FUNCTIONS OF REUSE AND RECYCLING IN THE SERVICE ECONOMY

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Abstract
The present paper aims at communicating the business world the vision of sustainable competitiveness entailing the adoption of the new business models of producing, selling and maintaining performance over time. These models include strategies that can head firms in designing and producing goods that facilitate the efficient use of resources throughout their entire life cycle including the end-of-life phase. A description of the industrial and service economy highlight that a transition towards the functional service economy requires a shift to a recycling society, where waste is considered and used as a resource. The closure of loops is represented by closed-loop supply chains and a sustainable product-life cycle leading to the products' second life, where various rules, business strategies and scientific and engineering instruments are applied. Reuse and recycling are basic strategies incorporated in the sustainable product-life cycle and their applications and implications in the service economy are thoroughly investigated. The findings conclude that for the extension of products' service-life all parties of the entire supply chain need to cooperate in an environment characterized of reduced resource throughput, minimized waste generation, access to information and optimized infrastructure. In this framework, the paper concludes with a suggestion of a synergy of proactive Small and Medium Enterprises (SME's) coexisting in Eco-Industrial Parks for the advancement of their CLSC capabilities. This research enlightens firms about the key corporate strategies of the functional service economy and the business practices and tools that optimize quality and performance while maximizing profits and minimizing the environmental footprint.
Keywords
Product life cycle, Service economy, Reuse, Recycling, Closed loop supply chains

1. Introduction
The increasing concerns about the depletion of natural resources on the one hand and the increasing generation of waste volume on the other, both as consequences of the intense industrial activities have led scientists to rethink and reevaluate not only the rules of manufacturing operations but the entire economic model of our industrial economy. Production is associated to productivity and volume. The highest the productivity, the larger the economies of scale are and accordingly the highest the business profitability is. Usually producers’ liability ends after the product is sold without carrying any responsibility for the waste management and consumers tend to replace the damaged, used or unwanted products with new ones. This scheme implies a short product-life span and a rise in landfill and incineration processes. As a result, consumers have acquired an overconsumption attitude, closely related to ownership.

The reconsideration of this economic model draws the conclusion that decoupling value creation from resource input is imperative. The efficient use of resources throughout the entire product-life cycle demands the implementation of key strategies that will illustrate the transition to the functional service economy. Firstly designing and executing prevention strategies with the exploitation of science will provide knowledge-based solutions. Secondly manufacturers selling performance, services or results will lead to the Extended Performance Responsibility (EPeR). Additionally, manufacturers and managers with loop responsibility will create the closed loop economy and those in charge of maintenance and operation will contribute in optimizing utilization. Thus together with independent remanufacturers, who result in product-life extension, they will open the door to a new field of job creation potential. Consequently the functional service economy is based on functions or performance and people are not buying products but functioning systems and system functioning over time as a permanent service (Stahel, 2010).

This paper presents business practices and tools that lead firms to decouple wealth from resource overuse along raw material extraction, production, utilization and end-of-life. It focuses on the service-life extension of goods and components through improved operation and maintenance methods. Which strategy should be executed in every single phase of the product life cycle? What tools are necessary for the strategies execution? What is the benefit?
The study seeks to give answers to the above questions by investigating the correlation of corporate strategies and scientific instruments along the phases of the product-life cycle. To this end it underlines the importance of implementing scientific and engineering innovation as a key factor to optimize performance.

The remainder of this paper provides the theoretical background supporting reuse and recycling among other priorities of waste prevention. For a deeper understanding of the terms and the benefits derived the study presents the implementation of reuse and recycling in a large manufacturing company that serves as a paradigm of sustainable innovation, sustainable production and design for reuse. The final part concentrates on the cooperation and interaction between the supply chain parties for the successful formation of a Closed Loop Supply Chain (CLSC). In this context it suggests the synergy of proactive SME’s interacting and coexisting in Eco-Industrial Parks (EIP), as a scheme for the improvement of their CLSC capabilities.

