NANOTECHNOLOGY AND ACCOUNTING ISSUES

Abedalqader Rababah*

* Faculty of Business Studies , Arab Open University-Oman Branch, Oman

How to cite this paper:
Rababah, A. (2017). Nanotechnology And Accounting Issues. *Risk governance & control: financial markets & institutions, 7(2,1),* 224-230.
http://dx.doi.org/10.22495/rgcv7i2c1p10

ISSN Online: 2077-4303
ISSN Print: 2077-429X

Received: 04.10.2016
Accepted: 13.03.2017

JEL Classification: E43, G3, E44
DOI: 10.22495/rgcv7i2c1p10

Abstract

Nanotechnology is a new advanced technology used in the industry. This study conducted an investigation on the literature and highlighted the accounting issues which related to the implement of nanotechnology, especially the change of cost structure and expected solutions for the increasing of indirect costs which need more accurate allocation to the unit of products. Also, this study investigated on the future expected accounting risks for using nanotechnology. Finally, this study will open the door for further studies about nanotechnology and different accounting issues in the future.

Keywords: Nanotechnology, Accounting, Production Costs, Cost Structure, Risks

1. INTRODUCTION

Nano is the accurate metric measurement unit that is known up to now (nanometer), the length of it amount to one in a billion from the meter; which equal to ten times the atomic measurement unit known as angstrom. To make this definition closer to reality; it is known that the size of nano smaller about 80,000 time than hair diameter, the size of red blood cell amount to 2,000 nanometer, and the nanotechnology as a term used also to mean smallest materials techniques or accurate microbes technology. The nano science considers the separated boundary between molecule's and cell's science and micro's science.

Nanotechnology can be represented in the implementing of nano components or structures in tools and devices which have a nanon dimension. Several researches and studies appear about the concept and the definition of nano technology. In 1959; the famous physics scholar Richard Foynman spoke in front of the American physical association at his famous lecture that addresses the issue of (There is a wide space in the bottom) saying that the substance or item at the nano level (before using this name) with few numbers of atoms perform at different form than in the case of it is sensible size or shape. He referred also to the possibility of developing a method to move atoms and substances at an independent way to achieve the require size, and at these levels a lot of physical concepts will change. As an example; gravity become less important, and in reverse; the value of atoms structures in the item will increase. It was expected that the researches about item descriptions at the nano level will have a rational role in changing the styles and shapes of human life. (Nanotechnology website (not dated) and Wikipedia (not dated)).

This effort has been continued by others, thus the carbon tubes as the first products of nanotechnology implementation in the production process were obtained in 1991. (Dai, Chang, Baek and Lu, 2012). Since then, a number of products have been made through nanotechnology implementation in the pharmaceutical products processes, food, transistor motors, disks for computers and a lot of other merchandise and services. However, although the uses of these products are not popular now, today there are many eastern countries that perform investment on this technology. (Iavicoli et al., 2014).

Afterward; scholars and scientists have been trying to utilize and develop this technology until it became possible to produce several nano-products in the modern countries. We expect production nanotechnology to develop and expand even more in the future which will cause series of economical and industrial revolutions in the world. The concepts of nanotechnology depend on particles with size of less than a hundred nanometer which give the materials a new characters and behaviours. This because the particles shows new physical and chemical concepts which lead to a new behaviour depend on the size of the particles (Dai at al., 2012).

Whenever the item size became close to the atomic dimensions, the item or material goes under quantitative mechanical laws instead of traditional physical laws. The dependency of material's behaviour on its size give us the ability to control the engineering of its characteristics, and as a result of that, researchers conclude there are magnificent technical effects to this concept which contain diverse and extensive technical aspects that include the production of strong and light materials, high quality, less cost, reduce the processes of shipping, transporting, and storing of products, because the ability to produce the products quickly, and on

demand in any nano-factory in the entire world. (Nanotechnology website (not dated)).

