Productisation: A Review and Research Agenda

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Abstract:

Productisation relates to the process of analysing a need, defining and combining suitable elements, tangible and/or intangible, into a product-like defined set of deliverables that is standardised, repeatable and comprehendible. This paper clarifies the concept of productisation by surveying the extant literature and reporting the origins, characteristics, benefits and features along with aiming to support future work. The analysed literature is categorised, its content is analysed, and the need for a clear framework is highlighted. The results indicate that productisation has a specific role in addressing the challenges of being able to describe and explain complex, often abstract offerings and producing them, involving activities both to ensure adequate standards and those activities leading to selling the products. A well productised product is easier to buy, sell and market, has stronger features and may enable benefits depending on the product type. Productisation has implications through having a complementary role amongst well established functions and in strengthening the linkage of market needs and engineering-oriented development. The concept requires further development. Potential future research directions are presented.

Keywords: Productization; Productize; Product management; Literature review; Categorisation; Content analysis.

1. Introduction

Producing products can be challenging for companies and their manufacturing systems. Ambiguities and difficulties arise in understanding and describing the necessary elements and requirements, both internally in the organisation and in facing outwards towards customers. However, it is not only complex products consisting of tangible and intangible elements that involve challenges; products of an intangible nature also may present similar challenges. Hence, software, services and even technologies on the verge of becoming future products also would benefit from increased clarity, both internally within a company and externally to aid in selling the products.

The literature has been referring to the concept of productisation for the past 20 years in conjunction with the problems involved in transforming suitable components into more product-like, defined sets of deliverables. Currently, there are an increasing number of articles that refer to productisation. The concept seems to have roots and is present mostly in North American research and that of West and North European origin. However, the content and the level of discussion vary to a great degree and can be quite unclear. Most of the existing articles fail to provide deep insights into the concept. Moreover, there have been no obvious efforts to clarify the discussion on productisation.

In this paper, we present a literature review on the concept of productisation. Our main objective is to clarify the concept and bring together previously disparate streams of work. We also provide a platform for a future framework to enable the advancement of relevant knowledge and to give some direction for related future work.

Productisation appears in the literature as the process of analysing a need, defining and combining suitable elements, tangible and intangible, into a product-like object, which is standardised, repeatable and comprehendible (e.g. Flamholtz, 1995; Pyron et al., 1998; Segarra, 1999; Leon and Davies, 2008, Jaakkola, 2011; Banhazi et al., 2012). However, as none of the existing work provides adequate clarification on the concept, and the concept is not established in the literature, attention is needed. For example, our work shows there are 338 journal articles that have relevance. However, productisation has not been widely represented within the operations/production management literature, nor has the contribution been summarised.

This review is particularly focused on productisation; however, the concept relates to other well-established discussions. For example, regarding product development, Krishnan and Ulrich (2001) indicate how different parties focusing on marketing, engineering, organisations or operations management have different perspectives on products. Browning et al. (2002) point out how product development activities contribute to customer value, and Cooper and Kleinschmidt (1995) discuss new product success. Commercialisation, on the other hand, is focused on introducing products to the markets (e.g. Snow et al., 2011), with a clear marketing focus. The role of marketing is discussed in terms of managing various aspects between the customer and the company (e.g. Moorman and Rust, 1999). Meeting customer demands and the resulting product proliferation are also discussed (e.g. Forza and Salvador, 2002; Zhang et al., 2005; Bramham et al., 2005). The elements products constitute are referred to in many articles (e.g. Bitran and Pedrosa, 1998; Mitola, 1999; Fricker, 2012), and manufacturing industries competing and creating new value (e.g. ElMaraghy and ElMaraghy, 2014; Steenkamp, 2014), as well as efficient product diversification have been covered (Panzar and Willig, 1981; Teece, 1980; Schuh et al., 2013). Hence, product and production competences are best considered from many

viewpoints. Mass customisation focuses on the customer, with manufacturing, scale and cost perspectives (e.g. Liao et al., 2013; Partanen and Haapasalo, 2004), and the product management literature reflects a product focus and bridges the gap between the engineering and commercial aspects (e.g. Roach, 2011), with an emphasis on product life-cycle considerations (e.g. Tyagi and Sawhney, 2010). The difference arises from the motivation and the focus of the discussion, whilst some similarities exist. The relationship of productisation to the established discussion is not clear.

Therefore, we aim to contribute to the discussion at the interface of engineering and management by highlighting the concept of productisation by conducting an extensive literature search on a relevant topic to find answers to two research questions:
RQ1: How do the existing journal articles convey productisation?
RQ 2: What are the characteristics, benefits and features of productisation?

The paper is structured so that the methodology is described first, followed by defining categories for the located articles and classifying the findings. The content of productisation discussion is analysed and key findings are compiled. The implications of the findings are discussed and an initial foundation is laid for future work.

2. Methodology

This study is founded on an extensive literature search. According to Fink (2004), a research literature review is a systematic, explicit and reproducible method for identifying, evaluating and synthesising the existing body of recorded work. The review is conducted using systematic, rigorous standards typical to systematic literature reviews (Okoli and Schabram, 2010; Fink, 2004). A systematic literature review is a means of identifying, evaluating and interpreting all available research relevant to a particular research question, or topic area or phenomenon of interest (Kitchenham, 2004). The inclusion criteria are the selected keywords and their appearance in the articles, those found by using the chosen databases and the selected quality criteria of limiting our sources to peer-reviewed journals as they can be considered validated knowledge and are likely to have the highest impact in the field.

The approach used in this study follows content analysis, a research technique for systematic, qualitative and quantitative description of the content of literature in an analysed area (Li and Cavusgil, 1995).When carrying out a study on the state of knowledge in a field or subject, three principal basic approaches have been used (Li and Cavusgil, 1995). One of these three approaches is the Delphi method, through which experts familiar with the studied area are surveyed (Dalkey and Helmer, 1963). The second one is meta-analysis – an approach in which empirical studies on a studied subject are collected and analysed statistically. For example, Montoya-Weiss and Calantone (1994) used this approach for analysing the determinants of new product performance. The third approach, the one utilised in this study, is content analysis – a research method used for systematic, qualitative and quantitative description of the content of the literature in a particular field or on a particular subject.

The procedure for conducting content analysis is seen to contain two main steps: (1) defining sources and procedures for the search of articles and (2) defining categories for the classification of the collected articles (Li and Cavusgil, 1995; Seuring et al., 2005; Marasco, 2008). These two steps have been applied in the review of the literature referring to productisation. In this study, only journal articles are included in analysing the research surrounding productisation. Any books, business periodicals, conference proceedings and other written material have been left

outside the scope of the study. The literature for inclusion contained published journal articles but was not limited to any particular journals. Keyword searches were conducted through article databases including Google Scholar, Scopus, Emerald and Science Direct. The keywords utilised in this study contain all the grammatical forms of productisation, including transatlantic spelling differences. The utilised keywords were expected to appear in the articles. Should the keywords appear only in the list of references or within biographies and not in the actual discussion, the article was not analysed further. Once articles were identified, their references were reviewed to aid in locating additional papers, resulting in some beneficial findings. Journal articles were carefully read to understand their content and analyse their contribution to the research questions and aims. As the terminology surrounding the topic of interest is not cemented, some additional keyword searches were also made to reveal the surrounding discussions. The search procedure was repeated a few times during the research to confirm that articles had not been missed and to ensure the inclusion of very recent publications. This procedure yielded a total of 338 relevant journal articles that were identified by the databases and search engines combined. In addition to the identified relevant articles, a very small number of articles were discarded as non-relevant. Also, even though a number of other potentially relevant publications, aside from journal articles, may be found using the keywords, they were not included in this study. The reference list to this article contains all the found articles. Although there is always the possibility that some articles have been missed, the reviewed journals constitute a reasonably representative body of the productisation-related research work that has been published.