2. Product Life Cycle
The traditional-Forward Supply Chain (FSC) includes a series of activities conducted by suppliers, subcontractors and distributors concerning the domains of Research and Development (R&D), product/service design, raw material supply, manufacturing, marketing, sales, transportation and distribution as well as after sales service. However, the ever increasing volume of global environmental regulations and legislation on hazardous materials, like Waste Electrical and Electronic Equipment (WEEE) and Restriction of Hazardous Substances (RoHS) in Europe, are forcing firms to employ practices that at the same time reduce their environmental impact and provide them with a competitive advantage through the identification of new business opportunities. Hence, these practices deal with the FSC expansion to another series of activities that take place after the products reach their end of life. These activities compose the Reverse Supply Chain (RSC) and tackle collection and disassembly, repair, remanufacturing, reuse, material recycling, recovery and disposal. FSC and RSC form the CLSC (Talbot et al., 2006; Krikke et al., 2004) that is capable of raising the environmental performance of industrial operations to new standards (Talbot et al., 2006; Pappis et al., 2004). All RSC activities support the notion of using waste as a resource and thus play a significant role in improving the environmental performance of industrial operations.
2.1 Raw material extraction

Though the RSC activities take place after the products have reached their end of life, this does not imply that firms should only be reactive and develop waste management aspects. Conversely, they need to demonstrate a proactive stance throughout the entire product-life cycle including also the FSC activities. Therefore the implementation of Dfe rule begins from the raw material extraction phase. According to Stahel (2010), extraction or production of basic materials, such as steel and cement consume roughly the three-quarters of all industrial energy. The environmental issues associated to growing and extracting raw material centre on management practices and encompass all the consequences of human, natural and economic capital exploitation. The design of human protection needs to meet all employees’ requirements as well as local inhabitants and stakeholders rights and interests in the exploitation of physical resources. Natural protection regards land management and renewal, as a critical process that needs to take place after the raw material extraction activities. Remediation strategies for contaminated soil and groundwater and landscape restoration not only contribute to pollution and waste prevention but also to the overall economic development of regions. However, for the companies’ economic development it is necessary to establish a raw material management program. Such a program can maximize the efficiency of the entire conversion process of raw material into end-products through tracking purchases and usage of materials, linings and trimmings as it controls the resource throughput. Both, controlling raw material extraction and resource consumption while being environmentally responsible are associated to supplier integration in pollution prevention. Supplier integration in pollution prevention verifies that the raw material complies with all the environmental and quality standards but also the customers’ specifications. These standards are included in various Environmental Management Systems (EMAS), such as ISO 14001.

2.2 Production

Another dimension of Dfe is the design for dematerialization, which consists of energy and material conservation, source reduction and servicization. This discipline forms the best option to decouple economic growth from resource consumption (Fiksel, 2009). Energy and material conservation incorporate product-life and functionality extension, remanufacturing of components, recycled or renewable materials and reduction in life cycle resource intensity. Design for source reduction includes lowering products size and mass (down-sizing), remanufacturing, reducing complementary material and packaging (solvents, catalysts, process water, pallets etc) as well as simplifying and reducing the manufacturing process scale. Instead it can be turned into a more efficient procedure with reduced temperature and pressure requirements and higher product output (Fiksel, 2009). Finally servicization is
linked with product leasing and product substitution with services. An example of leasing, which nowadays is becoming popular is car-sharing. The concept refers to drivers-users, who fulfill their need without being drivers-owners, while the car rental company retains ownership and responsibility. Another important aspect of fulfilling customer needs and creating customer value is offered by the Product Service Systems (PSS), a product design methodology that combines products and services to fulfill consumers’ needs. In a broader business context it deals with renting, leasing and similar concepts given that products are operated by the manufacturing companies (Sundin et al., 2009). The target of this approach is to design economic, functional, aesthetic and safe products with the ultimate goal to provide solutions instead of products. Multi-functionality, developing and using components that have more than one function in a product is also taken into consideration when designing a PSS.