Based on Center for Responsible Nanotechnology the implementations of nanotechnology in manufacturing process require three steps. The first step, used in the 1990s was the ability to manipulate atoms—that is, to select them up and rest them in required positions. This ability will let the produce of items to include no scrap with approximately ideal effectiveness and accuracy. The second step will be the production of assemblers-equipment that can be programmed to influence atoms and molecules. Assemblers will have a sub microscopic robotic arm managed by computer control. This strategy will produce assemblies at the nano level, disposing atoms into their appropriate place. Finally, step will be the making of sufficient assemblers to make consumer merchandise. This will be achieved through the use of replicators—assemblers that are programmed to make additional assemblers. The capacity to develop nano-robots self-replicate is an important solution in creation nanotechnology. (Center for Responsible Nanotechnology (not dated)).

Despite the fact that nanotechnology is considered a new relatively, the finding of devices that work within that concept and the finding of structures with nano dimensions is not a new thing. It is known that the biological systems in the living body create some very small device or parts which get up to nano measurement limit. The living cells consider an important example for natural nanotechnology, in which cell is a warehouse for large number of biological machines at the size of nano, and will create proteins inside of it in the form of grouped lines at the size of nano called ribosomes, and then will formulate it by using another nano device called Golgi. We can even say that enzymes itself consider a nano machine which do separate particle (molecule) or croup it accords to the need of the cell, and so it is possible for artificial nano machines to interact with it and reach the target goal; such as cell contents analysis, and the delivering of medicine to it, or destroying it when it becomes harmful. (US National Institute of Health (not dated).

Observers expect nanotechnology to affect our live at a large scale, but there are worries from the potential environment and hygiene effects of the nanotechnology, and applying of this technology in the militarism fields. It also mentions that the financing of researches related to the environment and hygiene effects of the nanotechnology must be accordant with the financing of researches related to the development of this technology. It must find and create the necessary ways to observe the potential new risks, and deal with it at an efficient manner to secure the future for this new technology (Rickerby & Morrison, 2007 and Iavicoli et al., 2014).

Although nanotechnologies have many economically significant applications in a various range of industries, and many countries around the world paid attention for using nanotechnology in the industry, there is a lack of studies in accounting field related to the implementation of nanotechnology in the industry. Nanotechnology will influence to many accounting issues, and this will encourage enhancing some accounting policies and systems. As a result the aim of this study is to increase the awareness level about nanotechnology in the accounting area, and open the door for further studies about nanotechnology and different accounting issues in the future.

This research paper will concentrate on several accounting issues that were mentioned in previous studies or it has been deducted; such as reducing the cost of production unit and the change in cost structure with high increasing in fixed cost, and that need an accurate allocation to the unit of production. There are also some other issues like job opportunities, the financing of nano projects, and the rise or increase of its cost at the first time of establishing it. This paper has suggested some potential solutions to those accounting issues and problems which face companies using nanotechnology. The previous studies stopped at expecting what will happen when using nanotechnology in the industry, but they did not anticipate any solutions to the prospective problems, and they did not provide or introduce any clear opinions. This study consider also as a new study that focus on a new accounting issues related to the nanotechnology, and it will also open the field to more studies in the future.

This paper contains of five sections. First section was an introduction. The following section is literature review. Methodology is presented in the third section. The fourth section covers the research results. And finally, the conclusion of the research will end the paper.

2. LITERATURE REVIEW

2.1. Nanotechnology Impact on Economy and Products

Researchers and practitioners expected that nanotechnology will have many economically significant applications in a various range of industries in the future, this include Chemical industries, materials and manufacturing, engineering and construction, nano-electronics and computer technology, pharmaceutical and medical industries, aeronautics and space exploration, agriculture and water environment and energy, global trade and competitiveness. The using of nanotechnology will generate many benefits to most of the products and materials this include enhanced efficiency in optics, lower costing, better ductility and toughness, higher strength and hardness for materials, Some managers and practitioners said that nanotechnology will cause industrial revolution in the globe (Iavicoli et al., 2014). The National Nanotechnology Initiative (NNI) expected that "the entire or most of semiconductor and pharmaceutical industry will rely on nanotechnology in the near future".