Based on the database searches and the analysis during this study, the articles referring to productisation can be divided into four categories. These categories are as follows: *Productisation of Products* – Those articles that convey productisation as being linked to offerings that constitute tangible and intangible elements and that are often provided with supporting services. *Productisation of services* – Those studies that convey productisation to be linked to offerings that constitute services that are often abstract and intangible. *Productisation of software* – Those articles that convey productisation to be linked to offerings that are software based, consisting of computer programs, procedures, associated documentation and data for delivery to users. *Productisation of technology* – Those articles that convey productisation to be linked to future offerings that constitute technology currently under development. The biggest difference to the category of productisation of products, or the other categories, is the discussion being more at the frontier of technological knowledge in terms of products and manufacturing technologies and/or the discussion being closely related to technology topics. Those very few articles that contain miscellaneous discussion, not related to the above four categories, have been left out of the scope of this study. The four categories of articles referring to productisation each have their own characteristics and clear commonalities to a degree.

3. Classification and review of the productisation literature

This section presents the classification of journal articles referring to productisation based on a content analysis conducted during this study. Table 1 illustrates the distribution of the reviewed articles by the content categories. There are a total of four content categories, including; *productisation of products*, *productisation of services*, *productisation of software* and *productisation of technology*. The categories are based on the context of the discussion on productisation in the articles. Each article belongs to only one category.

It can be seen from Table 1 that the concept of productisation, in journal articles, is linked to the productisation of products in 33% and to the productisation of services in about 25% of the articles. The productisation of software and of technology roughly account for 21% of all the published journal articles each.

Table 1 Distribution of articles by content (productisation)

Content category	Number of articles	Percentage of articles
Productisation of products	112	33.1
Productisation of services	83	24.6
Productisation of software	72	21.3
Productisation of technology	71	21.0
Total	**338**	**100**

Appendix A provides the details of the classification by content, providing details of all the reviewed articles that fall under each category. Should anyone be interested in searching for references under the category topics, the details may prove beneficial.

Table 2 illustrates the distribution of articles on productisation by the publication year. Based on the publication years, the articles that refer to productisation seem to be mostly relatively new. In all the four identified categories, the majority of articles have been published since 2000.

Table 2 Distribution of the articles by the publication year

Category \ Publication year	-1994	1995-1999	2000-2004	2005-2009	2010-2014	Total
Productisation of products	6	14	16	31	45	**112**
Productisation of services	1	5	4	27	46	**83**
Productisation of software	3	13	8	29	19	**72**
Productisation of technology	3	7	15	22	24	**71**
Total	**13**	**39**	**43**	**109**	**134**	**338**

Figure 1 illustrates the origins of journal articles referring to productisation, as given in the affiliations for the first author.

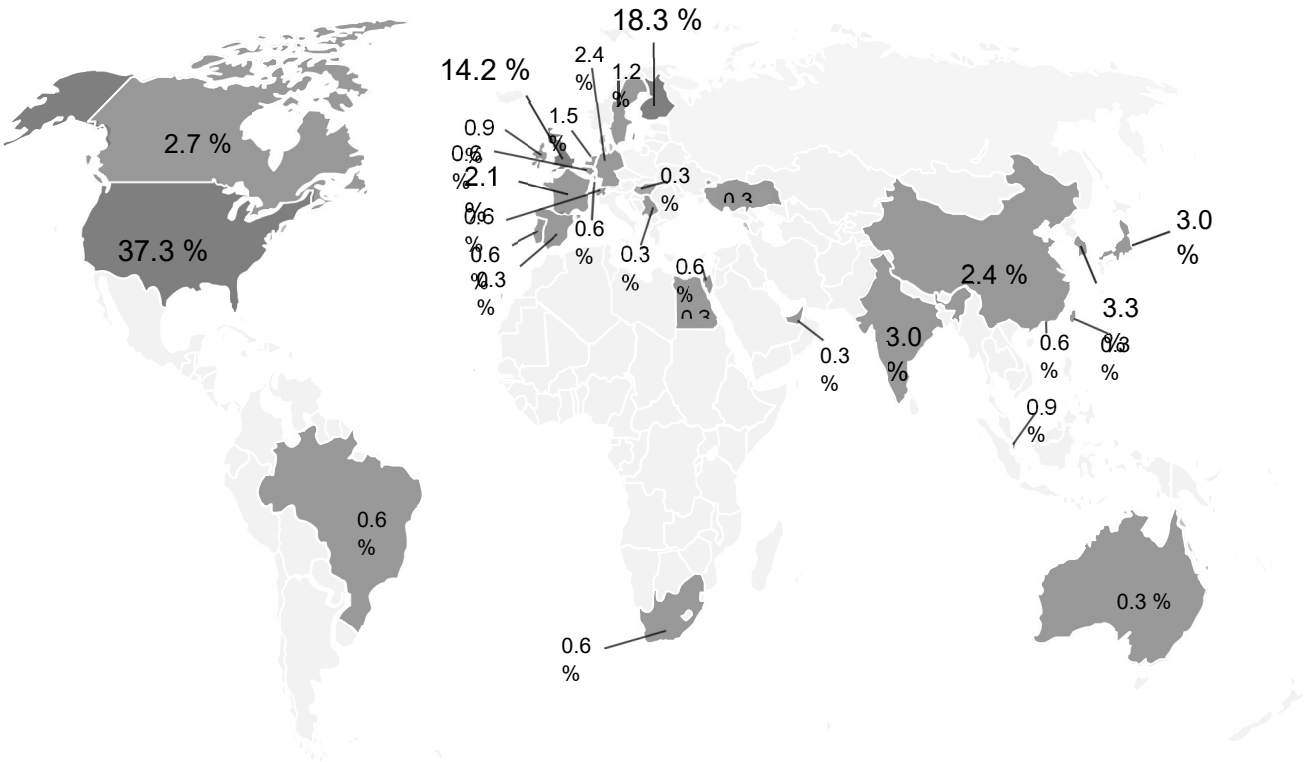

Figure 1 Journal articles by origin by the affiliation given for the first author

The largest share of journal articles that refer to productisation originate from the USA, with 126 articles, as given in the affiliations for the first author. Finland and the UK have the next most, with 62 and 48 articles. South Korea is the origin of 11, while India and Japan are the origins for 10 journal articles. Should the European Union countries be seen as a single origin, the share of articles would be 146, or 43.2% of the published journal articles.

Figure 2 presents the origins of the journal articles that refer to productisation, divided into the four classification categories. The origins of the articles are presented as given in the affiliations for the first author.

