

**PRODUCT SERVICE SYSTEMS:
EXPLORING THE POTENTIAL FOR ECONOMIC
AND ENVIRONMENTAL EFFICIENCY**

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Abstract

Product Service Systems (PSS) is a business model whereby companies sell the services associated with a product. Under this model, companies sell a “product-service package” such as maintenance agreements, product leasing, and product management services. Research in the PSS area claims that this product-service mix can lead to an increase in economic and environmental efficiency (eco-efficiency). This project uses economic theory to explain the conditions under which PSS can increase these efficiencies. It proposes that the transfer of property rights towards the manufacturer has the potential to increase economies of scale, reduce information asymmetries and create stronger incentive structures that can eventually drive economic and/or eco-efficiency. These effects are further demonstrated through the use of examples from the PSS literature.

1.0 Introduction

In the past decades, a transition from manufacturing to services has been notable in advanced economies. In the U.S., services have become the leading economic sector, contributing to approximately 80% of the country’s GDP (U.S. Bureau of Economic Analysis, 1997). There are multiple examples of corporations in the U.S. and Europe that are growing the service aspect of their business. They are selling product functionality rather than products: flooring services instead of carpeting, document management instead of photocopiers, and clean clothes instead of washing machines. This product-service mix is commonly known as Product Service Systems (PSS). Many researchers (Stahel, 1998; Goedkoop 1999; White, 1999) view this concept as having great potential to achieve economic and environmental efficiency¹. They claim that PSS can deliver financial benefits, while reducing the environmental impacts associated with the product’s life cycle. For example, selling services may create an incentive for the manufacturer to redesign products to extend their life span, therefore reducing energy and material intensity (Stahel, 1994).

PSS contributions proclaim to achieve economic and environmental efficiency. However, literature in the PSS area lacks explanations of why services can be responsible for these efficiencies. This project seeks to fill these gaps. It will use relevant economic theory to create hypotheses that seek to explain: what are the characteristics that can increase the potential of PSS to achieve economic and environmental efficiency? A model outlining these characteristics is

¹ These terms are defined and contrasted in Section 3.

presented and explained. This is part of a working effort for a Master Thesis to be completed during the Spring of 2004.

2.0 Product Service Systems: Definition and Categorization

The IIIIEE² defines PSS as “a system of products, services, networks of actors and supporting infrastructure that is developed to be: competitive, satisfy customer needs and have a lower environmental impact than traditional business models”. In this definition, PSS shifts the strategic focus from a pure product³ to an integrated product-service strategy. This definition also implies that the existence of financial and environmental benefits is a necessary condition of the concept. An example of a company who has adopted a PSS model is Xerox. The company offers integrated services across the document cycle: document outsourcing, document production assessment, network (software and hardware) re-design, and training. All of these services are associated with the implementation or use of Xerox photocopiers.

There have been various attempts to categorize the diverse types of PSS arrangements. Below is a description of the three main categories of PSS (Tischner, 2002) that have been generally accepted by researchers in this field. These categories were formed based on the interface and relation between the service provider and the customer.

- 1. Product-oriented services:** Customer retains ownership of the product. An extended product service is provided by the manufacturer or a service provider. The most familiar examples of these services include maintenance agreements, repairs, upgrades, and warranties. Take-back and recycling services are other examples within this category.
- 2. Use-oriented services:** Product is owned by the service provider who sells functions instead of products by means of modified distribution and payment systems. Typical examples include: leasing, pooling, and sharing (e.g. car sharing).
- 3. Result-oriented services.** Replace products with information and services by providing customers with a specific result rather than a specific product. For example, product substituting services. Products are substituted by new services, often driven by new technologies (answering machine is substituted by “mailbox system”). Also in this category is

² The International Institute for Industrial Environmental Economics (Lund University, Sweden).

³ Customer purchases good. No services are provided by an external party for that good.

the example of chemical management services (CMS). Under the CMS model a chemical company is contracted to provide chemicals, manage their use, transportation, and disposal. The chemical company is compensated by a management fee with a shared savings incentive. Other typical examples within this category include energy, refrigeration, and cleaning services.