To date, many applications of nanotechnology have emerged in the market. Vance et al. (2015) said that there are more than 1814 Nano-products from 622 companies in 32 countries; they add that most of these products related to paints and cosmetics (e.g., skin creams, shampoos, and sunscreens) industries. Other business products of nanotechnology already in use include pharmaceutical and health care products, hard-disks for computers and improvements to telecommunications. Nagaich (2015) in his paper "Nanotechnology: The vision of 2025" expected that "the most of health care industry will rely on nanotechnology in 10 years and that, by 2025. He added also that a clinical oncology nanotechnology application which is part of health care sector dominated the overall market in 2013, accounting for 35% of total health care market revenue.

The implementation of nanotechnology has a real influence on the economy by influencing on the production procedure because any change in production procedures will influence on the relationships among economic factors. The literature review expected that the implementation of nanotechnology will lead to a new interrelationship among production factors. The earlier studies show that any new innovation or technology will influence to the production factors through different ways started from types and amount of raw materials which must be consumed during the production process. The second way is associated with level of primary factors that are necessary for a certain level of products. Third way returns to the share of primary factors and intermediate goods and services in the inputs that are requisite for the products. And finally, the new technology influences the rate of imported merchandise and services to the intermediate inputs for products. However, nanotechnology influence on an economy by influencing on the production procedure through the fourth ways or characteristics mentioned above.

Dai, Chang, Baek and Lu (2012) said that nanotechnology, which is the manipulation of matter in the dimension of 1 to 100 nm will lead to produce a new device, structure, and material particularly carbon nonmaterial's by 2050, and this new technology will lead to enhancing the energy-conversion and storage with unique physico-chemical properties (i.e. small size, large surface area to mass ratio) to be employed in energy efficient as well as economically and environmentally sustainable green innovations. Dai et al. (2012) and Iavicoli et al. (2014) added that the previous studies during the past 25 years ago led to produce some material such as graphene, carbon nanotubes and fullerenes also there are developed high-performance energy conversion such as solar cells, fuel cells and finally the storage devices such as batteries.

Several empirical studies by researchers and practitioners such as Darby and Zucker (2003) and Bowers and Cernac (2008) suggested that nanotechnology will lead to rapid improvement in the production process. They expected to decrease the unit of product cost through more effective use of inputs. In the same way, West (2008) expected to produce many types of products fast like a printer and computer that can prepare many copies of data files with small cost, West (2008) added that nanotechnology will make products as cheap as the copying of files. However, this is expected in the future because nano-products can be produced with cost-effective and will conduct electricity at a higher rate than it is now possible. For this reason's nanotechnology seen as the next industrial revolution (Center for Responsible Nanotechnology, (not dated. a).

It's necessary to add her that nanotechnology is expected to do a basic function in bringing a key functionality across the entire value chain of a merchandise or products, Rickerby and Morrison (2007) asserted that this influence will be through the valuable properties of nanomaterials included as a small percentage in a final device, or through nano-enabled processes and applications without final products containing any nanomaterials. This impact for nanotechnology on the value chain of products will lead to produce a high-quality products at very low-cost, on other side using and improving nanotechnology will allow quickly establishing new nano-factories at the same characteristics. Nano-factories will lead to reduce many types of costs by decreasing of direct labor input or by eliminating distribution, shipping, storage, and other related costs. Under traditional technology, usually 80 to 90 percent of the total costs related to the early stages of a product's life cycle.

