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Product-Service Systems across Life Cycle

Urban Mining as a Case for PSS

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Abstract

Reports about the depletion and pollutant of the earth by human interference and the increasing need for urbanised areas require us to think differently about how we go about achieving this increased urbanisation. In this context, urban mining, where demolition sites are mined for increased recycling and value extraction. Due to high specialisation of construction equipment for this context, as well as sustainability being an important factor, product-service systems are suggested as a way forward in this area. This paper presents key topics that needs to be addressed when developing sustainable product-service systems for the urban mining segment. The idea is to transform from a traditional construction and demolition perspective towards a PSS-based construction product for an urban mining environment, incorporating a circular economy perspective. A modification to the common business model notation of business model canvas, with guiding questions is suggested. Opportunities for improved sustainability lies both in application – within an urban mining site – and in the enabling technology – when technology is specialised, owned by the provider, and utilised by multiple partners.

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Keywords: Business Model Canvas; Urban Mining; Product-Service Systems

1. Introduction

Ever more people are making the transition into urban areas. In 2014 54%, or the world's population were situated in urban areas, and the figure is expected to grow even more in the future, with 66% being urban by 2050 [1]. The lion's share of this growth is expected to be seen in Africa and Asia [1], which will basically catch up to the levels already seen in Europe and North America. This will likely see both the establishment of totally new rural areas, but also the current urban landscape will need to increase in capacity. Existing urban settings will be replaced by new ones with increased capacity, and new urban landscapes will be formed.

This expansion, as well as resetting, will require mining of new materials. However, in recent years, several alarming reports warn of the depletion and pollutant of the earth by human interference. Natural resources are depleted due to mining seemingly unsustainable quantities raw materials. According to a KPMG report from 2012 [2], 96% of global firms expect an impact on their business performance for reasons relating to raw material scarcity.

1.1. Urban Mining

Urban mining [3] depicts a novel segment of the construction industry where urban areas are 'mined instead of the bedrock. According to the European Commission [4], out of all waste generated in the EU, 25-30% is from construction and demolition. Value can be extracted from existing materials (e.g., concrete, valuable metals, etc.) in buildings and other structures. When resetting an urban neighbourhood, there is potential to utilize materials that were there already and not just go find fresh in the bedrock. Instead of exploiting the

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undeveloped land, developed–and used up – urban areas can be reset into appropriate new ones.

From a construction equipment innovation perspective, urban mining is an interesting segment to innovate capabilities and thus machines that can move the portfolio closer to support a circular economy in this sector. In this context, there is a need for new innovations (e.g., breakthroughs in communition, flotation, sorting, automation), where new construction equipment for urban mining needs to be developed.

This case study was performed in relation to a project with engineering design students from Stanford University (ME310 Product Design course[1]) and Blekinge Institute of Technology (PSS Extreme Innovation course[2]). The students have focused on recovering concrete in an urban mining scenario, sorting it from other materials and having an intermediate storage on site have (see fig 1) – showing opportunities for both financial and environmental gains, because recovered concrete is used as filling in new constructions without having to be taken off-site for recycling and storage.

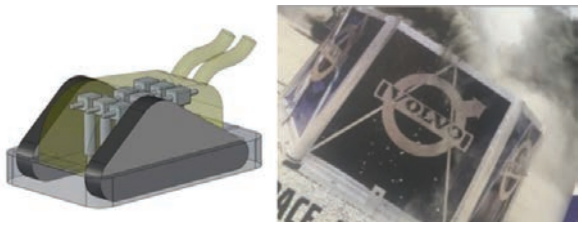

Fig 1. Urban mining prototypes concrete crusher (left) and on-site concrete storage (right).

Specialisation of construction equipment for many of the tasks potentially challenges the viability of the concept from a traditional product supply perspective. Therefore, product-service systems (PSS) [5] offers opportunities to explore more creative approaches to achieve a sustainable and holistic business case.

This paper aims to explore key areas of innovation, and how the business model can support a circular economy in urban mining applications and supporting construction equipment – stringing a balance between PSS, economic growth and environmental stewardship.