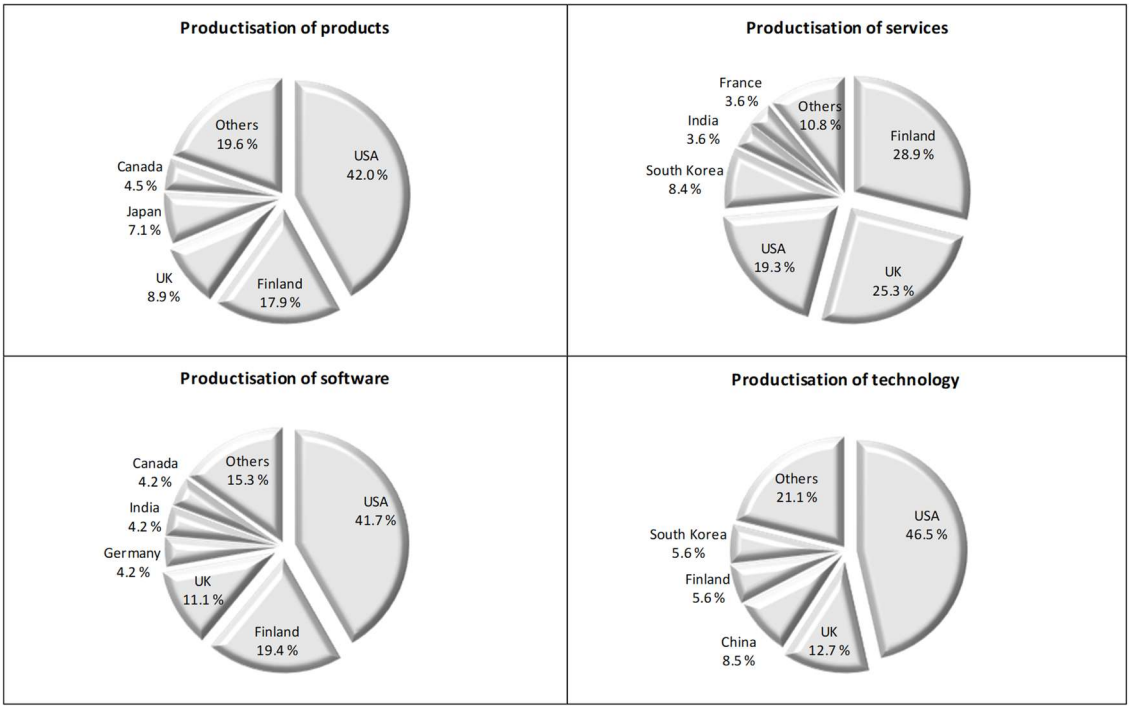

Figure 2 Journal articles by origin by the four classification categories

The largest proportion of journal articles that refer to productisation in the category *productisation of products* originate from the USA, with 42.0% (47). Finland and the UK have the next most, with 17.9% (20) and 8.9% (10) of the articles, respectively. Japan and Canada come next with 7.1% (8) and 4.5% (5) of the articles respectively. "Others" include France as the origin of three; Germany, India and the Netherlands as the origin of two and 13 other origins with only one article each. Should the European Union countries be seen as a single origin, the share of articles would be 39, or 34.8% of the published journal articles in the category *productisation of products*. The largest proportion of journal articles that refer to productisation in the category *productisation of services* originate from Finland, with 28.9% (24) of the articles. The UK and USA have the next most, with 25.3% (21) and 19.3% (16) of the articles, respectively. South Korea is the origin for 8.4% (7), and India and France have 3.6% (3) of the articles in this category. Others in the category of productisation of services contain Germany and Sweden as the origin of two and five other origins with only one article each. Should the EU countries be seen as a single origin, the share of articles would be 56, or 67.5% of the articles in the category *productisation of services*. In the category *productisation of software*, a large proportion of the articles originate from the USA and Finland, with 41.7% (30) and 19.4% (14), respectively. The UK is the origin of 11.1% (8) of the articles in this category. Germany, India and Canada have the next most, with 4.2% (3) of the articles each. Others in the category of productisation of software contain Japan, Ireland and the Netherlands each as the origin of two and five other origins with only one article each. If European Union countries are viewed as a single origin, the share of articles for the European Union would be 31, or 43.1% of the articles in the productisation of software category. In the category *productisation of technology,* the USA has the most journal articles, with 46.5% (33) of the published articles. The UK is the origin for 12.7% (9), and China is the origin for 8.5% (6) of the articles. Finland and South Korea each are the origin of 5.6% (4) of the articles. Others in the category of productisation of technology contain India and Singapore as the origin of two and 11 other origins with only one article each. If European Union countries are seen as a single origin, the share of published articles would be 19, or 26.8% of the articles in the category of productisation of technology.

4. Content analysis

The following sections present the findings, starting by defining productisation and followed by a discussion of the content categories. These sections further reveal the current state of the productisation concept.

4. 1 Defining productisation

A product can be tangible or intangible or constitute both elements. Traditionally, a product is understood as a manufactured material artefact. However, a service can also be a "product" that is provided to take care of a customer's needs without transferring the ownership of a tangible asset. Service has the nature of being abstract and intangible. A product can also be software-based, consisting of computer programs, procedures, associated documentation and data for delivery to users. Software also has the nature of being intangible. A product is the suitable combination of tangible and intangible elements that constitute an offering that can be sold to customers to satisfy their needs.

The process of translating, combining and forming a suitable mix of tangible and intangible elements into a product is referred to as productisation. Table 3 combines the descriptions of

productisation available in the literature and provides a timeline for the discussion. Practical case examples of productisation, as drawn from the literature, have been included in Appendix B.

Table 3 Productisation as described in the literature

Author	Description of productisation
Flamholtz (1995)	"Productisation is the process of analysing the needs of current and potential customers in order to design products, or services to satisfy their needs. The productisation process includes the design of a product, including services, and the ability to produce it"
Pyron et al. (1998)	"Productisation simply covers all activities required before a product is ready commercially"
Segarra (1999)	"making commercial products from prototypes"
Flamholtz and Aksehirli (2000), Flamholtz (2002), Flamholtz and Hua (2002), Flamholtz (2002), Flamholtz and Hua, (2003), Flamholtz and Kurland (2005)	"For a production firm productisation involves the design and manufacturing phases, whilst for a service firm, productisation involves forming a system for providing services to customers"
Alajoutsijärvi et al. (2000)	"Productisation is one of the key prerequisites for continued growth in the software business, to enable a shift from unique customer projects towards tangible standardised products"
Floricel and Miller (2003)	"Transforming research and knowledge into products, a part of value creation"
Danson et al. (2005)	"The process of defining products"
Fontes (2005)	Transforming technology into a product or service that the market will accept
Ruohonen et al. (2006)	Standardising originally customised products and making them standard mass products
Abram (2007)	Productise: to be able to physically point to ones products and services, to be able to name them and point out to them as if they were tangible.
Greco (2007)	"In productisation, validated concepts are converted into commercially ready products"
Baines et al. (2007)*	"The evolution of the services component to include a product, or a new service component marketed as a product"
Leon and Davies, (2008)	"The packaging of a service offering as a predefined series of modules, or a unified offering to the clients"
Cusumano (2008)	Activities involved in how to productise services so that they can be delivered more efficiently. Productisation can come from component or design reuse, computer-aided tools, automation and standardised process frameworks and training
Elbertsen and Van Reekum (2008)	"Productised, that is, made into a standard commodity or complete package"
Salmi et al. (2008)	"The aim of productisation is to give more tangible features for the service"
Czuchry and Czuchry (2009)	"Making the implementation of an idea become a reality as a product"
Aurich et al. (2009)*	"Reverse approaches (to servitation) implementing a productisation of services are untypical for the capital goods industry"
Youngdahl et al. (2010)	"Productisation of software, a process of converting routine software functions into modules that can be used as building blocks for a variety of applications"
Jaakkola (2011)	"Productisation is used to translate the abstract service and its creation into concrete exchangeable objects and controllable processes." "Three key practices: specifying and standardising, tangibilising and concretising, and systemising and standardising processes and methods"
Durugbo and Riedel, (2013)*	"Servitisation closely connects and integrates services with offered products for servitised products, whereas productisation does the reverse for offered services"
Banhazi et al. (2012)	"Productised, developed into a proper 'product'"
Cornelissen et al. (2012)	"Turning technology into an object, a product"
Chattopadhyay, 2012	"Productisation of service, i.e. the development of systemic, scalable and replicable service offerings"
Valminen and Toivonen, (2012)	"Productisation contributes to the competitiveness and efficiency, and facilitates the development of customer understanding"
Aapaoja et al. (2012)	"Productised services are partially standardised and partially customised to ensure efficient processes and meeting customer requirements"
Sharif (2012)	Productisation, creating new goods and services from research and development results
Beuren et al. (2013) *	"Productisation as the evolution of the services component to include a product or a new service component marketed as a product"
Heaslip (2013)	"…have become so well defined that the service component has in effect been productised"
Ohvanainen et al. (2013)	Productisation, a phase where service product takes its final form before launch
Djellal et al. (2013)	"'Productisation of services'. This means standardisation of services, so essentially the same service product can be replicated many times over with minimal variations"
Saarela et al. (2013)	"The goal of productisation is to clarify the service portfolio"

*This discussion refers to Baines et al. (2007) and/or Morelli (2003) as the source. Baines et al. (2007) seem to base their content on the productisation by Morelli (2003), who discusses the service component and products in conjunction with product-service systems, without using the terms productisation, or servitisation. A service "marketed as a product" in terms of the goal being to create a product-like object has similarities to some aspects of the concept of productisation presented in this article, yet productisation in this article has a broader meaning.

Finding 1: Productisation is the process of analysing a need, defining and combining suitable elements, tangible and intangible, into a product-like object, which is standardised, repeatable and comprehendible. Productisation activities cover those for a product to be ready commercially, so it can be produced, delivered, sold, purchased and used.

4.2 Productisation of products

Products in this category are either physical objects or contain both tangible and intangible elements, tangible referring to physical aspects and intangible to non-physical ones. Products can also be provided with supporting services.

