of manufacturers (Hornibook et al., 2013; O'Shea and Golden (2012); Dooley & Johnson, 2015; Golden et al., 2010), shareholder interest in corporate social responsibility (Ben-Amar & Mcilkenny, 2014); Aust, 2013; Parikalpana, 2014), desire to improve community relations (Gill et al., 2008), or to attract/retain high skilled employees that care about the environment (Kiron et al., 2013). Among the many papers on –*why*- companies report, (Aras and Crowther 2009) present the notion that reporting is more about convincing the investment community that the corporation doing the reporting is less risky, thereby reducing the cost of capital. In terms of –*how*- companies report, (Christofi, Christofi et al. 2012) argue that "*reporting practices need to undergo further standardization and enforcement to avoid, or give early warnings about, future corporate mismanagement that leads to socio-economic consequences detrimental to investors and consumers in general.*" Nor is there agreement about the value of reporting on "actual" sustainability. (Milne and Gray 2013) argue against the concept of the triple bottom line, pervasive to corporate reporting on sustainability, and conclude it is more likely to erode the transition towards a sustainable society than aid it.

Whatever the reasons, the public release of company level information on environmental and social practices in on the rise. (Ioannou 2014) report that over 6,000 companies issued sustainability reports in 2013. (Parris 2006) documents the rise in web sites that track and archive these types of reports. This paper leaves the question about *why* companies might wish to report or the value of such reporting on environmental improvement to other researchers. This note is a contribution in the direction suggested by Christofi, et al, by providing a theoretically grounded method to measure aggregate (corporate) performance for reporting purposes on an intensity basis.

Two of the better known organizations established for sustainability reporting include CDP (formerly the Carbon Disclosure Project) and GRI (aka Global Reporting Initiative). Founded in 1997, GRI is arguably one of the largest corporate sustainability reporting protocols with almost 8,000 companies and 25,077 sustainability reports within their global database, which can be sorted to evaluate by different sustainability metrics (GRI, 2015).

CDP which was founded in 2000 in London is more focused on climate change and resource management reporting by 4,500 companies, representing over 50% of the market capitalization of the world's largest 30 stock exchanges, and 110 cities from 80 countries. CDP partners with over 800 institutional investors holding US$95 trillion in assets who use company reporting to evaluate the risk in their investment portfolios (Matisoff et al., 2013); CDP, 2014).

Corporations, like national economies, are often comprised of a wide range of activities. This diversity of activities presents some unique issues for reporting performance. As various parts of a company grow or shrink the question arises, "how to add up apples and oranges?" The desire to report on environmental performance also shares the problem on how to describe the changing mix of corporate activities vis-à-vis the impact on the sustainability.

Organizations that encourage and support such voluntary reporting are also emerging. While there are a plethora of issues that arise about companies' impact on society, their contribution to climate change is one area that is commonly reported by companies. Standardized methods for computing greenhouse gases (GHG) have been developed, encompassing direct, indirect, and value chain emissions (Scope 1, 2, and 3) such as the Greenhouse Gas Protocol developed under the partnership between the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) and first published in 2001 (Green, 2010). As of August 2014, there were 115 organizations reporting that they used the protocol. While GHG is not the only important environmental issue, WRI and WBCSD, respond to this concern by saying (GHG Protocol, 2015):

> *"GHG emissions are a great starting point for businesses because of the data availability, their correlation with energy use, and often their correlation with other environmental impacts. The general accounting methodology of both standards can be adapted by businesses to account for other impacts.*"

The relationship between GHG to energy use, an often important and controllable cost of doing business, fits well into the "triple bottom line" view of corporate sustainability. Companies can benefit the environment and shareholders by lowering both emissions and energy costs.

Not all GHG reporting is voluntary. There are many markets where GHG emissions are regulated under a cap and trade system (Betsill and Hoffman, 2011), including the European Union (Trotignon, 2011), for electricity power plants located within the nine Northeastern U.S. states in the Regional Greenhouse Gas Initiative (RGGI, or ReGGIe) region, and the state of California (Burtaw et al., 2006). Large emitters in the United States must report emissions under the US. EPA Greenhouse Gas Reporting Program US EPA, 2015). Even in the mandatory case, companies may still wish to highlight their activities in formal corporate reports to the public.