However, most of the possible nanoproducts or nano production procedures are still under test in labs and very few products have reached the market to date. Iavicoli et al. (2014) recommended future studies to conduct further studies to test the applicability, efficiency and sustainability of nanotechnologies under more realistic conditions, especially to validate nano manufacturing system in comparison to current traditional technologies.

2.2. Nanotechnology and Cost Structure

Cooper (1988) said that using of advanced technologies in the production process will lead to greater mechanization and changes in the rate of variable or fixed cost. The cost structure changes involved direct labor costs being replaced by indirect costs or overhead cost which need correct allocation to products and services, although Cooper (1988) and Fadzil and Rababah (2012) said that using of a new technology in production process will lead to increase the rate of fixed cost and will decrease the rate of variable cost in the unit of product, they add that the profit margin and net profit for the unit of product which produced by a new technology will increase also, because the overall costs will be reduced by using the more effective technology. The researchers such as Bowers and Cernac (2008) reported that using of nanotechnology will reduce the cost of products.

However, when we reviewed the literature we did not find any study talking about the allocating of fixed or indirect cost to the unit of product which produced by nanotechnology method, and we did not find any study talking about the costing system which must be use in the new nanotechnology manufacturing environment. So in our study we will highlight this issue. Many researchers (such as Andersen, 1995; Horngren, Datar & Foster (2003); Cooper & Kaplan, 1988b; Drury, 2004) argued that cost allocations is very important because it helps in the valuation and assessments of inventory for external reporting purposes, for planning and monitoring the cost of activities and processes, and for various strategic decisions. Examples of such strategic decisions are: decisions to produce or buy some material and services important to different products or services in the firm, to price products and services, to add or remove various products and services, and to decide when to expand or contract the size of a segment of the company. Hansen and Mowen (2000) said there are many difficulties in assigning indirect costs to products. So the companies must use a new system, especially after using huge technology which leads the companies to move from direct labor to machine. As a result, more indirect or overhead costs are required to be allocated to products and services.

There are two cost allocation methods are using to calculate the unit of product cost traditional costing system and activity based costing system, and the following is pref summarize about these systems.

2.2.1. Traditional Costing Systems

Under traditional costing system there are two stages to allocate overhead costs to products or services (Drury, 2004). In stage one, overheads are initially assigned to cost centres (departments), and in stage two, overhead costs centres are allocated to cost objects (e.g. products). Horngren et al. (2003) argued that applying the two-stage allocation process needs four steps. These four steps relate to the two stage of cost allocation in traditional costing system. The first step is assigning all manufacturing overheads to production and service centres, then reallocating the costs assigned to service centres to production centres, following step is computing separate overhead rates for each production cost centre, and finally assigning cost centre overheads to products or other chosen cost objects. Thus, steps one and two relate to stage one and steps three and four relate to the second stage of the two stage allocation process.

Cooper (1988) said that traditional costing system depends on insufficient single volume measures of cost drivers (such as, machine hours or direct-labour costs) for allocating costs to products or services. He also argues that this will create mistakes in calculating the cost of product; he added that TCS was suitable when direct labour was very high in the production process. In other words, TCS are most suited for controlling variable costs, but not overhead or indirect costs.

However, many criticisms forwarded to traditional costing system since 1980s. Especially after the huge development in the production technology. Because of this system became unable to calculate the correct product cost, or help the managers in correct planning or decision-making (Johnson & Kaplan, 1987). So, the managers and researchers started thinking about solving to these problems by implementing more reliable and correct system to calculate accurate costs for products and service in the new business environment. The new system is called Activity Based Costing System (ABC).

