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Accounting for cost of pollution damages on wealths elements

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This paper attempted to present a simple workable accounting framework for allocating the costs of pollution damages on various polluting sources.The government and specialized authorities can use the cost allocation models to impose tax and fees on pollutant sources. Accordingly, pollutant sources are obliged to disclose taxes and fees explicitly in its financial statements as part of product or service costs. At the same time, the accounting profession could develop these measures while considering new projects that are expected to produce potential pollution damages. These measures will help as control devices to issuing licenses for establishment and operation of new enterprises. Also, usage of the proposed framework over a period of time will help in control the pollutant emissions within permissible levels internationally which is one necessary step of applying the concept of green accounting and sustainable development. A simple numerical example illustrates the theoretical discussion.

keywords: Allocation Models, Pollution Costs, Accounting Reports.

JEL Classification Codes: M41, N55, Q580, Q520.

1 Introduction

Up to the moment, still the control of environmental pollution emissions is difficult for many reasons; including measurement, allocation of pollution emissions costs, disclosure in the financial statements of the enterprises, laws, regulations, etc. (Muller et al., 2011, Tu and Huang, 2015). In our previous work, we have introduced a simple accounting

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framework to estimate the expected damage cost of water pollution on human resources (Al Barghouthi and Marie, 2016) as well as on other resources as agriculture, fisheries, livestock and birds (Marie and Albarghouthi, 2017).

This study aimed to complete our previous work where the main objective of all researchers in environmental pollution field is to reach a clean environment of pollution. This can be achieved through commitment of all economic sectors by international concepts and standards of environmental quality. The economic sectors will not respond to these concepts and standards voluntarily because this will increases their cost and reduces their target profits. Accordingly, this paper has three contributions to literature:

First, a simple mathematical framework is derived to allocate the estimated cost of pollution on different economic sectors, which cause environmental pollution, in the area under study. Second, demonstrate how the competent government authorities impose taxes/fees on economic sectors equivalent to their contribution to total pollution damages and its risks. In other words, how the government authorities compelling the economic sectors to bear the current and future costs of pollution damages that affect wealth components? Third, account for cost of pollution damages as a part of product or service costs and disclose it in financial statements of enterprises within each economic sector. In the next section, we will summarize the conclusions of the previous studies on policies and models used to allocate the cost of environmental pollution emissions to economic sectors and to disclose this cost in the enterprises accounts and its financial reports.

2 Literature Review

There are a large number of studies dealing with environmental pollution of air and water from several aspects. These aspects include polices, measuring the cost of damage caused by pollution and disclosure in national accounts and corporate accounts, controlling the level of emissions by encouraging or threat through competent government authorities. Some of these studies concerned in arriving at an effective regulatory regime in order to control the discharge of industrial effluents into their ecosystems in several countries (Rajaram and Das, 2008). However, Jordan et al. (2003) discussed the policy instruments that could led to water pollution mitigation. Kampas and White (2003) stated that: "one of the primary justifications for using transferable permits for pollution control is that they achieve a given level of emission reduction at the lowest cost". From different sight of pollution damages, Vardon et al. (2007) in his study focused on valuing several types of resourcing including water, forests, and minerals. Muller et al. (2011) discussed the external damages from air pollution. They argue that emissions should be valued by the damage they cause up to date. Moreover, many authors studied national pollution damages (Freeman III, 2002, Muller and Mendelsohn, 2007). One important empirical study to note is the recent work of Ho and Nielsen (2007) that computes air pollution damages by sector in China. This work reports the health damages from emissions of total suspended particulates, nitrogen oxides, and sulphur dioxide for 33 sectors of the Chinese economy. The study makes the important step of estimating the value of air pollution emissions, rather than simply reporting the quantity of emissions as prior research has done. The values reported by Mun and Jorgensen, however, are based on the average impact of emissions within enterprises, rather than the preferred marginal damage of each emission. Recently, leading world countries; including the European countries, the U.S., Japan, the UN and Taiwan have successively promoted environmental accounting guidelines and required enterprises to disclose environmental improvement information, so as to improve the environment through production that will unavoidably impact product manufacturing (Huy, 2014; Tu and Huang, 2015). Their study focused on the relationship between green accounting and green design for enterprises. They showed that the requirements of green accounting include: expanding corporate social responsibility, production cannot be exempted from environmental protection, the manufacturing of clean products can generate pollution, the external production cost should be internalized, the redesign to improve the product production process and packaging, reducing resource waste and implementing the (Reduce, Recycle, Reuse) 3R policy, lifecycle assessment for all assessments and developing environmentally-friendly products, which can be solved with green design. Nordhaus (2008) discussed environmental asset accounts. In the same research trend, Jorgenson and Landefeld (2006) have focused on including the income or receipts accounts, the balance sheet with assets and capital, as well as international accounts.