Table 4 summarises the characteristics of productisation in this category as conveyed in the literature. Unfortunately, many authors present productisation self-evidently as a part of other discussions among more established activities. Hence, the concept of productisation requires clarification.

Productisation in this context seems to involve the activities relevant to engineering work and the creation of a marketable offering. Hence, it seems that productisation, as a set of activities, positions somewhere at the interface of product development and commercialisation. In some ways, productisation goes beyond product development and engineering work by having a broader perspective and involving complementary activities to make products more understandable and tangible and create value to customers. On the other hand, productisation supports the introduction of products to the market but has a role more of systemisation to enable scalability, efficiency and meeting customer needs.

Table 4 Productisation of products as conveyed in the literature

Productisation in the category of products	References
A phase in developing products	Eliezer et al., 2009; Karjalainen and Lappalainen, 2011; Meehan et al., 2010; Ayanoglu, 1999, Eliezer and Staszewski, 2011; Nigussie et al., 2012; Czuchry and Czuchry, 2009; Klein et al., 2010; Mort, 2001; Fujishiro et al., 2011; Nakazawa and Tokuda, 2012; Yamane et al., 2012; Tanaka et al., 2012; Yoshitake et al., 2011; Tokumitsu, 1999; Ferguson and Kline, 1997; Lev. et al., 1995; Iskanius et al., 2006; Strand, 2005; Zhou et al., 2013; Pratap and Arunkumar, 2007; Leminen and Westerlund, 2012; Tan, 2003; Leon et al., 2007; Cummings and Haruyama, 1999; Fey, 1985; Huang et al., 2003; Martin, 1992; Parks and O'Hanlon, 1993, McDonald, 1996
Activity that follows a research and development (R&D) phase	Van der Loos, 1995; Segarra, 1999; Majava et al., 2013; Levänen and Hukkinen, 2013
Development phase: industrial design, conceptual design, detailed design, *productisation*, process planning, manufacturing, assembly, sales, maintenance and recycle or destroy	Ma and Fuh, 2008
Late product development phase	Belt et al., 2010; Harkonen et al., 2009
As a part of innovation cycle: R&D, new product development, *productisation*, after-sales and disposal	Maatta et al., 2009
Analysing the needs of customers, designing the product and developing the ability to produce it	Flamholtz and Hua, 2002; Flamholtz, 2002; Flamholtz, 2005; Flamholtz and Kurland, 2005; Flamholtz, 1995; Flamholtz and Aksehirli, 2000; Hanninen et al., 2014b Nakagawa et al., 2012
Involves a marketable mix of compatible hardware, firmware and software modules	Mitola, 1999
Making tangible / defining products	Muzellec et al., 2012; Danson et al., 2005

Enable the understanding of product content to enable better quality	Tikkanen and Jaakkola, 2010
All activities required before a product is ready commercially	Pyron et al., 1998
Related to commercialisation	Hossain, 2012; Hanninen et al., 2013b
Related to standardisation and enabling wider utilisation	Ruohonen et al., 2006; Wiig, 1997
Activities related to making something marketable	Leinonen et al., 2009; Henton, 2005; Tatsumi, 2011; Cheng et al., 2009
Value creation / hybrid value creation	Skervin, 2010; Velamuri et al., 2011; Bowman and Swart, 2007; Floricel and Miller, 2003

Finding 2: Productisation, in the context of physical products and those that contain both tangible and intangible elements, involves engineering-related aspects and supports the development of products and their introduction to the market. Productisation has a specific role along these functions.

4.3 Productisation of services

In the service industry, the object of exchange is abstract and intangible, and there is a clear distinction between services and tangible products (e.g. Shostack, 1977; Gummesson, 1991). Services are characterised by heterogeneity, customer participation and perishability (e.g. Chai et al., 2005). The literature referring to the *productisation of services* points out how service productisation is acknowledged among practitioners and is discussed commonly in managerial magazines and seminars but is not discussed explicitly in the academic literature (e.g. Jaakkola, 2011).

Table 5 summarises the characteristics of productisation in the category of productisation of services as conveyed in the literature. One of the challenges of companies operating in service industries relates to the abstract and intangible nature of the offering. Productisation, in this context, seems to have a role in addressing related inefficiencies and making services more tangible, product-like and repeatable. These potentially enable better scalability and understanding of the service content. The literature also refers to the content, packaging and pricing of services in relation to productisation but does not broadly discuss the relation to other activities. Productisation is somewhat indicated as an activity that precedes sales.

In general, the discussion on the productisation of services in the published journal articles seems to be somewhat limited and lacking depth. Also, the terminology utilised is not unambiguous. Nor are the issues discussed new, for example, Levitt (1976) had previously referred to standardisation of services when discussing the industrialisation of services.

Table 5 Productisation of services as conveyed in the literature

Productisation in the category of services	References
To address various challenges, including inefficient production of services and difficulties by customers and company employees perceiving the service offering	Valminen and Toivonen, 2012; Jaakkola, 2011; Ardley and Quinn, 2014
To make services more product-like, repeatable and tangible	Salmi et al., 2008; Bask et al., 2010a; Chattopadhyay, 2012;Valminen and Toivonen, 2012; Djellal et al., 2013; Stone, 2010; Karmarkara and Apte, 2007; Skalen and Hackley , 2011; Morrison, 2003; Nadim and Singh, 2008; Rissanen et al., 2010; Mattila et al., 2013; Gupta, 2011
Facilitates the development of customer understanding	Valminen and Toivonen, 2012
Packaging the service offering	Leon and Davies, 2008; Ukko et al., 2011; Bruce et al., 2008
Linked to content and pricing of services	Artto et al., 2008; Chattopadhyay, 2012
Developing well-defined service packages	Lukka and Partanen, 2014
Making services tangible and providing more product-like services through systemisation of their components	Nagy, 2013

Refers to heterogeneity – to visualise, model and scale the offering	Ritala et al., 2013
Highlighted as a pre-sales activity	Nysten-Haarala et al., 2010; Hanninen et al., 2013a, Hanninen et al., 2013c
Relates to modularity in services	Rajahonka, 2013
Relates to enhancing services	Anupam et al., 2006
Follows R&D	Daim et al., 2013

In addition, there is literature that may overlap with the focus of this article but where the main context is different. Productisation is also presented as the evolution of the services component to include a product, or a new service component marketed as a product, whilst discussing product-service systems (Baines et al., 2007). They also discuss servitisation of products, later broadly discussed in the literature. Productisation of services is also discussed as a reverse approach to the servitisation of products (e.g. Aurich et al., 2009; Wang et al., 2011; Clayton et al., 2012; Park et al., 2012; Kim and Yoon, 2012; Beuren et al., 2013; Laperche and Picard, 2013; Kindström and Kowalkowski, 2014;,Durugbo, 2014; Durugbo and Riedel, 2013). This discussion refers to Baines et al. (2007) as the source, who seem to base the content on Morelli (2003), who discusses the service component and products in conjunction with product-service systems without using the terms. Servitisation is seen to be coined by Vandermerwe and Rada (1988). Later, Baines et al. (2009) conducted a very good literature review on the "servitisation of products", a transition from selling products to selling integrated products and services. It seems that Thomas (1994) was the one first using the term productisation of services in the context of the line between products and services eroding. Geum et al. (2011a; 2011b) present productisation as a concept of evolution of technology-based services as a form of product. For clarity, this stream of literature is classified as relevant with some overlapping. The similarity seems to lie in the service sold as a product.

Finding 3: Productisation in the context of services addresses the objects of exchange that are typically abstract and intangible. Productisation has a specific role in clarifying the service offering, creating repeatability and enhancing understanding of the offering.

4.4 Productisation of software

Many of today's products are increasingly software-based, rather than electro-mechanical. A software product can consist of a set of computer programs, procedures, associated documentation and data for delivery to users. (e.g. Fricker, 2012). Software products are seen as flexible and soft, allowing relatively easy changes in a technical sense (Kilpi, 1997). The discussion on the *productisation of software* in journal articles seems to be somewhat limited and lacking depth. Nevertheless, the literature does refer to productisation, even if the term is occasionally taken for granted.