The GHG Protocol and other methods are readily used to report absolute emissions (levels) and the numerator for intensity (ratio of emissions to a measure of activity levels). Use of intensity reporting further reflects the possibility of growth within a company but with emissions growing at a lower rate. The Protocol provides the rigorous accounting framework for GHG, but not the choice of the denominator. (Freeman, Niefer et al. 1997) illustrate the problems with the choice of either physical units or dollar values (sales or value added) as a dominator for industry level energy intensity. Given a choice of an appropriate denominator against which to measure intensity, the index decomposition analysis literature addresses the issue of how the changing mix of underlying activities, with corresponding differences in intensity, influence the aggregate trends. One of the earliest papers identifying this phenomenon is (Myers J and L. 1978). This early literature focused on how the change in the underlying composition of industry, usually a trend away from energy intensive production, contributes to an observed decline in aggregate energy intensity. In some recent studies, the phenomenon moves in the other direction, for example (Choi and Oh 2014) examining trends in heavy industry growth in South Korea. (Ang and Zhang 2000) review this literature.

In the context of corporate sustainability reporting, this issue is just as vital. A company may experience rising energy and GHG emission if an energy intensive division is growing more rapidly than other divisions, such is the case for larger and more diverse multi-national firms. Failing to account for this may understate or even mask the efforts they make for efficiency improvements. On the converse, reporting declining energy and emissions, merely because an energy intensive activity or product is declining in the company's portfolio of product is not an accurate representation of a company's performance.

Given the parallel between corporate reporting problem and decomposition of country level aggregate trends, this note briefly presents an example to illustrate the problem, reviews a two-factor decomposition using the Fisher Index as presented by (Boyd and Roop 2004), computes an example using corporate data from Corning, and then discusses how other types of decomposition methods in the literature may apply to parallel issues in corporate sustainability reporting.

An Illustrative Example

Consider a company with two different operations producing different products. They may be entire divisions or individual plants, but the important distinction is that the two products they produce have an underlying difference in energy intensity that are a characteristic of the product itself. Consider Scenario one in table one. In this scenario division A produces a product that is twice as energy intensive than division B. Both divisions are actively pursuing energy improvements and achieve about 5% reduction in energy intensity, computed as the natural log of the ratio of FY2 energy intensity to FY1 energy intensity.. The corporate total of energy use and production reflects that same 5% decline in intensity.

Table 1 Constant Sales Corporate Scenario

Division - FY	*Production*	*Energy*	*Energy Intensity*	*% change*
A - 1	500	2000	4.0	
A - 2	500	1900	3.8	-5.1%
B -1	400	800	2.0	
B -2	400	760	1.9	-5.1%
Total - 1	900	2800	3.1	
Total - 2	900	2660	3.0	-5.1%

But what if sales in division A are falling? This is shown in table 2. The corporate aggregate intensity declines at almost 9%, but through no real additional improvement in energy efficiency, but due simply to lagging market performance in the energy intensive sector. While it is true that the aggregate *energy intensity* of the company has declined we believe that this would misrepresent the company's actual performance vis-à-vis *energy efficiency*. Table three shows the flip side; growth in the energy intensive division. Despite the same divisional level of improvement in energy intensity in the company, the growth of the energy intensive division results in a reported ~1% increase in aggregate energy intensity. The next section lays out the underlying concept of the price index number and shows how it can be applied to solve this pervasive problem in sustainability reporting.

Table 2 Declining Sales Scenario

Division - FY	*Sales*	*Energy*	*Energy Intensity*	*% change*
A - 1	500	2000	4.0	
A - 2	400	1520	3.8	-5.1%
B -1	400	800	2.0	
B -2	400	760	1.9	-5.1%
Total - 1	900	2800	3.1	
Total - 2	800	2280	2.9	-8.8%

Table 3 Increasing Sales Scenario

Division - FY	*Sales*	*Energy*	*Energy Intensity*	*% change*
A - 1	500	2000	4.0	
A - 2	750	2850	3.8	-5.1%
B -1	400	800	2.0	
B -2	400	760	1.9	-5.1%
Total - 1	900	2800	3.1	
Total - 2	1150	3610	3.1	0.9%

Index number approach

The concept of the price index is to answer the question, "If expenditures are going up, is it because of increased prices or increased consumption?" We really want to know the contribution and direction of both. This question is completely analogous to energy intensity, except that energy intensity plays the roles of prices

- Intensity = Energy Use / unit of Product
- Price = Total $ spent / unit of Product

The realization is that if the products in a price index can range from apples to oranges then we simply translate the data needs and formulas from index numbers to the "sustainability reporting problem."

To formalize this, following (Diewert 2001), the general form of the price index number problem arises from the following question.

How do we express the change in an aggregate expenditure value, V,
from a base time period (0) to the current period (t)?

$$V_t/V_0 = \sum_i p_{i,t} \cdot q_{i,t} / \sum_i p_{i,0} \cdot q_{i,0}$$

in the form of two functions P and Q that satisfy

$$V_t/V_0 = P(p_{*,t}, p_{*,0}, q_{*,t}, q_{*,0})\ Q(p_{*,t}, p_{*,0}, q_{*,t}, q_{*,0})$$

Where $p_{*,t}$ and $q_{*,t}$ are the prices and quantities, respectively, of i commodities at time t, and V_t is the total value of all commodities at time t.