Dealing with production the most important issue concerns safety. Within the limits of Dfe minimizing the hazard and risk of adverse human and ecological effects is designed through design for detoxification. This strategy aims at replacing toxic and/or hazardous materials that are involved in physical or chemical transformations of manufacturing processes with non-hazardous and environmentally benign ones (Fiksel, 2009). Companies accomplish this goal by applying cleaner production methods, such as technologies capable of minimizing the release of emissions and harmful wastes or through waste modification with the use of chemical, energetic or biological treatment. Although it is not considered as a strategy that leads to reduction of resource overuse, in combination with product recyclability performed at the end-of-life phase, it can contribute to a reduction of virgin resources’ extraction.

Besides the rule of Dfe, firms can create maximize profits with less resource consumption via scientific and engineering innovation. That is by applying automation, component standardization and using analytical and quantitative tools such as Life Cycle Analysis (LCA), Material Flow Analysis (MFA) and Substance Flow Analysis (SFA). Automation creates sustainable jobs and conduces to job cutbacks in manufacturing. It is time and cost efficient and requires a good know-how of technological applications. Thus, for promoting automation in manufacturing processes, companies should be able to organize training programs and workshops addressed to their employees with the target to train them in improving their expertise in operational procedures. Component standardization is also an issue of high importance, since its contribution is considerable not only in the production but also in utilization and end-of-life phases. In respect with production, standardizing the components
that are contained in the end-products turns the manufacturing process cheaper and easier as it saves of efforts in design and reduces both the quality control in production and the handling costs. In addition it assists to avoid situations such as surplus spares and out of production service parts, shortens the time that products are released to the market and improves product information to customers (Stahel, 2010). LCA and MFA map the type and amount of material input and output of the product life cycle, although they are not capable of assessing the impacts of flows on the environment. LCA is a global method that analyzes the environmental effects of a product’s or service’s function. Whereas MFA concentrates on the analysis of materials throughput or intensity of all technical processes operated in national economies, important sectors or functional systems and thus focuses on bulk or mass flows. SFA can be considered as a form of MFA but as it focuses on a specific substance or element embodied in various materials, it can also be extended to the flows of a specific substance in the environment. It specifies the cause of pollution problems and identifies options for solving or preventing them (Bouman et al., 1999).

Manufacturing companies interested in differentiating themselves from competition in environmental aspects employ environmentally responsible manufacturing (ERM) practices. That is to perceive any form of pollution as waste (Talbot et al., 2006; Curkovic et al., 2000) and focus on resource productivity. This fundamental value of ERM is shared with its antecedents, such as Total Quality Management (TQM) for the reduction of defects, Just-In-Time manufacturing (JIT) for the reduction of delays (Talbot et al., 2006; Chase et al., 1998) and lean manufacturing for the reduction of waste (Talbot et al., 2006; Womack and Jones, 1996; King and Lenox, 2001). Thus, the benefit of ERM is found in the maximization of resource productivity and the optimization of quality.

Finally contributing to the closing of loops in the production phase is also achieved through recycling post-industrial wastes, as it leads to asset recovery. However this is feasible and more efficient when applied to products that can be recycled in a molten phase, such as metals and paper. For other types of products characterized by various physical and chemical properties recycling is not that feasible because of the difficulty to separate mixed wastes.

2.3 Utilization
The transition to the service economy does not only require change in production patterns but also in consumption patterns. Consumers need to disengage themselves of being owners and become users. Economic success in the sustainable asset management of a
service economy derives from husbandry and stewardship, not from mass production (Stahel, 2010). Therefore the utilization phase plays a significant role in the product life cycle as consumers can considerably contribute to the sustainable economic development. Caring and sharing are the underlying principles of maintaining performance over time and signify constant awareness and motivation. Caring has to be rewarded by take-back strategies on a price depending on the products’ condition so that it leads to a significant quality improvement of the used products. In addition it is important both for private consumers and procurement managers to be able to measure the sustainable economic productivity of goods and not just their pure monetary value. This can be accomplished with the new metric that calculates the economic value achieved per unit of resource consumed, once price and weight are known (€/kg). This measure functions as a benchmark that encourages economic actors to identify their position and search for alternatives that provide a higher value-per-weight-ratio and thus become more competitive in terms of sustainability (Stahel, 2010).