2. Methodology

This research is based on case study [6], aiming to investigate and explore urban mining as a future business segment.

Data is collected in total 9 semi-structured interviews with experts from a construction equipment manufacturer, focusing on sustainability, product-service systems, general sales, and business models. The respondents have the freedom to discuss and have opinions related to the investigated topic.

In addition, site visits and observations serve as secondary data, sometimes informing the design of questions for the primary data collection.

The interviews have been transcribed and recorded to ensure traceability and have a higher reliability. Analysis has further been performed by means of pattern matching.

3. Literature review

3.1. Product-Service System

Servitization [7] – where service components are added to hardware-only products – is seen as an opportunity to generate new revenue streams, gain closer relations with customers [8], increase operational performance, and achieve sustainability commitments [9]. This, with products and services combined in a system to deliver value and functionality for users, is known as product-service systems (PSS) [5]. Companies provide customers with desired outcomes [10] instead of products.

There are three different types of PSSs [11]; *product-*, *use-*, or *results-oriented* offerings. With product-oriented PSS, the provider commits to deliver services in addition to the sold product [11]. With use-oriented PSS, the provider does not sell the product but makes it available under a leasing agreement [11]. With a result-oriented PSS, the provider delivers a certain result to the customer rather than a specific product or service.

PSS development is known as functional product development [9], where the solution (any combination of hardware, software and services) is developed in a coordinated development effort. In this context, creating value for customers throughout the lifecycle and hence understanding the customer needs will be paramount [9]. New competencies will be needed, especially in the interface with the customer in order to tie them into closer relationships [9]. Translated requirements from marketing staff are not enough as a basis. PSS designers will need to do needfinding [12,13] to better serve the customers with customised solutions. The PSS is conceived with a system view in mind [14], where features and gimmicks that do not add value will be depreciated.

PSS offers the opportunity to decouple growth from increased material consumption [15], thus serving an opportunity for reduced environmental impact.

3.2. Business Models

A business model is an abstract representation of business logic of a company; a comprehension of how a company operates, creates value [16] and makes money – that is, *what* is offered, *to whom* is it offered, and *how* can it be accomplished [17]. It is a blueprint of the company's logic of earning money [17].

Traditionally, a business model is descriptive (i.e., how a company conducts their business, not how they want to do business). However, a too static focus on creating customer value without regard to changes or competitive advantage might leave a firm vulnerable to both margin erosion and weak growth [18]. A challenge is to explore possible business model configurations and innovations that are likely to be successful for the company [19]. In recent years, business model

[1] http://me310.stanford.edu

[2] https://www.bth.se/tek/mspi.nsf/pages/pss-ei

innovation has become more popular, including moving away from purely seeing it as a static tool, to a transformational driver for change and innovation in the addressed model or organization [20].

Business Model Canvas

The *Business Model Canvas* [21] describes a visual map of a business model, consisting of nine elements called 'building blocks', which are presented in Figure 2: *customer segments*, *value propositions*, *channels*, *customer relationships*, *revenue streams*, *key resources*, *key activities*, *key partnerships*, and *cost structure*. The visual element provides a shared artefact for mapping, designing, inventing and discussing new business opportunities, thus providing a shared understanding of the business model [21].

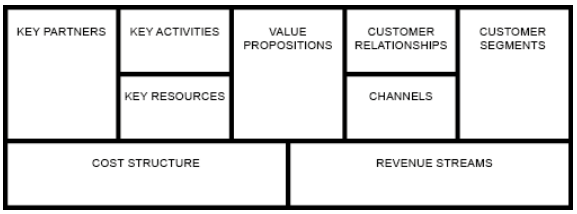

Fig. 2. Business model canvas (adapted from [21])

The core and the starting point of a business model (canvas) are the 'value proposition', which is essential to get right [21]. For each segment, there is a specific value proposition – a combination of products and services – that creates value for those customers. Osterwalder & Pigneur (2010) [21] have devised a value proposition canvas, stressing the importance of developing the value proposition in coherence with the targeted customer segment.