Other studies have focused on defining green accounting as a type of accounting that attempts to factor environmental costs into the financial results of operations, or to use lifecycle assessment to measure the environmental impacts of corporate activities, promote the use of clean production, adopt total cost assessment and combine traditional accounting to disclose the environmental financial information of the enterprises (U.S. Environmental Protection Agency website, 2015 and Ministry of the Environment Government of Japan, 2015).

Marrouch and Sinclair-Desgagné (2012) said that "an efficient pollution taxation scheme should charge each source according to its specific marginal contribution to social damages, or the fines are imposed if the regulated firm discharges pollution in excess of the levels specified in the permit. Generally, the fine is equal to the difference between the actual and permitted pollutant levels multiplied by the fine rate (Anderson and Fiedor, 1997)". Peszko and Lenain (2001) stated the objective of a pollution charge system anywhere in the world is to contain pollution levels by forcing polluters pay a price for their excesses. The charges are implemented by the governmental organizations and revised annually to adjust for inflation and non-compliance.

Other study by Fischer et al. (2004) reports that "the choice of mechanism for allocating tradable emissions permits has important efficiency and distributional effects when tax and trade distortions are considered. Increasingly in recent years, many countries have been incorporating economic instruments into environmental policy, particularly policies that fix emissions limits".

Muller et al. (2011) they designed and estimated the environmental accounts. While much has been written on the general topic, there appears to be no consensus about how to redesign the standard. National economic accounts are based on the principle that they cover those activities that are included in market activities. External effects are activities that are by definition excluded from market transactions, and they are therefore by definition and in principle excluded from the market accounts (Vardon et al., 2007). We conclude from the above that there are great interests by researchers, governments, policy makers in the problem of environmental pollution emissions in terms of concepts, contents, standards, and accounting treatments methods, and disclosure in the financial reports. However, most of these studies have not yet agreed on a standardized method for estimating and allocating the cost of environmental pollution emissions to various economic sectors and their subsidiaries (Chang et al., 2012; Ferreira et al., 2010). Therefore, our study in this field contributes by construction simplified mathematical models that can used easily to allocate the cost of pollution emissions to the economic sectors and its subsidiaries located in the study area. Therefore, our study in this field contributes by construction simplified mathematical models that can used easily to allocate the cost of environment pollution emissions to the economic sectors and its subsidiaries located in the study area. This is what we will present in the next section.

3 Pollution Emissions Allocation Models

In this section, we describe simple set of mathematical models that can be employed to allocate the total cost of pollution emissions on economic sectors and enterprises within each sector that are located in specific area. We begin with determination of the following aspects: Identify economic sectors that cause pollution emissions in the area under study, average contribution for each sector in total pollution emissions, estimation of relative risk of pollution emission factors caused by each economic sector, and finally formulate a set of simple mathematical models to allocate the total cost of pollution emissions on the causative economic sectors and enterprises within each sector.

3.1 Identify Sectors that Cause Pollution Emissions

Sources of pollution emissions depend on the country in question and the nature of the economic activities in which they are exercised. For example, in the US economy are rresponsible for one-third of air pollution damages in all sectors (Muller and Mendelsohn, 2007, Tol, 2005). They also found five industries stand out as large air polluters: coal-fired power plants, crop production, truck transportation, livestock production, and high way street-bridge construction. In United Arab Emirates, which is our study area, there are many economic activities that produce harmful emissions to the surrounding environment, include: heavy industries, oil refining, seaports, construction industry, perfumes, furniture, heavy traffic and etc.

3.2 Estimation of Incremental Emissions for each Pollution Element

One of our study objectives is to allocate part of incremental pollution costs for each economic sector equivalent to damages it caused to the area under study. Achieving this goal becomes very difficult because of the overlap of the external effects of pollution which makes it difficult to distinguish between what can be attributed to each sector within the study area. In other word, assessing the consequences that will be overlapped within each sector and its subsidiaries becomes very complicated. For simplification, assume the levels of permissible concentrations of each pollution element (i) in specific area was (NL_i), which can be determined by review international standards formulated by international regulators bodies. An actual measurement concentration of each pollution element (i) in the same area was (AL_i), which is reflected in the records of Meteorological Stations.