Table 6 summarises the characteristics of productisation in the category of productisation of software as conveyed in the literature. Productisation in the context of software has similarities to the context of services in terms of the abstraction and intangibility inherent to the software industry. Hence, standardisation is one aspect of productisation that is conveyed in the literature. Also, making a product tangible, packaging the content and aiming towards a product that can be offered to customers are brought forward as inherent to productisation. Productisation is also presented as an interface between development and the needs of the market and to have a relationship to marketing and commercialisation. The challenge involves the concept of productisation not being fully established in the literature whilst, however, used in the context of discussing software-related topics.

Table 6 Productisation of software as conveyed in the literature

Productisation in the category of software	References
Relates to the creation of a software product	Barzilay et al., 2009
"Characteristics and concerns that software systems should adopt as soon as they become a product. Deployment, security, configuration, and usability are such concerns."	
A marketing competence / related to marketability and development	Helander and Ulkuniemi, 2006; Yeates, 1999; Baumert et al., 1998; Mohapatra and Roy, 2012; Kiessling et al., 1994; Emmerich and Sawyer, 1998
Managerial area related to marketing	Helander and Ulkuniemi, 2012
Intertwined with the customer's value perception	Helander and Ulkuniemi, 2012
Means to make a product more tangible so that a buyer is able to test its functionality before the purchase decisions	Alajoutsijärvi et al., 2000

Central capability in product business	Alajoutsijärvi et al., 2000; Sainio and Marjakoski, 2009
Related to commercialisation	Feller et al., 2008; Seager and Gorda, 2009
Interface between development and the needs of the market	Carayannis, 1999; Carayannis, 1998
Related to value offering / value creation	Feller et al., 2008; Greco, 2007
Means for standardisation / relates to standardisation	Sainio and Marjakoski, 2009; Youngdahl et al., 2010; Vlaanderen et al., 2012
Correlates with standardisation and level of required support	Ojala and Tyrväinen, 2006
Relates to standardisation, but not directly linked to the extent users are listened	Iivari and Molin-Juustila, 2009
Aims at a product that can be offered to customers	Mont et al., 2006; Helander and Kukko, 2009; McBride et al., 2003; Ward et al., 2006 ; Takafuji, 2011; Yang et al., 2005; Kettunen, 2009; Murray, 1999; Larsson et al., 2009; Salo and Kakola, 2005
A phase after creating an initial prototype to prove a concept	Davey et al., 1995; Nguyen and Sohn, 2003; Tsou et al., 2005; Hori et al., 2004
Precedes software production	Wallin et al., 2002
A process involved in a software effort	Russell, 1994
Includes a shift towards tangible standardised products	Alajoutsijärvi et al., 2000; Parry et al., 2012
Relates to complete product development and internationalisation	Kuivalainen et al., 2007
Emerging trend	Mathur, 2006
Relates to the packaging of a product	Carayannis, 1998

Discussion similar to that on productisation can be found in articles on software product management (e.g. Ebert, 2009; Fricker, 2012; Helferich et al., 2006). Software product management is seen as a discipline and a business process that governs a product from inception to the market to generate the largest possible value to a business (Ebert, 2009). Nevertheless, the discussion on software product management is also seen to lack in some aspects, as for example Ebert (2007) calls for clarifying the roles of product manager, project manager and marketing manager to successfully define, engineer, produce and deliver a product.

Finding 4: Productisation in the context of software deals with the software-based objects of exchange that typically contain computer programs, procedures and data. Productisation contains a set of activities at the interface of development and the market with an aim towards standardisation, which enables repeatability and scalability.

4.5 Productisation of technology

The literature on *productisation of technology* contains discussion that is at the frontiers of technological knowledge in terms of products and manufacturing technologies (Thompson and Azvine, 2004; Shah et al., 2008; Sparkman, 2002; Elkind et al., 1999; Cross and Montemorra, 2012; Sturgill et al., 2008; Chew et al., 2006; Saultz, 1997, Wisely, 2007). However, unfortunately, in many cases when the literature refers to productisation, the concept is taken for granted and is not discussed thoroughly.

Table 7 summarises the characteristics of productisation of technology as conveyed in the literature. The existence of technology is often brought forward through products that can be sold in the market. Companies need to convert a technology or combine technologies into a product or multiple products to fill a specific need. Technology enables innovation that can be valued in the form of products. Nevertheless, a proof of concept during product development is not enough; thorough productisation is needed to enable widespread application. However, more than a product is needed for commercial success. It seems that productisation in the context of technologies positions between engineering-oriented development and commercialisation that aims to launch technology-based products in the market. Hence, productisation seems to provide an interface between engineering-oriented and marketing-oriented thinking. The specific focus of productisation involves coming up with a rational offering that enables effective operations whilst the offering is clarified to enable communication both internally and externally.

Table 7 Productisation of technology as conveyed in the literature

Productisation in the category of technology	References
Among activities for converting technology into products or services to fill a market opportunity	Fontes, 2005
Linked to proof of concept and widespread application	Myers et al., 2002
Linked to product development and technological innovation	Mathur, 2007; Karbhari, 1995; Smith et al., 2002; Quey and Malhotra, 2004
Follows research in attempts to capitalise on innovative technologies	Hantos, 2011; Zayadi, 2012
An essential follow-up measure for commercialising R&D, linked to new goods and services	Sharif, 2012
Linked to commercialisation	West, 2008; Autio et al., 2004; Peterson, 1995; Shapira et al., 2012; Kim and Ko, 2014; Wan et al., 2013
Positions between development and commercialisation	Xiuli, 2011
Stage between development and market launch	Oh et al., 2009; Zhu et al., 2012; Sahlman and Haapasalo, 2011
R&D variable among laboratories, patents, utility patents and types of funding applications	Sohn et al., 2012
Precede sales	Hytönen et al., 2012
Linked to patent/technology appraisal	Hou and Lin, 2006

Finding 5: Productisation in the context of technology addresses activities at the frontiers of technological knowledge. Productisation has a role in creating balance between engineering- and marketing-oriented views with a perspective that is product centric.

4.6 Characteristics of productisation summarised

In essence, productisation covers all activities before a product is ready commercially, including analysing a need and defining and combining suitable elements into a product-like object. Based on the analysed articles, productisation has some identifiable characteristics.

Table 8 summarises the characteristics recognised for the productisation categories utilised in this article. All the characteristics conveyed in the literature seem to have the common goal of productisation being an activity of manipulating something to make it a "product" – an object that can be sold commercially. The nature of some of the characteristics is influenced by the product type, whether the product is abstract and intangible or tangible and whether it is a service or based on software code. Also, some "products" have a lengthier productisation perspective than others.

Table 8 Characteristics of productisation summarised

Recognised characteristics	Productisation of			
	Product	Service	Software	Technology
A process / development phase	X	X	X	X
Standardisation / systemisation / better definition / reproducibility	X	X	X	
Making tangible	X	X	X	
Making something marketable / saleable / ready commercially	X	X	X	X
Value creation	X	X	X	X
Improving customer understanding / demonstrating value		X	X	
Packaging to a form suitable for customers		X	X	
Defining offering based on needs	X	X	X	X
At the frontiers of technological knowledge				X

Finding 6: Productisation has typical characteristics, many of which refer to the challenge of describing and explaining complex, often abstract offerings and the ability to produce them, either via means of manufacturing, a system for service provision or a combination of the two. Productisation

supports diversification by making the process of analysing needs and defining and combining suitable elements into product-like objects more efficient.

5. Future research needs for productisation

We are still in the early stages of investigating productisation, and significant work remains to be done to understand more deeply the different facets surrounding the concept. The literature to date has surfaced and pointed out many aspects that deserve future research attention. Nevertheless, the main challenge of productisation involves the concept of not being fully established in the scientific literature, even though the term is often used by practitioners and industrial managers. A definition for productisation can be constructed based on the previous literature, and some characteristics can be identified as discussed and summarised in the form of *Findings 1-6* in the previous sections.