2.2.2. Activity Based Costing System

Many researchers considered ABC to be the most important innovation in management accounting of the 20th century (Askarany & Yazdifar, 2007; Abdel-Kader & Luther, 2008; Rbaba'h, 2013). Kaplan and Cooper (1992) said that ABC is more reliable and more accurate than traditional costing system, Baird et al., (2007) described it as an improved way for allocating of indirect costs and evaluating product profitability. In addition, the results of these studies show that using traditional system to calculate cost of products will produce wrong reports, which is inappropriate for decision making. On the other hand, Kaplan and Anderson (2004) said that most of ABC practitioners have been expected to decrease costs by 3% to 5% and to increase revenue by 5 percent to 15 percent. Previous studies (such as Shields's 1995; Pierce and Brown 2004) said that ABC are used for product costing, pricing decisions, customer profitability, improvement in financial performance and budgeting.

However, the earlier studies suggested some differences between ABC and TCS related to both the nature of allocation bases and the number of allocation bases used to divide costs to cost object in the second stage. ABC conducting by two allocation stages to assign costs first to the activities then to products based on each products use of activities. This system is based on the concept that product consumes activities and activities consume resource (Cooper & Kaplan, 1991). Rasiah (2011) said that the two stages under this system contain four basic steps. These are: identifying activities, assigning indirect costs to activities, identifying outputs, and linking activity costs to outputs.

The mentioned four steps can be summaries into two stage allocation processes. First stage is the allocating indirect costs to the activities as determined before. This allocating is based on the suitable resource's driver. In the second stage of the ABC process, indirect costs are allocating to products or service activities during the production process. Cooper (1988) said that ABC system uses a number of cost drivers to allocate indirect costs to cost objects. Some of these cost drivers are used to allocate costs whose consumption varies directly with the number of products produced. On the other hand, other drivers are used to allocate costs whose consumption does not vary with quantity. Therefore, ABC systems use a greater number and variety of second stage cost drivers than traditional costing system.

In our study i strongly advice the nano-factories companies to start using ABC system instead of using Traditional Costing Systems, because the rate of overhead cost will increase and this companies will face cost allocation problem in the future under Traditional Costing Systems. Especially, when they produce more than one product in their companies.

2.3. Nanotechnology and Accounting Risks

Many advantages and benefits for nano-applications such as reducing production and storage costs, reducing pressure on raw materials, enhance the products quality, clean-up technologies as well as in fostering sustainable manufactured products. Opposite of these benefits, there are many challenges on health and safety risks, social issues, as well as uncertainty about market, financing and accounting risks. Therefore, our aim in this research is to highlight these accounting and financing risks.

The first risk for nanotechnology using is the high cost for establishing of nano factories. The companies which attending to set up nano-manufacturing techniques will pay more cost in the earliest stage and this will be more than the traditional manufacturing method, because The development of assemblers and replicators will need more costs, after that when the production process start a little more cost is incurred in the later stages during the production process, sales, and after sales. However, this will create problems for investors whom will pay a lot first cash outlay as a capital, also the creditors who will give the capital under high degree of uncertainty about the first cash outlay, due to the newness of nanotechnology. Moreover, the unpredictability of sales volume makes it difficult to forecast future free cash flows. Although the traditional manufacturing system costs is higher than nono-manufacturing costs, the high

investment to build nano-factories at earliest stage will increase the effects of forecast errors. As compared to nono-manufacturing traditional manufacturing costs will incur and paid step by step during production process, sales, and after-sales, so the risks under traditional manufacturing method will be less than the risks under nono-manufacturing method.

The second problem for nanotechnology is distorts the cost of products because the high rate of indirect cost which need accurate allocation to the unit of product, any wrong in calculating the cost of products will lead to wrong pricing decisions then decrease the competitiveness for the company. However, i highlighted this problem in the earlier part of this study which submitted suitable solution and i think the nano-factories managers will improve or discover a more effective system for this problem in the future.

Finally, I expected the world will face problem after using nanotechnology related to job opportunities because the nano-factories will use machines and technology in their production and sales ways more than workers and this will reduce the number of workers in production and sales lines, thus we will face unemployment workers and resistance to change by them to new technology (Sharify et al., 2010). In other side may be the new technology will create a new job and overcome to this possible problem. However, there is a need for further studies in the future on the potential problems and risks Especially given that some researchers and scientists such as Maynard (2004) and Hoyt and Mason (2007) expect that this technology may cause health problems for workers and consumers in the future, This will have an impact especially on the accounting community and the insurance sector.