In price indices the aggregate is total expenditures for a basket of goods and services. The analog in corporate reporting it to explain the change in some measure of sustainability. This paper presents energy as one example, but this approach applies to any well-defined sustainability measure such as carbon emissions, water use, etc. To relate the chosen measure of sustainability to the form of the price index problem, the index number approach to this reporting problem of relies on the identity

$$E_t = \sum_i y_{i,t} \left({e_{i,t}}/{y_{i,t}} \right) = \sum_i y_{i,t} I_{i,t} \quad (1)$$

Where E_t and $e_{i,t}$ denotes aggregate (corporate) and sectoral (product divisions, plants, etc) energy use, respectively; $y_{i,t}$ denotes sectoral production activity, and $I_{i,t}$ is sectoral energy intensity. This relationship can be expressed in terms of aggregate energy intensity, I_t, by dividing both sides by an aggregate measure of corporate activity, denoted Y_t, and defining $S_{i,t}$ as the ratio of the ith sector to the aggregate activity measure at time t.

$$I_t = \frac{E_t}{Y_t} = \sum_i \left({y_{i,t}}/{Y_t} \right) \left({e_{i,t}}/{y_{i,t}} \right) = \sum_i S_{i,t} I_{i,t} \qquad (2)$$

In either form, it is easy to see the parallels between the price index problem and the energy (intensity) decomposition problem. The price index is a two-factor decomposition. This approach can be extended to greenhouse gases using the three factor approach as presented by de Boer (2009) where the three factors are carbon content, energy intensity and mix of activities.

When $Y_{t} = \sum_i y_{i,t}$ it is common to use the notation $S_{i,t}$ to denote the share of sectoral production relative to total production. However, equation (2) does not impose that the aggregate, Y_t, be the sum, $\sum_i y_{i,t}$. In other words, it is not necessary to have to add up apples and oranges. This is very important for applying the index approach to the corporate sustainability reporting applications since it frees the company from tying intensity reporting to a single metric of production activity. Y_t can be any relevant measure of aggregate activity and the choice of units for each $y_{i,t}$, which could represent product division or even plant level data, may be chosen to reflect units which is most appropriate for measuring energy intensity at the corresponding level of the data. The denominators, Y_t and $y_{i,t}$, need not even be express as a simple ratio, but can be derived from statistical normalization, i.e. a regression based EnPI such as have been proposed by ISO 50001 and elsewhere.

Index number formulae

The Laspeyres approach is quite common in both price indices and early literature for energy intensity decomposition (for a survey see (Ang and Zhang 2000). This approach uses base period fixed weights. In terms of the energy intensity formulation (equation 2) we have,

Laspeyres $$L_{Str} = {\sum_i S_{i,T} I_{i,0}} \Big/ {\sum_i S_{i,0} I_{i,0}} \qquad (3a)$$

$$L_{Int} = {\sum_i S_{i,0} I_{i,T}} \Big/ {\sum_i S_{i,0} I_{i,0}} \qquad (3b)$$

where L_{Str} is the 'structure' index representing the changing mix, or structure of production activities, and L_{Int} is the 'intensity' index, representing the changing real energy intensity between the base perion (t=0) and the current, or end, period (t=T). By reversing the roles of the base period and the end period (t=T) we can obtain the Paasche index.

Paasche $$P_{Str} = \sum_i S_{i,T} I_{i,T} \Big/ \sum_i S_{i,0} I_{i,T} \quad \text{(4a)}$$

$$P_{Int} = \sum_i S_{i,T} I_{i,T} \Big/ \sum_i S_{i,T} I_{i,0} \quad \text{(4b)}$$

The Fisher Ideal index is the geometric average of the Laspeyres and Paasche indices,

Fisher Ideal $$F_{Str} = (L_{Str} \cdot P_{Str})^{1/2} \text{ (5a)}$$

$$F_{Int} = (L_{Int} \cdot P_{Int})^{1/2}. \text{(5b)}$$

The Fisher index mitigates problems with the choice of the base year and has other desirable properties for energy intensity decomposition as described by (Boyd and Roop 2004).

By using data from time periods between the base and end periods, 0 and T respectively, a chained index is constructed. If we denote the Fisher index for energy intensity between periods 1 and 2 as $F_{Int\ 1,2}$ and 2, and 3 as $F_{Int\ 2,3}$ then the chained index between periods 1 and 3 is simply,

$$F_{Int\ 1,3} = F_{Int\ 1,2} \cdot F_{Int\ 2,3} \qquad (6)$$

While requiring more data, the chained index is preferred since it more accurately reflects the evolution of energy intensity as the mix of production activities are evolving.