Future research will need to conduct empirical studies focusing particularly on all the discussed aspects of productisation. Also, completely new viewpoints may arise through empirical investigation. The specific features of productisation in terms of analysing the need and defining and combining suitable elements into product-like objects (e.g. Flamholtz, 1995; Danson et al., 2005; Abram, 2007; Elbertsem and Van Reekum, 2008; Jaakkola, 2011; Valminen and Toivonen, 2012; Ohvanainen et al., 2013) require further empirical studies to deepen the understanding on the concept. Further empirical studies are also required to strengthen the discussion revolving around the identified productisation categories of products, service, software and technology. Involving a large sample of companies operating in different contexts and industries might prove beneficial to deepen the knowledge surrounding the findings of this article. For example, no single study to date has explicitly adequately described the involved productisation-specific engineering-related aspects involved to support introducing products to the market.

The existing literature presents a number of characteristics of productisation (e.g. Flamholtz, 1995; Ma and Fuh, 2008; Danson et al., 2005; Ruohonen, 2006; Salmi et al., 2008; Jaakkola, 2011; Elbertsen and Van Reekum, 2008; Leinonen et al., 2009; Skervin, 2010; Nysten-Haarala, 2010; Helander and Ulkuniemi, 2012; Feller et al., 2008; Valminen and Toivonen, 2012; Leaon and Davies, 2008; Muzellec et al., 2012). All the individual recognised characteristics of productisation require further empirical validation. Research questions can be posed to address these characteristics:

- *How are the characteristics presented for productisation influencing companies' motivations for productisation? In more detail, how do productisation activities contribute towards customer value?*
- *How is the internal value of productisation visible in companies? In more detail, how do productisation activities contribute towards improving customer understanding?*

The characteristics could also be addressed further via analysing the literature outside that on productisation:

- *How do different streams of literature specifically address the characteristics identified for productisation?*

As productisation seems to have a relationship to the well-established functions that any company has, such as product development and marketing (e.g. Flamholtz and Hua, 2002; Leinonen et al., 2009; Helander and Ulkuniemi, 2006; Fontes, 2005; Van der Loos, 1995), further exploration of the linkages between productisation and other functions appears to be an important topic for future research. This is also supported by Simula et al. (2008). For example, Krishnan and Ulrich (2001) define "product development as the transformation of a market opportunity and a set of assumptions about product technology into a product available for sale". Much of the evidence presented in the earlier sections can be linked to product development through this definition. The evidence presented in the previous sections also makes references to marketing (e.g. Helander and Ulkuniemi, 2006; Yates, 1999; Baumert et al., 1998; Mohapatra and Roy, 2012; Kiesling et al., 1994; Emmerich and Sawyer 1998; Helander and Ulkuniemi, 2012), and references are also made to marketability (e.g. Mitola, 1999; Leinonen et al., 2009, Henton, 2005; Tatsumi, 2011; Cheng et al., 2009). Hence, the relationships to established functions require further clarification. The findings of this study indicate that productisation has a distinct role in the interface of engineering-oriented development and management and marketing considerations. In addition, based on evidence presented in the earlier sections, the terms that are more commonly used, such as commercialisation, managing innovation and probably others seem to have some connection to the concept of productisation. It is clear that the literature requires further elaboration on the relationship between productisation and other more established company functions and requires further evidence. Hence, research questions can be posed for potential future clarification, including:

- *How does the role of productisation differ from those of well-established company functions, and what kinds of further examples can be provided on the special characteristics of productisation?*

This is supported by the currently existing obscurity that surrounds the concept. Also, further clarification is needed on the following questions:

- *What are the specific activities of productisation towards the organisation itself, and what are potential other productisation activities that are needed to introduce products to the market – ones that support the work of other functions?*

Based on the productisation-related evidence presented in this study, and assuming that the literature adopts different perspectives on products within the academic communities (e.g. Krishnan and Ulrich, 2001), additional areas for further research arise:

- *Does productisation have its own specific perspective, or is the perspective a combination of those typical in academic communities for operations management, engineering design, organisations, marketing and such? Or is there another possibility?*
- *What are the performance metrics for productisation activities? Do they involve factors on comprehendability, level of standardisation, repeatability or something else? How do the performance metrics for productisation relate to those typical within specific academic communities?*
- *Is there a representational paradigm for productisation, similar to customer utility for marketing and process flow diagrams or parametric process performance models for*

operations management? Or how does productisation relate to those that are recognised in distinct academic communities?

- *What type of decision variables does productisation have – or should have? In the context of engineering design having variables such as product dimensions, configuration or function; operations management variables such as point of differentiation in the production process and marketing variables such as price and product attributes. How does/should productisation relate to the decision variables typical to different academic communities?*
- *What type of success factors are there/should there be for productisation?*
- *Does productisation have a true role in providing linkages within discussions that have mirrored the historical functions of an enterprise, and what is this role in practise?*
- *Are there any other viewpoints/perspectives the productisation discussion should acknowledge?*

The literature would clearly benefit from better case examples and deeper practical discussion on productisation and from productisation-specific studies conducted using different research methods. Noteworthy is that some company specifics may be involved when utilising the concept to refer to certain activities. The practical studies could include analysing productisation-related challenges and preconditions and modelling productisation processes – and maybe even tools relevant to modelling the productisation processes. Further research into when productisation is beneficial and further elaborating the value created via productisation might prove worthy of the effort. Also, as this study focused on the content published in journal articles, it might be worth thoroughly investigating the content of the productisation discussion available through other publication mediums. Nonetheless, as productisation is seemingly becoming an increasingly prevalent concept, numerous opportunities are provided for the research community.

In addition, even though not drawn directly from this work, considering productisation from the perspectives of suitable established theories, or middle range theories, and through their assumptions might prove an interesting perspective to provide further academic value. This could include, for example, taking a resource-based view (Wernerfelt, 1984) on productisation and considering which resources are essential for productisation. Alternatively, institutional theory (Scott and Meyer, 1991; Scott 2001) might provide interesting viewpoints.

6. Conclusion

This study brings together research surrounding the concept of productisation to contribute to a product offering - centric discussion. We report the origins, characteristics and features along with the potential benefits of productisation. Our review has identified 338 relevant journal articles through different article databases. The content of these have been analysed, interpreted and summarised. Six key findings are presented. In short, productisation is the process of analysing a need and defining and combining suitable elements into a product-like object that can be sold to customers. The concept is relatively new, with the majority of articles being published since the turn of the millennium. The concept has roots and is present mostly in North American research and that of West and North European origin. To date, the concept is not widely represented within the operations/production management literature. However, there are an increasing number of writings that refer to the concept – hence the need to clarify the meaning and the content.

The presented findings have *implications for practice,* including productisation reducing the ambiguity that often surrounds the offering. Well-defined products help in communicating a company's offering and relevant aspects, both internally and externally with potential customers. The importance of productisation is emphasised with product complexity, intangible elements and dispersed company operations. Productisation can support an understanding of what is provided to customers and how these deliverables are composed. This can provide new opportunities for efficiency and potentially also enable better valuing of the viewpoints of different company functions. This paper brings together the currently existing productisation discussions and provides a platform for a further framework. Companies may use certain terminologies internally to cover different activities. For example, while using productisation, certain company specifics may be involved, hence the need for a clear framework. The findings can support the development of product management operations by supporting a better understanding of product content and relevant processes and by making the pricing and selling of products easier.

This paper also has *relevance to the literature* in the field of operations/production management – for example, *product development* can have different viewpoints on engineering, marketing, management and operations (e.g. Krishnan and Ulrich, 2001). Productisation complements these viewpoints by emphasising activities that make an offering more rational and understandable. Also, this paper can be seen to support the literature that relates to mass customisation with customer focus amongst the key issues (e.g. Liao et al., 2013; Partanen and Haapasalo, 2004). Nevertheless, whilst mass customisation focuses more on manufacturing, scale and cost, productisation has a role in clarifying the offering. C*ommercialisation,* on the other hand, is focused on introducing products to the markets (e.g. Snow et al., 2011), but whereas commercialisation could be considered to have more of a marketing focus, productisation has a role in the interface of both engineering and marketing. However, one could always argue under which label a certain discussion belongs; hence we claim only that the concept of productisation provides a *product-centric focus* and potentially provides linkages between the needs of the market and engineering-oriented development. Naturally, there may be some differences in emphasis on productisation depending on the product type. The need for the concept may have arisen from the needs for intangible products, but it seems to have become more widely spread and increasing in importance. The views of this paper on productisation are supported by, for example, Nagy (2013), who point to how productisation seems to have arisen from the marketing field and now involves activities from the initial product idea to commercialisation with customer focus. The exact content and positioning of the concept requires further research.