3.0 Economic and Environmental Efficiency

PSS contributions proclaim to achieve economic and environmental efficiency. Economic efficiency refers to an allocation of resources that maximizes net benefits (Tietenberg, 2000). From the perspective of the firm, economic efficiency is either achieved by increasing profits, or decreasing costs. A firm will produce at output and input levels up to the point where the marginal private benefits are equal to the marginal private costs. PSS can achieve private economic efficiency if the services provided can either increase the private benefits or reduce the private costs in comparison to a pure product offering.

From society's perspective, the economic efficiency⁴ may differ from the private efficiency (i.e. the firm) in the presence of market failure(s). A market failure occurs when free markets, without government intervention, fail to deliver an efficient allocation of resources. An efficient allocation from society's perspective would require commodities to be produced up to the point where social marginal benefits⁵ equal the social marginal costs. In a free market, a firm may choose to only take private costs into account, ignoring the external costs imposed to third parties (e.g. unregulated pollution). Consequentially, the marginal social cost associated with the actions of a firm may be higher than the marginal private costs, resulting in an inefficient allocation of overproduced goods. PSS can increase social economic efficiency if the services provided have the ability to reduce market failures in comparison to a pure product offering.

Environmental efficiency, also known as eco-efficiency, is described as an allocation that maximizes value, while minimizing environmental impact (WBCSD, 1999). It is defined as:

$$\text{Eco-efficiency} = \frac{\text{Value-added output}}{\text{Environmental impact}}$$

⁴ Referred as "social economic efficiency"

⁵ Equivalent to marginal private benefits + marginal external benefits, where "private" refers to the individual consumers or firms that are directly responsible for the action and "external" refers to third parties. The same concept applies to marginal social costs (equivalent to marginal private costs + marginal external costs).

Value-added output can be measured in the form of number of units sold, profits, and sales, amongst other value indicators (WBCSD, 1999). Environmental impact refers to three types of environmental indicators: raw material consumption, waste and discharges to the environment, and land use area associated with the life of a product or service (Hoh, 2001). The concept of eco-efficiency provides an indication of how specific production and economic activities may influence the state of the environment. PSS can achieve eco-efficiency when the service provided results in increased environmental benefits per output unit as compared to a pure service offering. PSS can increase eco-efficiency when the addition of services results in a reduction of materials flow, energy use, water use, and hazardous waste, amongst others (Tischner, 2002).

It is important to distinguish between economic and eco-efficiency. While economic efficiency seeks to maximize net benefits (e.g. profitability for the firm or net benefits to society), eco-efficiency seeks to reduce environmental impact per output unit (measured in production quantity or financial value). An alternative may be economically efficient, but not eco-efficient and vice versa. In practice, if the production of widgets is cheaper when producing more waste, this alternative may lead to economic efficiency, but not to eco-efficiency. However, there are also cases when pursuing eco-efficiency may increase economic efficiency. A process that is re-designed to reduce raw material use, may decrease the environmental impacts associated with resource consumption, while decreasing the cost of material.

4.0 Economic Theory and PSS

Implicit in the definition of PSS is the notion that all PSS arrangements require a transfer of property rights⁶ (Hockerts, 2000). Manufacturers or service providers gain the right to use, manage, transform or gain income from the product in question. The transfer of property rights from the customer to the manufacturer can create new incentives and mechanisms that can increase economic efficiency and eco-efficiency. This is summarized in the following proposition:

PSS have the potential to increase economic and/or eco-efficiency when a transfer of property rights leads to one or more of the following conditions:

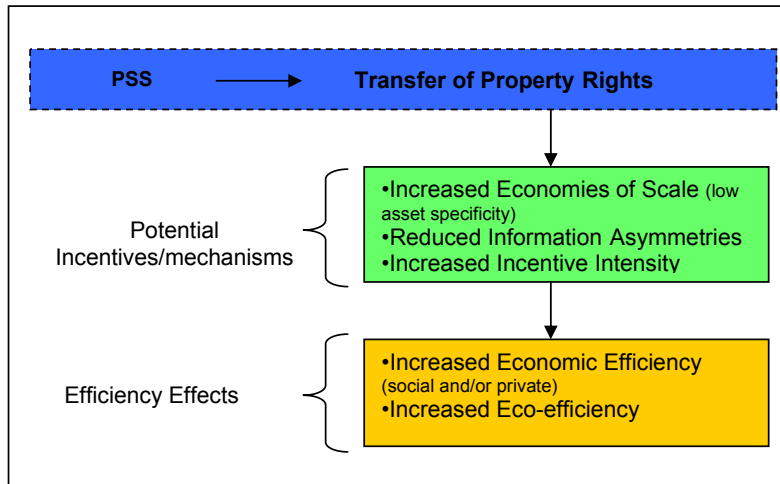
- Increased economies of scale in comparison to a pure product offering
- Reduction of information asymmetries in comparison to a pure product offering