3. METHODOLOGY

A qualitative method used in this study depending on literature reviews. This is likely to be the methodology of theoretical analysis: choice and discussion of theoretical material and descriptive material. A library-based or theoretical is a crucial tool for assessing and developing the knowledge base within a research field.

Literature reviews in accounting and nanotechnology often considerably more stringently presented than other empirical research because a lack of companies implementing nanotechnology, then difficulties in collecting data by other methods. The purpose of this paper is to elaborate on the importance of literature reviews in the area of accounting and nanotechnology.

The author combines electronic and manual searches to find relevant studies using key words like “nanotechnology and accounting or” production costs” or “cost structure” or “risks” or “environment”. The search yields a total number of 26 published studies in refereed journals; only articles in English were selected. Only twelve of the twenty six studies were specific related to nanotechnology and the others relate to technology and cost structure. For each reviewed stream of research, the author presents its theoretical underpinning and summaries its main results.

The literature was classified to the following streams: Nanotechnology Impact on Economy and Products); Nanotechnology and Cost Structure ii); Nanotechnology and Risks iii). Then, each study summed up in table which show the list of Authors, Research questions, Sample, Methodology, and Main findings. The largest groups of published studies relate to nanotechnology and risks, and then published studies relate to nanotechnology impact on economy and products. Finally, some empirical studies focus on nanotechnology and cost structure.

This research represents a historical record, an introduction and guidance for researchers who aim to examine the relationships between nanotechnology implementation and accounting methods. It conducts a content and critical analysis for reviewed studies, and highlights a new links between accounting issues and nanotechnology which neglected in previous studies. In addition, some of studies which related to nanotechnology and accounting suffer from methodological weaknesses because a lack of companies which are implementing nanotechnology, therefore, this research provides an overviews, explanations, solutions and predictions to some accounting issues which resulted from nanotechnology implementation by using more reliable method.

4. RESULTS

Content and critical analysis is introduced and applied for reviewing some literature reviews about implementing nanotechnology in the industry, which published in peer-reviewed journals until 2016. Each paper was assessed and summed up for the aim of research. This analysis led to increase the awareness level about the influence of nanotechnology procedures on the production process, then summarizing the relationship between nanotechnology and accounting. This research explains the impact of nanotechnology on economy and products, on cost structure, and summarizing the expected accounting risks after implementing nanotechnology. The result shows that nanotechnology influence on economy by influencing production procedures through the four ways which were mentioned in part 2.1. Nanotechnology will enhance products quality, reduce products cost and it will reduce shipping and storage cost. The results explained the relationship between implementing nanotechnology and cost structure by increasing fixed cost which need more accurate allocation to the unit of product. However, when we reviewed the literature we did not find any study talking about the allocating of fixed or indirect cost to the unit of product which produced by nanotechnology method, and we did not find any study talking about the costing system which must be use in the new nanotechnology manufacturing environment. So in this study I highlighted this issue. and I strongly advice the nano-factories companies to start using ABC system instead of using Traditional Costing Systems, because the rate of overhead cost will increase and this companies will face cost allocation problem in the future under Traditional Costing Systems. Especially, when they produce more than one product in their companies (see part 2.2).

Finally, the research results show problems of nanotechnology using such as high cost for establishing nano-factories especially, at the earliest stage. Another accounting problem is distorts the cost of products, any wrong in calculating the cost of products will lead to wrong pricing decisions then decrease the competitiveness for the company. Last problem is causing health problems for workers and consumers in the future, this will influence on the accounting community and the insurance sector. Therefore, I strongly advice future studies to conduct more studies related to accounting problems after implementing nanotechnology (see part 2.3).