The *limitations* of this article include the analysis covering only those journal articles that refer to productisation and that were available at the time of search through the utilised article databases. The contributions are limited to those that can be distilled based on existing publications. The quality of the analysed articles is not analysed. This article may ignore some relevant knowledge published in other forms of literature aside from journals. Also, there is the possibility that the context of some individual sources may have been slightly misjudged due to limited discussion surrounding the topic of this work. Nevertheless, the number of analysed articles reduces the significance of individual pieces of work for the findings. Including additional knowledge from other sources might somewhat influence the results and the conclusions drawn. The choice of terms utilised during the literature searches may also have influenced the results.

The findings in this article provide beneficial insights into how previous papers convey productisation and give indications on its relevant characteristics, benefits and features. This work shows the need for a clear productisation framework and provides a platform for more detailed future work. The concept of productisation seems to have a specific product-centric role in the interface of engineering-oriented development, management and marketing considerations – one that helps in clarifying and communicating the offering. More studies are required to support the work of practitioners and further strengthen the studied concept.

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Appendix A

Table A References by the content classification

Classification category	References
Productisation of products	Abram (2007), Almond and Snelling (1999), Andriole (2010), Ayanoglu (1999), Bancroft (2005), Banhazi et al. (2012), Belt et al., (2010), Benedict (2012), Beuren et al. (2013), Bowman and Swart, (2007); Cheng et al. (2009), Cornelissen et al. (2012), Cummings and Haruyama (1999), Czuchry and Czuchry (2009), Cruz-Neira et al. (2010), Danson et al. (2005), Dondi et al. (2002), Durugbo and Riedel (2013), Eliezer et al. (2009), Eliezer and Staszewski (2011), Farra et al. (2011), Fay (2003), Ferguson and Kline (1997), Fey (1985), Flamholtz (1995), Flamholtz and Aksehirli (2000), Flamholtz (2002), Flamholtz and Hua (2002), Flamholtz and Hua (2003), Flamholtz (2005), Flamholtz and Kurland (2005), Floricel and Miller (2003), Fujishiro (2011), Geisler (1993), Hanninen et al. (2013b), Hanninen et al. (2013c), Hanninen et al. (2014a), Hanninen et al. (2014b), Harkonen et al., (2009), Henton (2005), Hicks (2001), Hossain (2012), Huang et al. (2003), Ibrahim (2012), Iskanius et al. (2006), Kaliski et al. (2008), Karjalainen and Lappalainen (2011), Kasik (2011), Kasvi et al. (2003), Klein et al. (2010), Knight (2008), Knouse et al. (2009), Kumar and Kopitzke (2008), Lawso (2011), Leinonen et al. (2009), Leminen and Westerlund (2012), Leon et al. (2007), Lepore et al. (2013), Lev et al. (1995), Levänen and Hukkinen (2013), Ma and Fuh (2008), Maatta et al. (2009), Majava et al. (2013), Martin (1992), McDonald (1996), Meehan et al. (2010), Miller and Floricel (2004), Miller and Olleros (2007), Mitola (1999), Morellas et al. (2003), Mort (2001), Muzellec et al. (2012), Nakagawa et al. (2012), Nakazawa and Tokuda (2012), Nigussie et al. (2012), Parks and O'Hanlon (1993), Parvinen et al. (2013), Pratap and Arunkumar (2007), Pyron et al. (1998), Rapple (2012), Raty (2010), Rees and Protheroe (2009), Ruohonen et al (2006), Saadé (2012), Schlansker and Rau (2000), Segarra (1999), Sen et al. (2011), Simons et al. (2002), Skervin (2010), Smartt and Ferreira (2010), Spithoven et al. (2010), Srikrishna and Krishnamoorthy (2012), Starkweather, (2003), Stein et al. (2007), Strand (2005), Sugerman et al. (2009), Suran (1965), Tan (2003), Tanaka et al. (2012), Tatsumi (2011), Tikkanen and Jaakkola (2010), Tirpak et al. (2006), Tokumitsu (1999), van Berkel et al. (2005), Van der Loos (1995), Velamuri et al. (2011), Vogel (1997), Wiig (1997), Winters (1993), Yamane et al. (2012), Yoshitake et al. (2011), Zhou et al. (2013)
Productisation of services	Aapaoja et al. (2012), Alter (2012), Antonacopoulou and Konstantinou (2008), Anupam et al. (2006), Ardley and Quinn (2014), Arora et al. (2001), Artto et al. (2008), Aurich et al. (2009), Baines et al. (2007), Bask et al. (2010a), Bask et al. (2010b), Bask et al. (2011), Brazier and Cookson (2005), Bruce et al. (2008), Calo et al. (2012), Carreira et al. (2013), Chattopadhyay (2012), Clayton et al. (2012), Crane (2005), Crane (2007), Cusumano, (2008), Daim et al. (2013), Djellal et al. (2013), Hao (2008), Gallacher (2006), Geum et al. (2011a), Geum et al. (2011b), Gupta (2011), Hanninen et al. (2013a), Heaslip (2013), Houlder and Williamson (2012), Jaakkola (2011), Karppi (2012), Kim (2009), Karmarkara and Apte (2007), Kim and Yoon (2012), Kindström and Kowalkowski (2014), Klaus and Maklan (2007), Kreger (2003), Laperche and Picard (2013), Leng et al. (2008), Leon and Davies (2008), Lukka and Partanen (2014), Maklan and Klaus (2011), Maklan and Knox (1997), Mathieson (1997), Mattila et al. (2013), Meyer (1999), Moon (2007), Moreno et al. (2009), Morrison (2003), Nadim and Singh (2008), Nagy (2013), Nam et al. (2009), Nysten-Haarala et al. (2010), Ojanen et al. (2009), Park et al. (2012), Pepper et al. (1997), Rajahonka (2013), Ramstad, (2008), Reitman (2001), Rekola and Haapio (2011), Rissanen et al. (2010), Ritala et al. (2013), Saarela et at. (2013), Salmi et al. (2008), Selviaridis and Spring (2010), SenGupta (2011), Seshadri (2011), Shin et al. (2009), Skalen and Hackley (2011), Stone (2010), Thomas (1994), Tietze et al. (2013), Toivonen et al. (2008), Ohvanainen et al. (2013), Ukko et al. (2011), Valminen and Toivonen (2012), Wang et al. (2011), Vähätalo (2012), Wardlaw (2005), Williams (1995), Yang et al. (2010)
Productisation of software	Alajoutsijärvi et al. (2000), Alonso (2003), Barzilay et al. (2009), Basili, (1995), Baumert et al. (1998), Boehm (2010), Borocki et al. (2011), Campbell-Kelly and Garcia-Swartz, (2009), Carayannis (1998), Carayannis (1999), Carmel (1995), Davey et al. (1995), Davis and Sun (2006), Dinov (2011), Duncan, (1997), Emmerich and Sawyer (1998), Feller et al. (2008), Figueroa and Ortega (2009), Gillespie (1998), Goth (2007), Greco (2007), Guha et al. (2006), Helander et al. (2011), Helander and Kukko (2009), Helander and Ulkuniemi (2006), Helander and Ulkuniemi (2012), Hori et al. (2004), Iivari and Molin-Juustila (2009), Jin et al. (2011), Kettunen (2009), Khusidman and Bridgeland (2006), Kiessling et al. (1994), Kuivalainen et al.