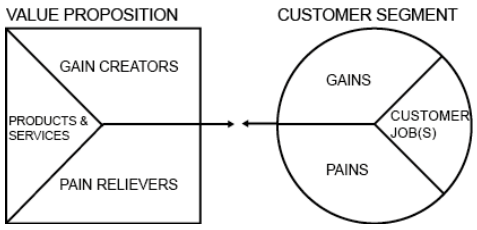

Figure 3: Value Proposition Canvas (adapted from [21])

PSS business models

From a business model perspective, PSSs are commonly characterised by the three dimensions of being either product-, use-, or result-oriented offerings [11], which have fundamental differences in creating, delivering, and capturing value [22]. Several review articles on PSS (e.g., [15,22]) acknowledge that there is scope for developments in this area, but that it is the most accepted at this stage. Barquet et al (2013) have developed a framework that comprises of three parts; the business context, the types of PSS and the PSS characteristics [23]. The business context analyses the current situation with the PSS requirements and restrictions to decide whether to develop a new or an existing model. The types of PSS relate to which of the three (product-, use-, or results-oriented PSS) options best suits the goals. Finally, the last step embraces what is needed to develop and deliver the PSS offer, noted in the business model canvas format. The idea with the approach is to give companies a reference for PSS implementation.

3.3. Sustainability

Sustainable development rests on the three main pillars of economic growth, environmental protection and social equality – utilising and driving the development of new technologies to tackle future problems of both environmental and human or social nature [24]. Although ecologic sustainability with safeguarding climate change, depletion of natural resources and the future prosperity is a key topic on the agenda now, it is important to do so while assuring that poverty comes down and society has a long-term economic welfare.

Often, however, economic growth has taken the lead, while the other two pillars suffer, basically being on a collision course with one another.

PSS as an opportunity for sustainability

There is a conception that PSS implementation drives environmental benefits [22]. However, this is not a given, as the pursuit of economic gains can challenge the environmental benefits in some implementations [25]. There are however major opportunities for working actively towards a more sustainable society [26] with PSS implementation because it is possible to unlink environmental pressure from economic growth [5]. According to Mont (2002) [27], PSS should minimize environmental impact by closing material cycles, reduced consumption through alternative use, increased resource productivity and dematerialization, and providing system solutions to improve resource and functional efficiency. If ownership stays with the providers, maintenance and repair mean costs instead of a lucrative aftermarket business for the provider [9]. Reduction of waste and spare parts, which lead to lower costs, because the functional offering means that the manufacturer has the incentive to use the equipment as efficiently as possible [9].

4. Results

The case study has focused on exploring urban mining in relation to business models, sales, product-service systems, and environmental expectations. The business model is central to all change and exploration of new offerings; essentially any change is accompanied by a business model. Margins, volumes and aftermarket opportunities are central to any new business opportunity decision. Therefore, it is interesting to explore how urban mining can be enabled from the business model perspective. Presently, there are few specialized construction machines that are well adapted to the urban mining segment. One reason is that few can bear the high initial investments that would be needed in relation to the business case. However, results from the initial exploration projects on the topic (as presented in the introduction) shows that there are potential to achieve both financial and environmental gains from tapping into the urban mining area. Being an unexplored area, urban mining solutions would need to be developed in some

partnerships where margins and volumes are not in stark contrast to other sectors.

Value for customers and how needs and requirement are met is understood primarily from the perspective of increased productivity and cost of ownership. In this space, it is important to lead the way and show that customers can increase their capability and muscle for the future by moving into this space. Quantifying the added value that a service present is important because customers will not ask for something that does not offer increased productivity or lower total cost of ownership. Closer relationships with customers and a clearer communication of offered value are essential, especially when moving towards PSS offerings.