Consequently, it is possible to measure the increment in pollutant concentration in this area (ΔSP_i) by the difference between the actual levels (AL_i) the acceptable levels (NL_i), for each pollution element (i), i.e.

$$\Delta SP_i = AL_i - NL_i \tag{1}$$

3.3 Estimation of Sectors Contributions in Incremental Emissions

To estimate the attributed contribution to each economic sector, we assume that the concentration levels of pollution elements can be measured in each economic sector as well as in the other economic sectors located in the same region. To illustrate, assume there are four economic sectors in the area under study marked with symbols: $J1, J2, J3, and J4$. The concentration of emission in each sector marked with symbol (SL_{ij}), and total emission for all sources (ΣSL_{ij}). Accordingly, the incremental emissions (ΔSP_i) can be distributed to the four economic sectors assumed in the area under study. Where the contribution of each sector (D_{ij}) is determined by concentration ratio of emissions in that sector (SL_{ij}) divided by total concentration ratio of emissions from all sectors (ΣSL_{ij}) multiplied by the incremental pollutant concentration in that area (ΔSP_i), i.e.

$$D_{ij} = \Delta SP_i \frac{SL_{ij}}{\Sigma SL_{ij}} \tag{2}$$

3.4 Risk of Emissions Caused by each Sector

The next step, to estimation of contribution for each sector (D_{ij}), is to estimation of relative risk attributed to each economic sector (R_{ij}). The experts opinions, technicians and various stakeholders in the Ministry of Environmental Affairs are necessary and helpful in this regard. In simple mathematical way these relative weights can be estimated by dividing the contribution matrix of four sectors (D_{ij}) by total matrix of incremental pollution concentration in the same area, i.e.

$$R_{ij} = \frac{D_{ij}}{\Sigma \Delta SP_{ij}} \tag{3}$$

3.5 Allocation of Incremental Emissions Cost on Economic Sectors

Using the first and second models we were able to estimate the increment emission of each pollution element (ΔSP_i) and contribution ratio of each sector in incremental emissions (D_{ij}) respectively. The third model is used to estimate the risk matrix of emissions caused by each economic sector (R_{ij}).

The next step is to allocate the cost of incremental emissions on economic sectors. For this step, the cost of excess pollution emissions elements than internationally allowable emissions in the study area needs to be estimated. This work has been addressed in several previous studies (Muller et al., 2011, Al Barghouthi and Marie, 2016, Tu and Huang, 2015, Marie and Albarghouthi, 2017). Based on the foregoing, these costs can be distributed to various economic sectors operating in this region by using the fourth model as follows:

$$E(TC_{ij}) = \left(\sum_{j}^{J} R_{ij} \right) \left(\sum_{w}^{W} TC_{iw} \right) \quad (4)$$

where

$E(TC_{ij})$	Matrix of allocated cost per economic sector in the area under study
ΣR_{ij}	Matrix of estimated relative risk weight from each pollutant (i) for each sector (j)
j	Economic sectors within the area under study ($j = 1, 2, , J$)
$\sum_{w}^{W} TC_{iw}$	Total cost matrix for the increase in emissions of pollution elements on wealth items $w = 1, 2, ..W$

3.6 Distribution of Allocated Costs on Sectors Subsidiaries

The next and final step in our proposed models is to distribute the cost allocated to each economic sector on its subsidiaries. We agree that all enterprises in a particular economic sector are competing mainly in the use of same inputs, manufacturing processes, and marketing its similar outputs. In other word, within a given economic sector, all enterprises are supposed to offer similar products to be sold at fixed competitive prices. Accordingly, the cost allocated to each economic sector can be distributed on its subsidiaries based on the size of output divided by the gross output of total subsidiaries within this sector. Thus, an enterprises share is determined by percentage of its output to gross output of the sector's enterprises multiplied by the cost allocated to this sector. To illustrate, assume that the industry sector (J_1) consists of (N) enterprises that produce similar products and sell them at same prices. Assumed also that during the current period the production volume of these enterprises are referred to as $J_{11}, J_{12}, J_{13}, J_{14}, and J_{15}, ., J_{1N}$. Therefore, the cost share attributed to specific enterprise (CJ_{11}) can be estimated by the following equation:

$$CJ_{11} = E(TC_{ij1} \frac{J_{11}}{\left(\sum_{n=1}^{N} J_{1N} \right)} \quad (5)$$

4 Applicability Test of the Proposed Models

Due to the difficulty of obtaining actual data for the variables required in this study, we assumed a simple numerical example to show how the proposed models are implemented. To illustrate the applicability of the proposed models expressed in equations (1-5), assume a simplified hypothetical case where there are four sectors (JN) caused emissions of four pollution elements (D_i) in Dubais geographical area: industries (J_1), oil refining (J_2), traffic (J_3), and construction activity (J_4); permissible levels of pollution (NL_i); actual levels of pollution in the study area (AL_i); actual pollution levels per sector (SL_i). Based on these assumptions, table (1) shows simple example to explain the allocation procedures of our proposed models (equations 1-4) as reflected in tables 2-4.