Simple example

Applying the formulas above for the Laspeyres and Paasche intensity indices to the example data in table 2 (declining sales scenario) are shown below. Both the Laspeyres and Paasche indices give the same result so taking the geometric average results in the Fisher index of 0.95. Taking the natural log is an annual growth rate of -5.1%, the same as in Scenario 1. This value reflects the "true" underlying change in energy intensity. The Laspeyres and Paasche indices are usually not the same. This is an artifact of the simple example where both divisions have identical intensity changes over time. The index number approach also correctly computes a -5.1% change in intensity for the increasing sales scenario example with valued from table 3.

$$L_{Int} = S_{A,1} I_{A,2} + S_{B,1} I_{B,2} \Big/ S_{A,1} I_{A,1} + S_{B,1} I_{B,1} = \frac{500}{900} \cdot 3.8 + \frac{400}{900} \cdot 1.8 \Big/ \frac{500}{900} \cdot 4 + \frac{400}{900} \cdot 2 = 0.95$$

(7)

$$P_{Int} = S_{A,2} I_{A,2} + S_{B,2} I_{B,2} \Big/ S_{A,2} I_{A,1} + S_{B,2} I_{B,1} = \frac{400}{800} \cdot 3.8 + \frac{400}{800} \cdot 1.8 \Big/ \frac{400}{800} \cdot 4 + \frac{400}{800} \cdot 2 = 0.95$$

(8)

Application to Real Company Data

The simple example demonstrates that the index approach correctly measures the aggregate intensity change that would have been obvious from the sector level details. In the 2-sector data there is an identical -5.1% change in intensity in *both* sectors. The value of the index approach is when it is applied to the very messy data of the real world. This is illustrated using quarterly data from Corning, Inc. from 2008 to 2012.

Quarterly energy use and production levels for the seven primary divisions were merged with corporate level sales from public reports. Corporate revenues were deflated to 2012 constant dollars. using the BLS producer price index (PPI) for glass and glass product manufacturing. While not all of Corning's divisions produce these types of products this was chosen to be closer fit to Corning than an the aggregate PPI or GDP deflator. Separate data were available for electricity use and fuel use, reported in common units so an aggregate energy consumption number could also be computed. Division production level are measured in unit of saleable product (UoSP). These are the same production units that are used internally by Corning[1]. This is not a problem since the index number approach is robust to choice of units for energy and the denominator for the measure of energy intensity. The choice of the denominator for the disaggregate data should be chosen to best represent the link between energy and production activities in each division. Corning feels this is the case since it is the choice of production data they use for a variety of internal reporting.

Figure 1 plots the aggregate energy intensity for each division (Energy/UoSP) and corporate level energy intensity (Energy/Sales). There is quite a bit of volatility. This is likely due in part to the recession and also some possible seasonality in the third and fourth quarters for some divisions and years. Some divisions appear on a downward path and others roughly constant. Corporate intensity is also fairly flat over the four years. It would be difficult to make meaningful statements about Corning's energy efficiency from this figure.

[1] The units used for energy and UoSP are not given in this paper to mask proprietary company information.