Coming to sustainability, it is not always the top priority for customers, although larger companies are more concerned about it. Synergy effects, such as lower fuel consumption, is overall important because the gains are a direct and short term, and also then coincides with the longer-term business and image gains. PSS can impact the environmental strain by affecting recycling rates, emissions (i.e., fuel consumption), particle and NOx emissions as well as material choices. These things combined, there is an opportunity in urban mining to couple with a shift towards PSS, where manufacturers offer total solutions. PSS should be implemented already at the beginning of the design process, to be proactive with downstream information such as service, maintenance, and usage data. However, not all customers will have the readiness for shifting to PSS. Lifecycle perspectives and altered cost structures where the total cost of ownership might be lower (due to better operations) but higher visible costs might be unfamiliar for some, which means that there is a need to further inform about the benefits. The business model is seen as an important instrument for understanding, designing and enabling the PSS-based urban mining segment.

5. Guideline for Urban Mining-based Business Model

This section of the paper presents, organised around the business model canvas, a guideline on how to better adapt the solution towards a PSS-based urban mining offering. These are formalised as key questions to investigate. This investigation would then answer if a PSS is right, and which nature it should have.

Customer segment:

With different customer segments, different user behaviour [23] and hence different readiness for PSS adoption. For many, there is a culture change in terms of ownership, availability, responsibility, and costs [23]. Actions may be needed to inform and quantify soft values and to tailor the PSS towards the needs and readiness of specific customers.

Q: Do you need to develop your customer?

Value Proposition:

Central to creating value with PSS is to enhance the customer satisfaction. Here integrations of products and services mean that there can be a functional guarantee, a lifecycle responsibility and essentially a total cost of ownership reduction [23]. In addition, closer relationships also increase value with added trust in the delivery.

When integrating customers into the PSS offering, it is important to provide functionality to them closer to you. Increased producer responsibility, telematics, proactive service and maintenance, continuous updates, capital and initial cost reduction, are some examples. Making these benefits visible is important. Using Functional Product Development [9] is suggested for this integration.

The urban mining business segment—incorporating PSS and sustainability—requires new operations. Are these within the core purpose? Can it serve as a catalyst affecting both direct and indirect sales?

Q: Do you have the possibility to offer efficient and total covering services in relation to the system? If not, do you need to develop additional services to cover the offer?

Q: How do you integrate the customer into your offering? How does this benefit your business?

Channels:

To secure value throughout a PSS offer there needs to be a continuous and close relationship with the customer. Here it is important to be able to highlight the advantage with PSS [23], which includes training the dealers who directly interface with the customers. Using, for instance, telematics, it is possible to customize special offerings. This mentality also needs to follow to 2nd and 3rd generation aftermarket, to tailor towards their needs.

Q: How do you develop channels that allow you to integrate and continuously reach your customer?

Customer Relationships:

PSS requires an intensified and longer-term relationship with the customer, both on hard and soft values. Operational links, information exchange, legal ties and cooperative rules need to be in place [23]. Beyond that, there also need to be an interface with other stakeholders and understand how they affect the offering.

Q: How can you manage the increased interaction with the customer that is required by the PSS value proposition, both personally and technically?

Q: How do plan to identify and include all stakeholders affected by your offering?

Revenue Streams:

Companies must understand how they integrate product-service contracts with performance-based pricing (i.e., availability, how often it is used, end-result of use, collateral of value entities) [23], establish accessibility contracts and licenses, and capitalize on indirect sales through a prolonged lifetime and the 2nd/3rd generation aftermarket.

Q: What changes are required in your operations to change from direct sales to an indirect sales focus?

Key Resources:

New competencies dealing with knowledge about downstream phase, and hence cultural changes and new infrastructure [23] will be needed to move into the PSS area.

Companies may either need to develop it bottom up, acquire it by hiring, or by partnering or merging with another firm.

Q: Do you have access to the knowledge capital necessary to provide a total solution offering? If not, how can this be acquired?

Key activities:

Total offers require to accurately reflect and communicate value to the customer. Quantifying soft values in a complex industry such as the C&D industry requires information from multiple channels, such as direct information and monitoring [23]. Therefore, companies providing PSS offers must ensure they obtain necessary information to quantify soft values.