⁶ Property rights: A bundle of entitlements defining the owner's rights, privileges, and limitations for use of the resource (Tietenberg, 2000).

- Stronger incentive structure that is better aligned with financial performance in comparison to a pure product offering

A model for this proposition is presented in figure 1 and further explored in this section.

Figure 1: Model for PSS Contribution to Economic and Eco-efficiency



4.1 Asset Specificity and Economies of Scale

Transaction Cost Theory (TCT) (Williamson, 1985) is used in neoclassical economics to predict the most efficient structure of transaction governance. This theory has been developed to facilitate an analysis of the “comparative costs of planning, adapting, and monitoring task completion under alternative governance structures” (Williamson, 1985, p.2). It seeks to answer whether transactions⁷ should take place within the organization, in the market (outsourcing), or in a hybrid model that combines the previous two choices. TCT suggests that transactions should take place where transaction costs⁸ are minimized (economic efficiency is maximized). It further assumes that transaction characteristics such as *opportunism* and *asset specificity* will give rise to these costs.

Opportunism refers to an effort to realize individual gains through a lack of honesty in transactions (Williamson, 1973). That is, actors may act in self-interest in ways that can increase

⁷ Defined as a voluntary exchange between two or more agents where all parties are expected to be made better off.

⁸ Transaction costs: defined as any obstacle to market exchanges that interfere with or discourage the process of transacting. Examples include: cost of writing contracts, the cost of finding parties with whom to trade, cost of enforcing arrangements, and costs of bargaining (Cowen, 1988).

their own performance (Williamson, 1975). This creates the need to construct more complex contracts and to measure performance, both of which can increase transaction costs. Opportunism can be observed in a situation of high asset specificity. An asset is “specific” if it makes a necessary contribution to the production of a good and it has much lower value in alternative uses (Klein, 1978). An example of a specific asset is a car part for Toyota that cannot be installed in any other car brand. These are usually goods or activities that are directly related to a company’s core competency. Because of the high levels of information exchange, TCT views asset specificity as a potential for opportunism that gives rise to transaction costs. Therefore, transactions with high specificity should take place within the firm. In contrast, low specificity means that little information needs to be shared between the parties. For example, many companies use the same computer hardware to support their operations. Since companies may not have particular requirements on how to operate computers, the information exchange between the companies and IT outsourcing parties may be minimal. In this case, it may be economically efficient to conduct transactions in the market (via outsourcing). Low specificity also allows service providers to bundle demand and exploit *economies of scale* (Arnold, 2000).

PSS is an outsourcing model where transactions take place in the market. As TCT specifies, this will most likely occur in situations with low asset specificity, where transaction costs are lower. Servicizing items with low asset specificity leads to the application of economies of scale. A manufacturer may provide the same services to different customers, thereby creating a critical mass and leveraging production and administrative costs amongst its customer base. This can be observed in chemical management services (CMS), whereby the supplier becomes the chemical service provider and gains the right to deliver and manage chemicals (Kaufmann, 2000). For example, Radian International, LLC provides chemical management services to its manufacturing clients, from sourcing and inventory management, to delivery, use and waste management of chemicals (White, 1999). Since chemicals are generic assets and are not considered part of the “core” business of Radian’s clients, Radian can apply similar services and knowledge to its entire customer base. These economies of scale allow the company to maximize its profitability, thereby achieving economic efficiency.

Radian collects chemical wastes from most of its clients. High volumes of waste create economies of scale that drive the implementation of re-cycling and re-use processes. These

processes have the potential to reduce the externalities⁹ associated with waste disposal. An externality is a type of market failure which produces an effect to a third party that is not taken into account. In the case of waste, the emitter may not fully consider the environmental and human health effects of its disposal practices. In this case, the marginal social cost (which includes the external cost) may be higher than the marginal private cost (disposal cost paid by the emitter). The reduction of waste can lead to a reduction in marginal social costs, thereby increasing social economic efficiency. Waste reduction also contributes to eco-efficiency increases through the minimization of environmental impacts.