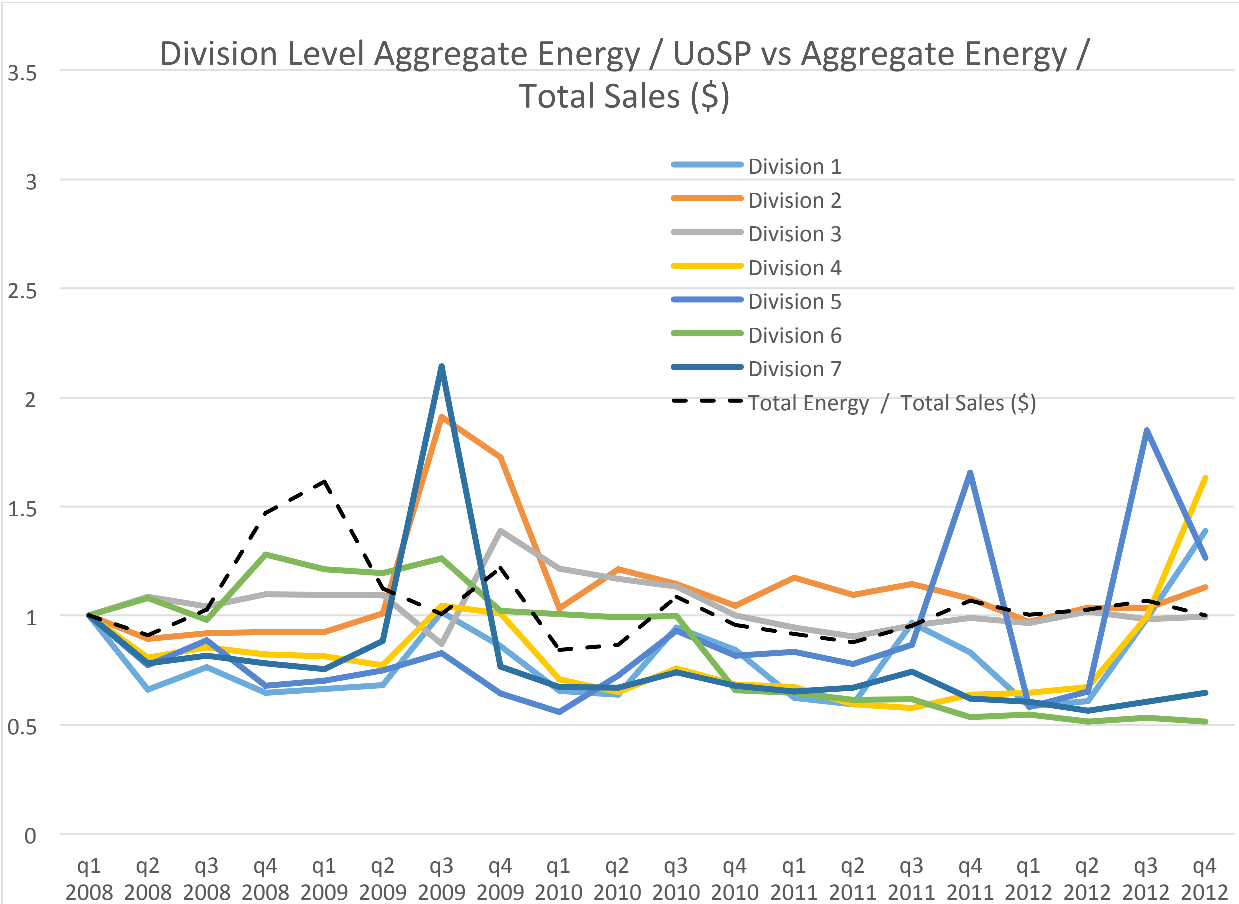

Figure 1 Aggregate Energy Intensity

Looking at the fuel and electricity intensity in the seven divisions (figures 2 and 3 respectively) reveals that most of the volatility is from the fuel use. However, it is still difficult to make meaningful statement about overall corporate performance from these data.

Computing the Fisher indices for total energy, electricity, and Fuel separately make reporting the corporate energy efficiency picture clearer. The index is computed quarterly using the formula above and then chained to the first quarter of 2008. These indices are show in figure 4. As in figure 1, total energy divided by sales shows no appreciable improvement, but the fisher index tell a different story. The value of the chained indices in the fourth quarter of 2013 are 0.9346, 0.9448, and 0.9368 for total energy, electricity, and fuel respectively. This is a quarterly intensity decline of 0.3-0.35%; an annual decline of 1.4-1.7% depending on the type of energy. Since there is a pattern of seasonality in the 3rd and 4th quarter, the increase in Q4 2012 may not be indicative of the overall trend, so a simple exponential curve is fit with the constant constrained to unity. This results in a 0.8% average quarterly rate of decline in total energy intensity; 1.2% quarterly average decline for fuels and 0.4% for electricity. This is in stark contrast to the corporate energy use per dollar of sales. The difference reflect the changing mix of divisional activity; the relative growth in the more energy intensive divisions in Corning masks the energy efficiency improvement in the company overall.