Table 1: Assumed Permissible and Actual Levels of Pollution

Code D_i	NL_i	AL_i		SL_i		
			J1	J2	J3	J4
D.01	75	197.69	254.35	180.2	173.2	183
D.07	32.5	96.33	89.8	153.3	45.9	0
D.08	30	42.68	45	41	43.90	40.8
D.12	4	18.85	21.4	18.7	16.6	18.7

Table 2: Sectors Contributions in Incremental Emissions: Model (1) & (2)

Code D_i	ΣS_{ij}	ΔSP	D_{j1}	D_{j2}	D_{j3}	D_{j4}
D.01	790.75*	122.69**	39.46***	27.96	26.87	28.39
D.07	289	63.83	19.83	33.86	10.14	0
D.08	170.7	12.68	3.34	3.04	3.26	3.03
D.12	75.4	14.85	4.21	3.68	3.27	3.68

* 254.35+180.20+173.20+183.00 = 790.75 ——- Table (1)
** 197.69 75.00 = 122.69 ————— Table (1)
*** 122.69*254.35/790.75 = 39.46 ———— Table (1)

Table (4) shows the results of allocating the cost of incremental pollution emissions on different economic sectors, the next step is to use model (5) to distribute the cost of each sector on its subsidiaries. For illustration, assume that the industrial sector J1 consists of five enterprises ($J_{11} - J_{15}$) where the volume of production during the current period was 5,000 units, 8000 units, 12,000 units, 15,000 units and 10,000 units respectively . Thus, the total production of this sector is 50,000 units. Accordingly, the results of applying the fifth model are shown in table (5).

Table 3: Estimation of risk weight for each pollutant (i) in each Sector (j): Model (3)

Code D_i	%	R_{j1}	R_{j2}	R_{j3}	R_{j4}
D.01	100	0.32*	0.23	0.22	0.23
D.07	100	0.31	0.53**	0.16	0
D.08	100	0.26	0.24	0.26***	0.24
D.12	100	0.28	0.25	0.22	0.25****

* 39.46/122.69 = 0.32 ————- Table (2)
** 33.86/63.83 = 0.53 ———— Table (2)
*** 3.26/12.68 = 0.26 ————Table (2)
**** 3.68/14.85 = 0.25 ——— Table (2)

Table 4: Allocation of Incremental Emissions Cost on causative Economic Sectors: Model (4)

Pollution item	Estimated Cost	Industries	Oil Refining	Traffic	Construction
D.01	4,580,400.00	1,465,728.00*	1,053,492.00	1,007,688.00	1,053,492.00
D.07	2,435,789.00	755,094.59	1,290,968.17**	389,726.24	0
D.08	521,470.00	135,582.20	125,152.80	135,582.20	125,152.80
D.12	9,500,600.00	2,660,168.00	2,375,150.00	2,090,132.00	2,375,150.00
TOTAL	17,038,259.00	5,016,572.79	4,844,762.97	3,623,128.44	3,553,794.80

* 4,580,400.00 * 0.32 = 1,465,728.00 ———Table (3)
** 2,435,789.00 * 0.53 = 1,290,968.17 ———Table (3)

5 Discussion

In our previous section, we have formulated a simple mathematical framework to allocate the cost of environmental pollution on the economic sectors and subsidiaries located in study area. Due to lack of actual data, we have provided a numerical example to show how the proposed models are implemented. We concluded by estimating the share of each institution, located in study area, in the incremental emissions costs of environmental pollution elements. Accordingly, the next step is to indicate the role of the government and the competent authorities in compelling the enterprises to pay taxes (or fees) equal to the quotas allocated to them and to indicate how they are treated in their accounting records and financial reports. Along with the advocacy of sustainable development, green accounting expects to be legislated in the future, thus affecting the production and increasing its operational cost. Many countries around the world have mandated enterprises to establish green accounting and to disclose environmental information for the reference of interested parties. Green accounting known as environmental accounting is to measure, record and disclose the impacts of corporate environmental activities on its financial reports through a set of accounting systems. The definitions of green accounting in different countries are similar (Tu and Huang, 2015; U.N. Divi-