4.2 Information Asymmetries

Opportunism can also be observed in the presence of information asymmetries. This occurs when different parties have different levels of information; specifically when a party holds relevant information that the other does not (Vining, 1999). Economists consider information asymmetries as a type of market failure (Sligitz, 1985). They argue that under imperfect information, consumers and producers cannot accurately value the “true” cost and/or benefit of a commodity. Therefore, they will not make “optimal choices” (e.g. over consuming or under consuming), creating an inefficient allocation of resources.

Information asymmetries associated with a product can be reduced when PSS requires a transfer of property rights towards the manufacturer. Manufacturers hold full knowledge of their products and the ability to use resources more productively. However, opportunism motivates them to withhold information from their customers. These information asymmetries can lose relevance during PSS arrangements. In a traditional pure product transaction, consumers are concerned about the quality of the product and the validity of the manufacturer’s marketing claims. These concerns are reduced in PSS, since the consumer may contract a service, rather than purchasing the product. However, new information asymmetries may arise in the form of “service quality” uncertainties. Contrary to pure product transactions, these asymmetries can be mitigated through the use of service contracts that stipulate quality standards. PSS can therefore increase economic efficiency (in comparison to a pure product) when the costs of contracting and monitoring a service are lower than the uncertainty costs associated with the product quality and performance.

⁹ An externality exists when an individual’s actions affect the utility of another individual’s actions, and the individual who produced the effect does not have the correct incentive to take the effect into account because there is no requirement, incentive or penalty in place that causes the individual to fully account for the effect. An externality implies a divergence between marginal social costs and marginal private costs (Dahlman, 1979).

The reduction of information asymmetries could also result in eco-efficiency gains with respect to a product's design, manufacturing, use, and end-of-life management. The shift of property rights towards the manufacturer increases incentives towards more reliable and durable products. For example, as part of a product-based PSS, Xerox offers maintenance services for its photocopiers (for both sold and leased). Within these agreements, Xerox is liable for the repair costs, including labor and parts. The company now has an increased incentive to improve the quality and reliability of its photocopiers. This results in the reduction of total parts replaced, which contributes to an increase in eco-efficiency.

4.2 Incentive Structures

The decision to produce within or outside of the firm is dependent on the rewards and team production structures (Alchian, 1972). When rewards are not well tied to productivity or performance, incentives to increase efficiency are not maximized. For example, if employees are only compensated through an hourly rate, they may not have an incentive to maximize productivity. In this case, outsourcing could produce higher efficiency levels.

In PSS applications, like CMS, the customer pays the manufacturer per unit output, instead of input materials. This payment structures reward productivity directly (unit of output) and create an incentive for the manufacturer to reduce the costs associated with the service. The manufacturer and the customer share the same incentives: lower materials throughput and increase process efficiency (Kauffman, 2000). This can be observed in Navistar's (a leading truck engine manufacturer) decision to contract Castrol Chemical to supply and manage the plant's coolants. Castrol gained the property rights to manage Navistar's coolants. Since Castrol has expertise in the use of its products and is being compensated per unit output (sub-assemblies and/or finished product), it has an incentive to minimize coolant use. Castrol claims to have reduced coolant use in Navistar by over 50 percent (Kauffman, 2000). It would have been difficult for Navistar to achieve these benefits without Castrol's intervention. Navistar's employee's pay is not a function of performance and the incentive of Navistar's managers to economize would have not been as strong as for Castrol's management.

PSS can achieve economic efficiency when it creates strong incentive structures (like those described above). From an economic efficiency standpoint, the arrangement needs to be profitable for both parties involved. In the example above, Castrol would seek to maximize its

profitability by decreasing material use, while Navistar would reduce waste disposal costs (material handling, transportation, and risks associated with disposal). Under strong incentive structures, PSS also has higher potential to achieve eco-efficiency than a pure product offering. In a pure product scenario, Navistar would have purchased the coolant from Castrol and assign use and disposal responsibility to its management. The lack of incentives to increase productivity, would have created higher levels of coolant use and waste disposal than the PSS scenario; therefore reducing the potential for eco-efficiency. As described in section 4.1, PSS ability to increase eco-efficiency (from waste reduction in this case) can also lead to the internalization of the externalities associated with waste disposal practices¹⁰. The ability to decrease external effects can thereby decrease marginal social costs and ultimately increase social economic efficiency.