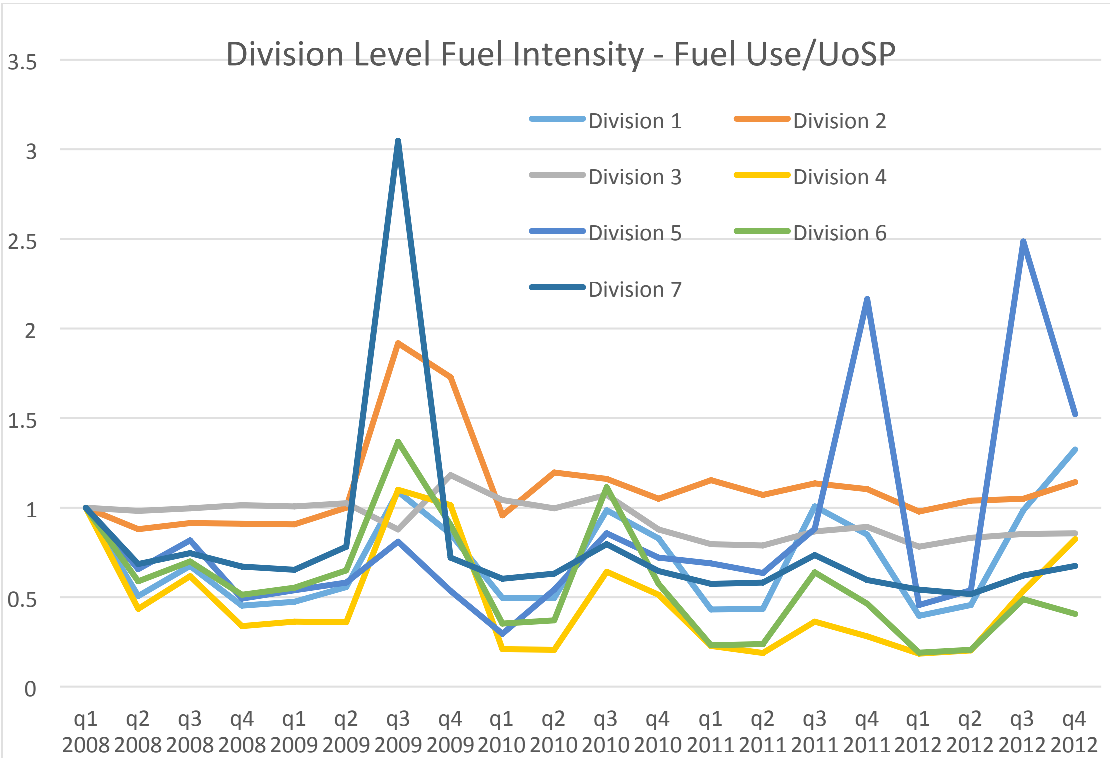

Figure 2 Division Level Fuel Intensity

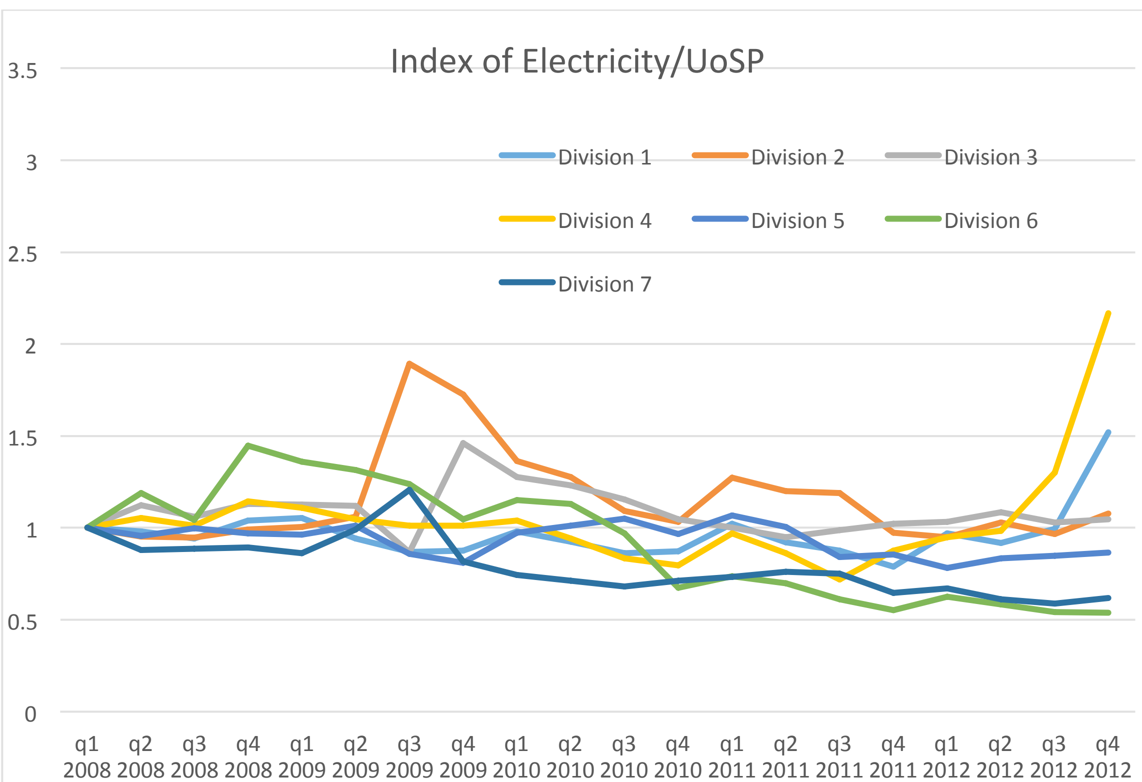

Figure 3 Division Level Electricity Intensity

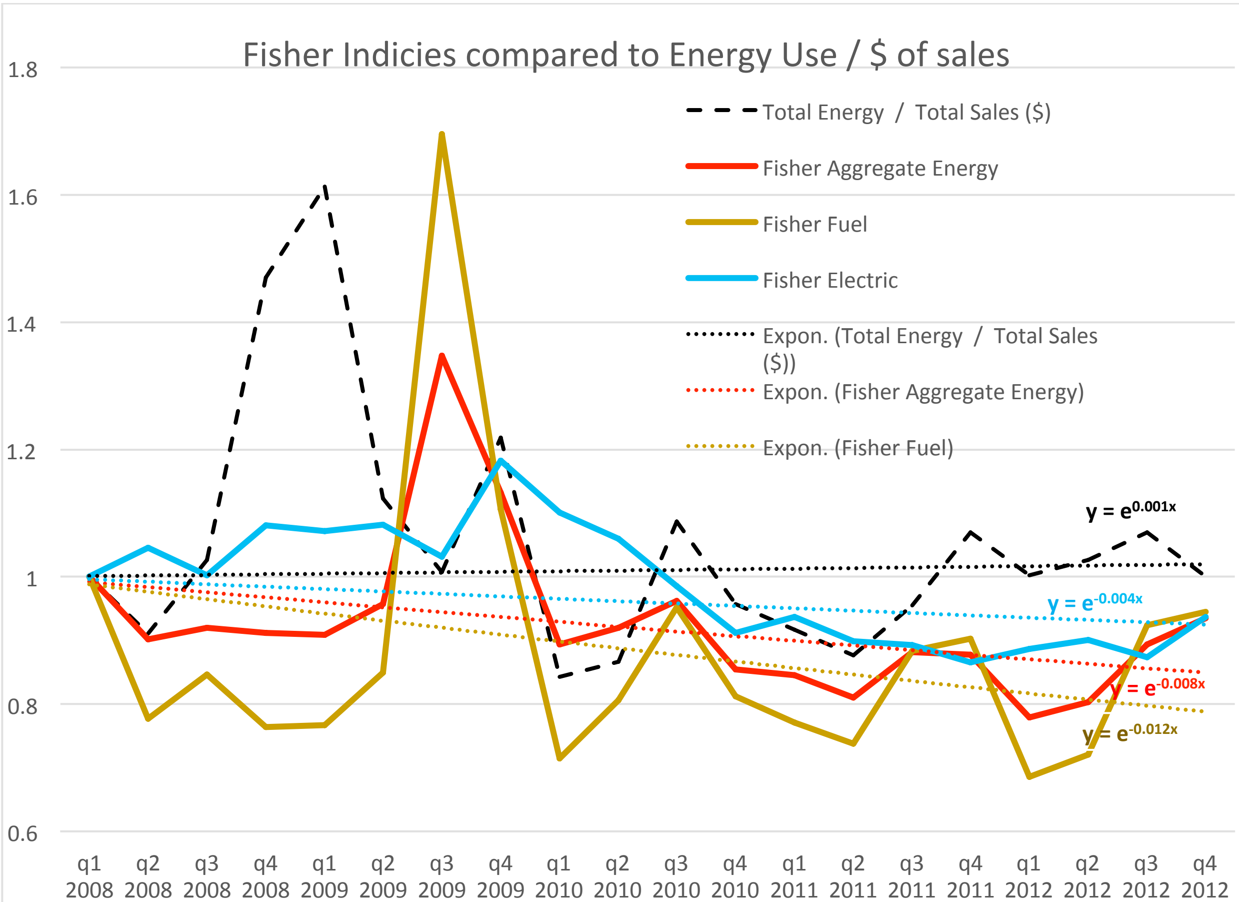

Figure 4 Fisher Indices for Total Energy, Electricity, and Fuels

While the Fisher index is known to have superior properties to either the Paasche or Laspeyres indices, it is useful to illustrate how using one of these fixed weight indices might affect the outcome using the same data from Corning. The Laspeyres index has a lot of intuitive appeal since it uses base period fixed weights and corporate reports often reference a fixed base year. For example, the U.S. DOE Better Plants Better Buildings Program (2015) recommends a corporate level aggregation approach that can be shown to be equivalent to the fixed base year Laspeyres index (although they do not identify it as such). The formula they present uses base year energy share weighted growth rates in energy performance, with the energy performance derived from either intensities or a regression based normalized energy. In either case, their recommended formula for corporate aggregation approach can be shown to be the same as the Laspeyres approach above.

If one applies a Q12008 base period Laspeyres index to the Corning energy data, the results are shown in figure 5. The Laspeyres index tracks the Fisher index for several quarters, then the impacts of Laspeyres' fixed base period weights begin to have an effect. By the end of the time period, the fixed base period weights of the Laspeyres' index understates the level of corporate energy intensity changes. If one uses the exponential trend line as an overall measure, the Laspeyres is a ~0.3% per quarter decline in intensity and the Fisher index is ~0.8% per quarter; resulting a ~2 percent difference per year. This difference is substantial.