Table 5: Distribution of Allocated Costs on Sectors Subsidiaries: Model (5)

Pollution item	Industries	$J_{11}5000units$	$J_{12}8000units$	$J_{13}12000unitsy$	$J_{14}15000units$	$J_{15}1000units$
D.01	1,465,728.00	146572.8	234516.48	351774.72	439718.4	293145.6
D.07	755,094.59	75509.46	120815.13	181222.7	226528.38	151018.92
D.08	135,582.20	13558.22	21693.15	32539.73	40674.66	27116.44
D.12	2,660,168.00	266016.8	425626.88	638440.32	798050.4	532033.6
TOTAL	5,016,572.79	501657.28	802651.64	1203977.47	1504971.84	1003314.56

sion for Sustainable Development, 2015; Huy, 2014; Moorthy and Yacob, 2013; Peszko and Lenain, 2001). It use lifecycle assessment to measure the environmental impacts of corporate activities, promote the use of clean production, adopt total cost assessment and combine traditional accounting to disclose the environmental financial information of the enterprises. Ministry of Environment Japan defined green accounting as quantitative assessment of the expenditures and benefits in environmental protection activities and specified systematic records and reports, maintenance of a positive relationship between the enterprises and the natural ecology, and promotion of effective and efficient environmental activities, in order to achieve sustainable development. The green accounting system in EU countries, such as Denmark and the Netherlands, is required by law to disclose environmental information to the government. Countries that have not legislated related laws, such as the U.S. and Japan, have mandated some enterprises to disclose environmental information. In Taiwan, the government has provided guidance to promote the green accounting system. Multinational corporations are increasingly concerned with whether their suppliers have disclosed green accounting information before proceeding with transactions. It is obvious that green accounting has become a mainstream trend in the world, and legislation of related laws is necessary. Once green accounting is enforced by the government, enterprises are required to internalize the external costs of the production activities, thus increasing the production and operational costs. To sum up, to meet green accounting rules, the allocated pollution costs should be disclosed in financial statements of the current economic sectors as a part of its subsidiaries operational costs. In terms of new projects, operating licenses are granted only if they comply with green accounting rules and internationally permitted levels of pollutant emissions. It should be followed up by governments and relevant stakeholders in order to ensure full compliance with rules and standards. New projects should commit to disclose the environmental information in their financial statements as a part of its operating cost.

6 Conclusions

This study addresses the issue of accounting for cost of pollution emissions on wealths elements. We have presented a simple workable accounting framework for allocating the costs of pollution damages on various polluting sources. This workable accounting framework was built on five mathematical models to estimate: the incremental emissions per pollution element, sectors contributions in incremental emissions, risk of emissions caused by each sector, allocation of incremental emissions cost on economic sectors, and distribution of costs allocated to sectors on their subsidiaries. Under our proposed models, taxes or fees are assessed by the amount of pollution emissions that an enterprise generates. Consequently, it is worthwhile for the enterprise to reduce emissions to the point where its marginal abatement cost is equal to the tax rate. If, however, the polluter pays for the pollution, either by buying permits or through pollution taxes, the costs of the pollution would be part of the enterprises cost of production and obliged to record it in their books and disclose it in its financial reports in a separate item. For environmental efficiency, the tax rate should be set equal to the marginal benefits of clean-up at the efficient level of clean-up, but policy makers are more likely to think in terms of a desired level of clean-up, and they do not know beforehand how enterprises will respond to a given level of taxation (Stavins, 2007 and Muller and Mendelsohn, 2009. On the other hand, we should extend the application of green accounting and environmental sustainable concepts to include all economic sectors and its subsidiaries. Accordingly, Green accounting can be defined as guidelines system for government and the competent authorities to develop rules, policies, and procedures on what enterprises should do in preventing environmental degradation and maintaining a sustainable and clean environment. I agree with the green accounting guidelines of the U.S., Japan and Taiwan, which include the following dimensions: (1) expanding corporate social responsibility; (2) internalize the external production costs; (3) clean production, zero pollution; (4) develop environmentally-friendly products; (5) production based on environmental concerns; (6) lifecycle assessment to reduce environmental impacts; (7) redesign the production process and packaging ; and (8) reduce resource wastes and implement (Reduce, Recycle, Reuse), 3R policy (Kathuria, 2006; Tu and Huang, 2015). These dimensions are considered rich floor for more future researches, in addition it should be adopted as a measure of environmental awareness and pollution alleviation.

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