5.0 Conclusion

This project presented a theoretical model that seeks to explain the conditions under which PSS will deliver economic and eco-efficiency. A model like this could benefit companies in understanding the specific circumstances in which PSS can deliver business success. However, future research is necessary to empirically validate this model. This could be best accomplished by analyzing trends across industries that are active in PSS and understanding the role that economies of scale, information asymmetries, and incentive structures play in the decision and success of PSS arrangements.

6.0 References

- Alchian, A., Demsetz, H., 1972. "Production, Information Costs, and Economic Organization" *The American Economic Review*, Vol. 62, No.5 pp.777-795.
- Arnold, U., 2000. "New Dimensions of Outsourcing: A Combination of Transaction Cost Economics and the Core Competencies Concept" *European Journal of Purchasing and Supply Management*, Vol. 6 pp. 23-29.
- Cowen, T., 1979. *The Theory of Market Failure*. George Mason University Press. Fairfax, Virginia.
- Dalham, C., 1979. "The Problem of Externality" *The Theory of Market Failure*. George Mason University Press. Fairfax, Virginia. pp. 209-234.
- Goedkoop, M.J., Halen van J.G., Riele, te H.R.M, Rommens, P.J.M., 1999. "Product Service Systems: Ecological and Economic Basics", The Hague, NL.

¹⁰ Under the condition that the external effects are not properly taken into account prior to the PSS (marginal social costs are higher than marginal private costs).

Hockerts, K., Weaver N., 2000. "Are Service Systems Worth Our Interest? Assessing the Eco-efficiency of Sustainable Service Systems". INSEAD Institute, France.

Hoh, H., Schoer K., Steffen S., 2001. "Eco-efficiency Indicators in German Environmental Economic Accounting", Submitted by Federal Statistic Office of Germany to the Conference of European Statisticians.

Kauffman, J., Votta T., Claussen, J., 2000. "Optimising the Chemical Supply Chain: The Trend Towards Chemical Management Services in the Semiconductor Industry".

Klein, B., Crawford, R., Alchian, A., 1978. "Vertical Integration, Appropriable Rents and the Competitive Contracting Process" *Journal of Law and Economics*, Vol. 21, No.2 pp.297-326.

Stahel, W., 1994. "The Utilization-Focused Service Economy: Resource Efficiency and Product-Life Extension" *The Greening of Industrial Ecosystems*, pp.178-190, Washington DC, National Academy Press.

Stahel, W., 1998. "From Products to Services: Selling Performance Instead of Goods", IPTS Report, Vol. 27.

Stiglitz, J., 1985. "Information and Economic Analysis: A Perspective", *The Economic Journal*, Vol.95 pp.21-41.

Tientenberg, T., 2000. *Environmental and Natural Resource Economics*, 5th Edition, Addison-Wesley.

Tischner, U., Verkuijl, M., 2002. "First Draft Report of PSS Review" Suspronet Report.

Vining, A., Globerman, S., 1999. "A Conceptual Framework for Understanding the Outsourcing Decision" *European Management Journal*, Vol 17, No.6 pp.645-654.

White, A., Stoughton, M., Feng, L., 1999. "Servicizing: The Quiet Transition to Extended Product Responsibility" Submitted to: U.S. Environmental Protection Agency, Office of Solid Waste.

Williamson, O.E., 1973. "Markets and Hierarchies: Some Elementary Considerations" *The American Economic Review*, Vol. 63, No.2 pp.316-325.

Williamson, O.E., 1975. *Markets and Hierarchies: Analysis and Antitrust Implications*. The Free Press, New York.

Williamson, O.E., 1985. *The Economic Institutions of Capitalism*, Free Press.

World Business Council in Sustainable Development (WBCSD), 1999. "Eco-efficiency Indicators: A Tool for Better Decision Making" www.wbcds.ch