5. CONCLUSIONS

Implementation of nanotechnology will cause industrial revolution on the future, and it will affect the economic and common aspects of the people's life through production process. Although nanotechnology will have many economically significant applications in a various range of industries in the future, there is a lack of studies in accounting field that mentioned the accounting issues which related nanotechnology implementation. Nanotechnology will influence to many accounting issues, and this will encourage enhancing some accounting policies and systems, as a result; the aim of this study is to increase the awareness level about nanotechnology in the accounting area.

The results of this research encourage manager and accountants to pay more attention in improving the accounting policies and costing systems that are used in nano-factories. The result shows that nanotechnology will influence the economy by influencing the production procedures through fourth ways, this result consistent with earlier studies such as (Sharify et al., 2010). However, nanotechnology will enhance the quality of products, reduce the cost of products and reduce shipping and storage cost, this result consistent with earlier studies such as West (2008) and Iavicoli et al. (2014).

The results explained the relationship between implementing nanotechnology and cost structure by increasing fixed cost which need more accurate allocation to the unit of product many researchers (such as Cooper, 1988; Drury, 2004; Fadzil and Rababah, 2012) expected this result when any factory use a new improved technology in production process. This research focused on the change of cost structure and the expected solution for indirect cost allocation.

Implementation of nanotechnology will do many advantages more than traditional manufacturing industry because its effects on economy, quality of products, and reduce the cost of products. In the other side it causes many accounting problems and risks related to the high investment costs, change in cost structure and job opportunities. Furthermore, debt holders and equity holders will be afraid of returns and the risk of default that will influence the financing of company implementing nanotechnology, the same result was suggested by Maynard (2004) and Hoyt and Mason (2007). However, this paper highlighted all of these accounting issues and it also reviews development in the research along with some discussions on challenges and perspectives in this exciting field.

My intent is that this paper will impact future nanotechnology and accounting research in different streams, these streams are: Nanotechnology Impact on Economy and Products); Nanotechnology and Cost Structure ii); Nanotechnology and Risks iii). This research represents a historical record, an introduction and guidance for researchers who aim to examine the relationships between nanotechnology implementation and accounting methods. It highlighted a new links between accounting issues and nanotechnology which neglected in previous studies. In addition, this research provides an overviews, explanations, solutions and predictions to some accounting issues such as the problems of insurance sector, unemployment workers and distortion product cost and which resulted from nanotechnology implementation.

REFERENCES

1. Abdel-Kader, M., & Luther, R. (2008). The impact of firm characteristics on management accounting practices: A UK-based empirical analysis. *The British Accounting Review*, 40(1), 2-27.
2. Anderson, S. W. (1995). A framework for assessing cost management system changes: The case of activity based costing implementation at General Motors. *Journal of Management Accounting Research*, 7(1), 1-51.
3. Askarany, D., & Yazdifar, H. (2007). Why ABC is Not Widely Implemented? *International Journal of Business*, 7(1).
4. Baird, K., Harrison, G., & Reeve, R. (2007). Success of activity management practices: the influence of organizational and cultural factors. *Accounting & Finance*, 47(1), 47-67.
5. Source: Center for Responsible Nanotechnology, at http://www.crnano.org/ timeline.htm
6. Cooper, R. The rise of activity based costing: Parts 1, 2, 3 & 4. *Journal of Cost Managemen*t (1988—1990).
7. Cooper, R., & Kaplan, R. S. (1988). Measure costs right: make the right decisions. *Harvard Business Review*, 66(5), 96-103.
8. Dai L, Chang DW, Baek JB, Lu W: Carbon nanomaterials for advanced energy conversion and storage. Small 2012, 8:1130–1166.
9. Drury, C. (2004). Management and Cost Accounting, London. Thomson Learning.
10. Fadzil, F. H. B. & Rababah, A. 2012. Management Accounting Change: ABC Adoption and Implementation. *Journal of Accounting and Auditing: Research & Practice*, 2012, 1-17.
11. Hansen, D. R. dan Maryanne M. Mowen (2000). Management Accounting, 5th Edition. International Thomson Publishing, (ITP).
12. Horngren, C., & Datar, S. ve Foster, G. 2003. Cost Accounting: A Managerial Emphasis, New Jersey, Prentice Hall International.
13. Horngren, C., & Datar, S. ve Foster, G. 2003. Cost Accounting: A Managerial Emphasis, New Jersey, Prentice Hall International.
14. Hoyt. V.W and Mason . E (2007).” Nanotechnology Financing and Accounting Risks”. *Journal of Chemical Health and Safety*. Volume 15, Issue 2, March–April 2008, Available online 24 August 2007. http://www.sciencedirect.com/science/ article/ pii/S1871553207000722