As already explained, technology is of vital importance in the application of cleaner production and the same goes also for the operation and maintenance processes. New technologies are capable of providing appliances with fault tolerant and self-protecting mechanisms against premature deterioration or destructive abuse during utilization. Furthermore component’s standardization has great significance also in this phase mostly regarding the reduction of operation costs. It makes repair easier and cheaper while it minimizes the possibility of errors during maintenance and encourages adaptation in changing needs, such as technological upgrading. However, there are no instruments capable of monitoring and determining the remaining technical life and utilization value of products or components before they reach their end-of-life. Hence, this is a great opportunity for technological development and consequently contribution to the optimization of physical assets management and the long-term quality management of functioning systems (Stahel, 2010).

2.4 End-of-life
All of the above strategies aspire to enhance the function of a life cycle with extended product service-life through minimized dependence upon natural resources and raw materials but intense use of renewable materials instead of depletable. However, sustainable asset management and waste prevention are not the only prerequisites for achieving the loops economy. The loops economy requires products to be designed as technical systems that facilitate maintenance and out-of-sequence disassembly.
Design for product recyclability, recovery and disassembly form the fourth discipline of DfE, design for revalorization (Fiksel, 2009). Product recyclability refers to the recovery of residual value for the already utilized materials and resources by giving them a secondary use. More specifically it implies waste homogeneity that provides assurance about the uniformity and reliability of the recycled products. As an example, SiTel Semiconductor BV, a Dutch company-expert in design, manufacturing and marketing of high-performance Complementary Metal-Oxide Semiconductor (CMOS) solutions for digital corded and cordless communication, has based its new product design and production methodology on maximizing product recyclability. Thus, components are made out of natural sources, when this is feasible, such as of pure sand and easily retrievable materials. Besides, the high-tech components are designed to extend product-life span and once contained into devices they extend their lifetime from seven to ten years. As a result the company has considerably reduced resources and power consumption with the employment of these business practices (Quality Manager, interview, May 11, 2009). Product recovery refers to techniques that create reusable components and packaging. Disassembly requires design for product simplicity and material separability to facilitate reprocessing and thus deploys optimization methods based on mathematical modeling of products and processes. The selection of the best sequence of disassembly operations among numerous possible sequences is made with mathematical programming (Lambert, 2005), hence another element which attests that the smart exploitation of science and technology is compelling for reaching the loops economy. Besides the fact that disassembly theory emerged because of the need for end-of-life processing, the methodology has proven benefits in all the phases of complex product-life cycle embracing aspects of reverse logistics. Reverse logistics objective is to optimize or turn more efficient all aftermarket activities, resulting to financial and environmental resources savings. In other words it consists of take-back schemes, conversely to forward logistics, where activities end when the product reaches the marketplace. Take-back schemes are the key for achieving the closure of the loops (Stahel, 2010). A representative example of implementing take-back strategies and especially reuse and recycling is provided by the Dutch company Océ, one of the world's leading providers of document management and printing for professionals and it will be presented in the next section.

Take-back strategies begin with collection and selection to assess the residual value of used products and components and carry on with dismantling. The next step deals with refurbishment or preparing for reuse, including checking, cleaning, repainting or other repairing recovery operations by which products or their components that have become
waste are prepared for reuse without undergoing preprocessing (EU Waste Directive, 2008/98/EC, 19 Nov 2008-1). Products that need to be reprocessed go through (re)assembly and testing. Océ assembly line includes the replacement of defective or obsolete components with Océ original or used components that have been reprocessed to new standards, whereas the critical ones are always being replaced with new ones. At this point component standardization plays again an important role as it opens the market for a profitable remarketing of components and as a result it provides an economy of scale in remanufacturing activities (Stahel, 2010). In continuation every system is individually inspected, adjusted, tested and checked for compliance to the original specifications and thus it is ready for its second life. Regular product audits by independent organizations and certification labels are important to confirm to customers that products are being produced in an environmentally friendly way. The final step refers to packaging and shipping, which by having been designed in a smart way they mean less post-consumption waste and transportation needs. Smart packaging design does not necessarily entail less materials but mainly different kinds of packaging, more qualitative and innovative. This can be coordinated by computerized methods and special software programs, as Océ applies to optimize track-loads (Corporate Communications Manager, e-mail, July 1, 2010).