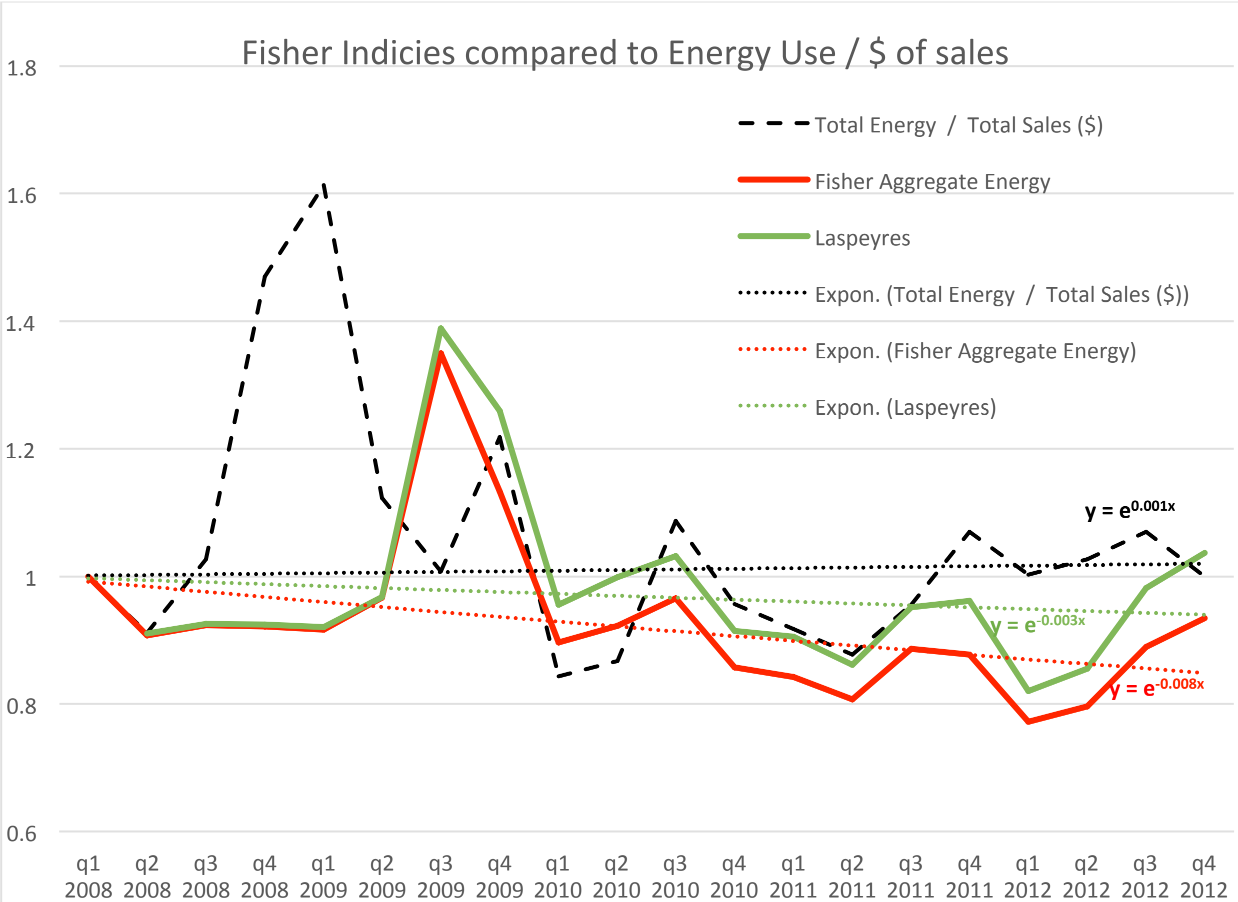

Figure 5 Comparison of Fisher and Laspeyres Indices

CONCLUSIONS

This note contributes to the literature on corporate reporting of sustainability. Its primary contribution is not on *why* companies might report, nor does it contribute on *what* they should be reporting, but rather on *how* they can report a meaningful measure of performance, on an intensity basis, when diverse corporate activities are changing. In a simple constructed example and one presented with real world data it is demonstrated that the Fisher index, developed for prices and as applied by the IDA literature is a good choice for computing overall performance. It is simple, easy to explain, and easy to interpret. In the case of Corning, using aggregate intensity based on total sales masks the real, underlying improvements by the company in energy intensity, as does using a base year weighted index. This example was for energy use, but it is straightforward to apply this approach to GHG emissions or other measurable environmental variables such as water use, resource use, solid waste management and air emissions relevant to CSR.

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