Q: Can you quantify your soft values? If not, what additional information do you need?

Key Partnerships:

Total offers for the urban mining segment require capabilities that one company might not possess. PSS networks of partners and suppliers [23] working jointly can be a way forward here. Building, securing, and maintaining strategic and close partnerships with trustable partners becomes key.

Q: Should the operations be conducted in-house or outsourced? Is there a need to establish any new partnerships allowing you to provide a total solution offering? If so, how do you plan on securing such partnerships?

Cost Structure:

Costs related to a PSS offering vary compared to a traditional product offering, because of—for instance, shared profit margins, lifecycle factors related ownership and maintenance as well as end-of-life costs. Value-based pricing and longer payback times are also factors that influence [23]. This requires more comprehensive information to deliver soft values and accurately construct a competitive price mechanism.

Q: What additional information do you need to obtain to build a precise and comprehensive PSS cost structure?

6. Discussion

This paper has touched upon urban mining as a future business segment for construction equipment industry. The urban mining segment requires highly specialized machines, for instance for reaching tight spaces of for detecting where certain (valuable) metals may be. In addition, since the site would be reset, there is also an opportunity to rethink what and how to reuse material, such as concrete. This suggests that an implementation of support would need an overall systems perspective [28], coupled with an exploration of a business model based on a PSS perspective [26], where the specialized capabilities would be provided to the customers when needed in their process and machines would still be the property of the providers.

It is expected that urban mining is becoming increasingly interesting as building material extracted at mines and quarries, such as sand and aggregates are limited resources. For several years, minerals and natural stone have been protected by legislation in many countries. Mining is also controlled by law to secure local sustainability in many dimensions - nature life, such as, bird habitats and recreation areas, fresh water reservoirs and ground water levels, effects on surrounding urban areas, to name a few. The necessary permits for starting a new quarry are becoming increasingly difficult to obtain, and expansion of existing quarries are no longer taken for granted. There have been incidents where natural sand has been illegally extracted during night time to provide to local construction work. Countries are going to protect their natural resources even more and the recycling business is growing year by year. With the urban mining concept, the recycling is taking place on site - eliminating unnecessary transports and minimizing the number of handovers between different actors. This will, of course, require a new conception of the construction site and require a new way of thinking, which opens up for new PSS opportunities.

An important activity to understand how this change will happen and what should be the design solutions is needfinding [12, 13], where the design team gains first-hand information about these sites. Other key activities entail developing total solution offerings based on a specific integration of product and service components, where service-enabling capabilities need to be integrated. In addition, business cases for the customer must be analysed in conjunction with the financial solution. Integrated PSS contracts provide a more evenly distributed flow of revenue, which means that even increased costs are managed with a longer inflow. Other costs include additional investments into enabling the service components as well as delivery of service.

Hence, potential for improved sustainability could be achieved both in application – within an urban mining site – as well as in the enabling technology – when the manufacturer assumes ownership of the technology and also can utilize it with multiple partners.

7. Conclusions

This paper presents key topics that need to be addressed when developing sustainable product-service systems for the urban mining segment. This work has outlined a guideline for how the business model canvas could be adapted [21] for specific urban mining contexts. The canvas business model notation, with guiding questions, is suggested as a vehicle to achieve this. The paper has presented a set of questions that could be posed when developing the business model. The idea is to transform from a traditional construction and demolition perspective towards a PSS-based construction product for an urban mining environment.

Potential new customers can include those that may have been hindered by the entry barrier. Also, there is potential in new aftermarket channels with second and even third generation customers having a version of a total offer. The value proposition includes a more even distribution of cash flow for the customers, a more active and prolonged aftermarket with proactive maintenance solutions enabled by telematics and data mining capabilities. These stronger ties also allow more vivid relationships with the customers.

This paper has presented some initial explorations into this topic. More research is needed to further investigate this topic of urban mining from a PSS and business model perspective, in relation to the engineering capabilities that are needed.

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