3. Reuse and Recycling
As reuse and recycling may remain unclear terms, it is useful to clarify their significance. Reuse refers to any operation by which products or components that are not waste are used again for the same purpose for which they were conceived (EU Waste Directive, 2008/98/EC, 19 Nov 2008-1). In other words reuse is connected with the idea of being second-hand, used or outdated. It reduces material flows as it does not consume virgin materials and reduces the waste volume but also reduces the energy flows as it conserves the energy embodied in the product. This reinforces the highest level of material reuse and has a far better impact on the environment compared to recycling. Recycling refers to any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic materials but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations (EU Waste Directive, 2008/98/EC, 19 Nov 2008-1).

Recycling, reuse and remanufacturing increase the recycled content of a product, contributing to a decrease in raw material extraction, energy consumption and landfill use (Talbot et al., 2006; Guide et al., 2003a). However, according to the EU Waste Directive, although both reuse and recycling are among the waste prevention priorities, as key
strategies are only considered the prevention strategies, thus reuse and product-life extension, consisting of repair and remanufacturing, while recycling is considered as a treatment strategy. Besides, transforming the existing content into new commodities and sources of revenue makes a perfect economic, environmental and social sense. Consequently reuse is the most sustainable option, which is also indicated in Océ reuse activities.

In Océ reuse and recycling processes are performed according to the company’s sustainable ethos and mission; point-out to customers the way towards eco-efficient solutions and eco-effective technologies to manage documents. For Océ, remanufacturing machines, units and parts has a major environmental benefit. The company’s idea about reuse is that objects do not need to be produced using virgin materials, which means environmental savings in terms of raw material extraction, processing and transportation. Therefore, reuse saves both money and time for the firm, as new orders for new objects won’t be required at all. Recycling always involves sorting materials according to their class, so as to maintain the highest quality in processing and avoid down-cycling by compromising the high quality of materials with hazardous substances and impurities of materials of other type.

4. Conclusion and suggestions
This paper elucidated that appraising waste and using it as a resource is essential to complete the transition from the industrial towards the service functional economy, where companies will produce, sell and maintain performance and results over time. Knowledge, engineering and scientific innovation, technology and take-back networks are the drivers for the closure of the loops and consequently the extension of product-life cycle. Therefore the information and contribution provided by these factors needs to be accessible by all CLSC parties to optimize quality, service and results, save time and bring financial and environmental benefits by decoupling wealth from resource consumption.

Saving time and money while achieving high performance and being environmentally ethical, is the new challenge for businesses. Empirical research unfolds that large multinational industries are frequently more capable than SME’s of attaining this aim with or without outsourcing parts of CLSC activities. According to Talbot et al., (2007), proactive SME’s have a strong potential in improving CLSCs environmental performance although if they lag too far behind with reference to their CLSC capabilities they can cause harm to the successful deployment of CLSCs. Thus, improving SME’s CLSC capabilities is suggested as
an issue that deserves attention. Taking the opportunity of this suggestion, the present paper concludes with an attempt to propose a relevant scheme intending to offer a contribution to the field.

4.1 The role of Industrial Ecology in CLSC

Nested within the interdisciplinary field of industrial ecology and its broad spectrum of applications cooperation and interaction, essential features for the formation of a successful CLSC, are represented by the synergy of business entities. A synergy of proactive SME’s that share information and exchange energy and material flows while being located in a region of geographical proximity and optimized infrastructure compose an Eco-Industrial Park (EIP). Companies coexisting and operating in EIPs develop symbiotic relationships and are able to develop knowledge and technology. Thus, being favored by their interdependence won’t allow them to lag behind. Conversely, within the optimized infrastructure they will have the opportunity to advance the RSC activities, promote eco-innovation and increase economic growth while generating social and environmental benefits.
References