	(2007), Käkölä et al. (2011), Larsson et al., (2009), Mathur (2006), McGregor (2008), Mead et al. (2010), Mohapatra and Roy (2012), Mont et al. (2006), Murray (1999), Murray et al. (1999), Nguyen et al. (2012), Narasimha et al. (2010), Nguyen and Sohn (2003), Nyberg et al. (1995), Ojala and Tyrväinen (2006), Ojala and Tyrväinen (2008), Parry et al. (2012), Pearson and Allison (2009), Poliakov et al. (2005), Pooja et al. (2012), Rainsberger (2007), Russell (1994), Sainio and Marjakoski (2009), McBride et al. (2003), Salo and Kakola (2005), Seager and Gorda (2009), Solchenbach et al. (1994), Stroeh et al. (2013), Suprem et al. (2013), Takafuji (2011), Tessler et al. (2003), Tsou et al. (2005), Ulkuniemi and Pekkarinen (2005), van Gurp et al. (2010), Vlaanderen et al. (2012), Wallin et al. (2002), Ward et al. (2006), Yang et al. (2005), Yeates (1999), Youngdahl et al. (2010)
Productisation of technology	Allhoff and Lin (2006), Autio et al. (2004), Baines and Pulley (2003), Ballato and Stern (1999), Banerjee (2009), Bridges (2000), Buchanan et al. (1988), Chew et al. (2006), Clarysse et al. (2011), Coldren et al. (2004), Cooper (2008), Cooper and Wachter (2013), Corsi (1999), Cross and Montemorra (2012), Daghfous (2004), Datta et al. (2011), Daughton (1991), Davies (2010), Edwards (2003a), Edwards (2003b), Elbertsen and Van Reekum (2008), Elkind et al. (1999), Fontes (2005), Han et al., (2013), Hanchi et al. (2011), Hantos (2011), Harris (1984), Her and Lim (2010), Hou and Lin (2006), Hytönen et al. (2012), Karbhari (1995), Katopis et al. (2006), Kim and Ko, (2014); Korba (2007), Lacey (2005), Lewis (2000), Lynn and Heintz (1992), Mathur (2007), Myers et al. (2002), Oh et al. (2009), Peterson (1995), Poore (2003), Probert et al. (2013), Quey (2004), Rajanna (2013), Ranjan and Khalil (2008), Sahlman and Haapasalo (2011), Sharif (2012), Saultz (1997), Savaton et al. (2006), Shah et al. (2008), Shapira et al. (2012), Shum and Watanabe (2007), Shum and Watanabe (2010), Smith et al. (2002), Sohn et al. (2012), Sparkman (2002), Sturgill et al. (2008), Thessler et al. (2011), Thompson and Azvine (2004), Van Den Elst et al. (2006), Von Wartburg et al. (2005), Wan et al., (2013), Wertlen et al. (2012), West (2008), Wisely (2007), Wolf (2000), Xiuli (2011), Yang and Park (2009), Zayadi (2012), Zhu et al. (2012)

Appendix B

Table B Examples of productisation cases drawn from the literature:

Product	How is productisation conveyed	Author
Media asset management system – part of broadcast infrastructure, hardware and software elements, potentially with supporting services	a standardised offering, cheap and fast to deploy, a "product" that is easier to support	Bancroft (2005)
Precision Livestock Farming systems –for improving the efficiency of production, while increasing animal welfare. Advanced ICT, Hardware, software, supporting services.	developing into a proper "product"	Banhazi et al. (2012)
PowerScope tool - uses statistical sampling to profile energy consumption details of mobile computing systems. Consists of hardware and software.	activities relevant for making available commercially	Benedict (2012)
Skin care cream – suitable chemical composition for the intended use to ensure desired qualities, practical packaging for the application and product image considerations.	activities relevant to making marketable as a product	Cheng et al. (2009)
A projection-based, surround-screen virtual reality display. Typically very expensive one-of-a-kind systems consisting of specialised projectors, framing, and screens. Consisting of off-the-shelf affordable HW, SW, and support services.	combining the product for a need by using suitable components	Cruz-Neira et al. (2010)
Small distributed power generation (DG) units. DG is a small source of electric power generation, or storage located close to the load.	standardisation	Dondi et al. (2002)
Complex GSM system-on-chip (SoC) based on the Digital RF Processor.	combining and defining into a saleable whole	Eliezer et al. (2009); Eliezer and Staszewski (2011)
A mobile sensing and imaging system for real-time monitoring of spine health, HW, SW	combining and defining into a saleable whole	Farra et al. (2011)
Programmable automated welding system (PAWS)	combining and defining into a saleable whole	Ferguson and Kline (1997)
Creating integrated circuits custom digital LSI/VLSI	combining and defining into a saleable whole	Fey (1985)
Fuel-efficient, economical automobiles, Zap-Mail	translating technology into saleable whole	Flamholtz (1995)
Highly efficient SOFC (solid oxide fuel cell) modules	activities before ready commercially	Fujishiro (2011)
Optical fiber data links and optical sensors for in-well data transmission (oil industry)	combining and defining into a saleable whole	Geisler (1993)
Bioinformatics devices, HW, SW, potentially supporting services, can also be SW only in some cases	activities before ready commercially	Greco (2007)
Wireless handheld devices that record orders using automatic speech recognition (ASR) SW, HW, potentially supporting services	activities before something is marketable	Henton (2005)
Thin film transistor-liquid crystal display (TFT-LCD)	activities before ready commercially	Huang et al. (2003)
Integrated controls for building systems, including heating, cooling, lighting and ventilation, that commonly work separately as 'isolated islands'	combining and defining into a saleable whole	Karjalainen and Lappalainen (2011)
Installation equipment and processes for near shore wind farms	standardisation	Lawso (2011)
High-end automated security system. DETER (Detection of Events for Threat Evaluation and Recognition)	combining and defining into a saleable whole	Morellas et al. (2003)
Application specific standard products (ASSPs) in semiconductor industry	standardisation	Nakagawa et al. (2012)
Graphics processing unit (GPU)	combining and defining into a saleable whole	Nakagawa et al. (2012)
wireless sensor nodes that enable ubiquitous networked sensing environment	combining and defining into a saleable whole	Nakazawa and Tokuda (2012)
Microelectromechanical system devices, including accelerometers, gyroscopes, pressure sensors, magnetometers, oscillators, inkjets, digital mirror devices, etc.	combining and defining into a saleable whole	Pratap and Arunkumar (2007)
PowerPC 750 microprocessor	all activities required before a product is ready commercially	Pyron et al. (1998)

Third-generation surveillance system (3GSS) for public safety.	combining and defining into a saleable whole	Raty (2010)
Microprocessors based on Instruction set architecture	defining and developing into a saleable whole	Schlansker and Rau (2000)
Swimmer Detection Sonar Network SDSN	combining and defining into a saleable whole	Stein et al. (2007)
Monopivot centrifugical blood pump	defining and developing into a saleable whole	Yamane et al. (2012)
Parallel Air Flow Inverter	defining and developing into a saleable whole	Yoshitake et at. (2011)
Data sanitisation service offering	the development of systemic, scalable and replicable service offerings	Chattopadhyay, 2012
Support service for HP's OpenCall media platform	packaging and defining into a saleable whole	Gallacher (2006)
ICT services (IBM, Ericsson, and Cable & Wireless)	packaging and delivering on a more industrialised basis	Leon and Davies (2008)
Maintenance services	standardising the content	Nysten-Haarala et al. (2010)
Performance management expert services	standardising and defining the content	Ukko et al. (2011)
Software services Tata Consulting Services, Wipro, Infosys, eBay, eTrade, Expedia, Google, Lending Tree	standardisation	Cusumano, (2008)
Enterprise SW solutions	standardising and defining the content	Ojala and Tyrväinen (2008)
Energy sources that offer a low risk profile with better GHG emissions	defining and developing a future product	Datta et al. (2011)
New breakthroughs in Ferroelectric materials	defining and developing future products	Daughton (1991)
Pervasive computing technologies	defining and developing future products	Davies (2010)
Integrated analytical bio-sensors	defining and developing future products	Elkind et al. (1999)
Patterned media-based head-disk interfaces	defining and developing future products	Hanchi et al. (2011)
Artificial Intelligence products	making available commercially, from a prototype to a product	Harris (1984)
Embedded sensors for hand held devices (location shift, minor displacement, barometric pressure, weather changes, light intensity, magnetic field proximity of objects etc.)	defining and realising into tangible solutions	Rajanna (2013)
Chips using sub-micron and deep sub-micron technologies	defining and developing future products	Savaton et al. (2006)
Voice applications that use voice recognition	defining and developing into products	Smith et al. (2002)
Security Printing Deterrents, difficult-to-reproduce printing effects	defining and developing future products	Sturgill et al. (2008)
Giant Magneto- Resistive (GMR) read heads, Tunneling Magneto-Resistance (TMR) devices	defining and developing future products	Wolf (2000)