15. Johnson, H. T., & Kaplan, R. S. (1987). Relevance lost: The rise and fall of management accounting: Harvard Business School Pr.
16. Kaplan, R. S., & Cooper, R. (1992). From ABC to ABM. Management Accounting, 54-57.
17. Kaplan, R. S., Anderson, S. R., & Research, H. B. S. D. o. (2004). Time-driven activity-based costing: Division of Research, Harvard Business School.
18. Iavicoli, I., V. Leso, W. Ricciardi, L. L. Hodson and D.M. Hoover, 2014. "Opportunities and challenges of nanotechnology in the green economy. *Environmental Health Journal*. ISSN: 1476-069X, 2014. http://www.ehjournal.net/content/13/1/78.
19. Maynard A.D (2004). "Nanotechnology: assessing the risks" Nano Today, Volume 1, Number 2; May 2006. ISSN: 1748 0132.
20. Nagaich.U (2015). Nanotechnology: The vision of 2025, *Journal of Advanced Pharmaceutical Technology and Research* (JAPTR), http:// www.japtr.org
21. Organisation for Economic Co-operation and Development: OECD/NNI International Symposium on Assessing the Economic Impact of Nanotechnology Background Paper 3: The Economic Contributions of Nanotechnology to Green and Sustainable Growth. 2012. in http:// www.oecd.org/sti/nano/49932107.pdf.
22. Pierce, B., & Brown, R. (2004). An empirical study of activity-based systems in Ireland. *The Irish Accounting Review*, 11(1), 55–61.
23. Rbaba'h, A., "The influence of company characteristics factors to activity based costing systemimplementation, *Journal of Education and Vocational Research*, 4(2): 36-46 (2013).
24. Rasiah, D. (2011). Why Activity Based Costing (ABC) is still tagging behind the traditional costing in Malaysia? *Journal of Applied Finance & Banking* 1(1), 83-106.
25. Rickerby D.G. and M. Morrison (2007) "Nanotechnology and the environment: A European perspective", Science and Technology of Advanced Materials 8(1-2): 19-24.
26. Sharify, N., A. Sharify, F. Sharify, 2010. The effects of nanotechnology implementation in manufacturing on products costs and employment. Paper to be presented at the 18th International Input-Output Conference, Sydney, Australia.
27. Shields, M. D. (1995). An empirical analysis of firms' implementation experiences with activity-based costing. *Journal of Management Accounting Research*, 7(1), 148–165.
28. Source: NSF National Nanotechnology Initiative http://www.nsf.gov/crssprgm/nano/
29. Source: US National Institute of Health, http://nano.cancer.gov/learn/understanding/
30. Vance, M. E., Kuiken, T., Vejerano, E. P., McGinnis, S. P., Hochella, M. F., Jr., Rejeski, D. and Hull, M. S. (2015). Nanotechnology in the real world: Redeveloping the nanomaterial consumer products inventory. Beilstein *Journal of Nanotechnology*, 6, 1769-1780. http://dx.doi.org/ 10.3762/bjnano.6.181.