Obsolescence, conceptual model and proposal for case studies

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Abstract (Revised)

What is obsolescence? There is a general understanding that buildings, similar to machinery, should be demolished and replaced when they become obsolete. The truth of this assertion is found problematic, as obsolescence is not clearly understood in conceptual or practical terms. Understanding obsolescence is important. It presents a serious threat to built property as it rarely accounts for the immobile, long lasting and capital-intensive characteristics of property, or its societal and cultural significance. Minimizing obsolescence and extending longevity are therefore indispensable for maintaining the investments involved.

In this paper the characteristics of obsolescence are explored to address how buildings can be diagnosed and to what extent demolition is an unavoidable consequence. A conceptual model is developed which allows for different kinds of obsolescence to be characterised. The usefulness of the model can be tested by analysing cases of obsolescence. A proposal for case studies is described.

Keywords: building management, building pathology, decision making, life cycle extension, obsolescence, demolition, building stock

1. Introduction

What is obsolescence? Numerous older buildings have been demolished because of being obsolete. The recent discussion about the demolition of Ringo Starr's birthplace illustrates the emotional character of the subject, but also the general understanding that the life span of buildings, like machinery and durable consumer goods, is determined by becoming obsolete with demolition as a necessary end (Taylor, 2011). But is this assertion true? Clearly, it is not true for monuments and other structures with heritage or other intrinsic values that may not be demolished, nor it is true for empty out-of-service structures on valueless land that no one will demolish, and even not for obsolete worn down property as long as the owners and users continue to desire it and it does not harm its environment.

Obsolescence is a serious threat for built property. Most buildings are immobile, long lasting and capital intensive and have societal and cultural significance. The uncertainty about most buildings' future life is high. Therefore minimizing obsolescence is important for maintaining the physical, economic and societal investments involved. However, the available knowledge about the prevention and management of obsolescence is scarce. The available theoretical knowledge is limited, empirical data are scarce and evidence-based applicable expertise is hardly present or accessible.

Based on the available literature and previous research, in this paper answers are explored for three research questions:

1. What is obsolescence, what is its role in the life cycle of buildings and its effect on the built environment?
2. How and to what extent can it be avoided, diagnosed and cured?
3. How can a conceptual model of obsolescence be tested in case studies?

The wider goal of the research is to create an inventory of knowledge to prevent unwanted, unnecessary obsolescence and to optimize the sustainable use of a building stock by life cycle prolongation and reduction of demolition. However, the immediate goal of this paper is to provide a conceptual framework and propose a test in case study research.

2. Obsolescence and the end of life phase: a theoretical approach

2.1. What is obsolescence?

The Oxford English Dictionary defines the adjective 'obsolete' as 'no longer used or practised; outmoded, out of date', or 'worn away, effaced, eroded; worn out, dilapidated; atrophied', and the noun 'obsolescence' as 'the process or fact of becoming obsolete or outdated, or of falling into disuse', or more specifically 'the process whereby or state at which machinery, consumer goods, etc., become obsolete as a result of technological advances, changes in demand, etc.' (OED, 2010). Merriam-Webster's Dictionary adds to the adjective 'no longer current, old-fashioned' (M-W, 2010).

In practice, the term 'obsolete' is mainly used to point at the discarding of all kind of subjects. A search on Google Scholar resulted in about 300,000 hits, commonly articles like "Is xxx obsolete?", with xxx varying from market mentality to vectorcardiography and prisons. Interestingly, none of the first 250 results were about buildings[1].

2.1.1. *Obsolescence of building stocks*

Obsolescence of buildings can be approached from different perspectives: causes, effects and/or scientific domains, each with different definitions as described below. Until now, scientific publications about obsolescence were rather scarce. The majority of theoretical and empirical studies are found in the economic domain, in particular in property investment where obsolescence is defined as one of the cases of depreciation (Baum, 1991). Other sources define obsolescence more generally as the loss of a building's performance over time and/or the last phase resulting in the end of the service life and most often demolition (Iselin and Lemer, 1993; Nutt et al., 1976).

Obsolescence of building stocks, domestic as well as non-domestic, is broadly defined in this paper as a process of declining performance resulting in the end of the service life.

In the field of housing and property management, obsolescence has increasing significance for design and management. The factor of time, often referred to as the fourth dimension in building, implies change and most often degradation of performance, usability, occupants satisfaction and life cycle costs of built facilities (Iselin and Lemer, 1993). Given the immobile, long lasting and capital intensive character of built property and its societal and cultural significance on the one hand and the high uncertainty about their future lives on the other, minimizing obsolescence should be an essential professional skill of designers, developers and facility managers. Given the awareness of the paradigm change from the massive new construction in the 20th century to sustaining the existing stock in most developed countries, the significance of careful maintenance and adaption is undisputed but still often ignored (Thomsen, 2010). The awareness of the huge ecological burden embedded within the existing building stock, implies the consequential need for physical and social sustainable maintenance and improvement of the existing built environment as a valuable resource. This further underpins the significance of the useful service life of the building stock and the need to anticipate deconstruction and recycling processes at the design stage (Golton, 1997).

Obsolescence of building stocks is only partly a physical phenomenon. It is essentially a function of human action or disregard. Therefore a distinction should be made between actual and potential performance. Buildings are complex man-made artefacts and can only survive by means of regular reinvestments in maintenance and adaptation. As a result, the total life cycle costs will generally be a multiple of the initial building costs (Boussabaine and Kirkham, 2004; Woodward, 1997). These high costs demonstrate the relevance of avoiding and minimizing obsolescence and the need for knowledge how to achieve that.

2.1.2. *Causes of obsolescence*

Obsolescence can have a wide range of causes. This is mirrored in the available literature, showing a confusing variety of categorisations like physical, economic, financial, functional, location, environmental, political, market, style and control obsolescence. Most of the literature focuses on a specific causal factor, subsequent explanation and a problem solving concept.

One main causal factor, inherent to the word obsolete, is acknowledged overall in the literature: the factor of time (i.e. age and the aging process). But age alone is not a decisive clarification, considering the huge diversities in occurrence of obsolescence between and within buildings and building types. Why are some very old houses still very popular while others are demolished before the surrounding trees grow to maturity? For more clarity and a better understanding, it is first necessary to order the subject by distinguishing the major characteristics: the nature of causes and effects, the different levels of scale, the building category and building type, and the kind of tenure and control.

Several authors have tried to develop a causal explanatory taxonomy of decay and obsolescence. Most of the attention was originally placed on the physical decay of the buildings and building parts, but the awareness of the behavioural and environmental impact has gradually grown. Nutt et.al. (1976) based their model mainly on the market position of residential property. Prak and Priemus (1986) based their comprehensive model on multiple case studies of residential stock including the infamous demolition of the Pruit-Igoe project in St Louis, US where they distinguish physical, social and economic causes. In a similar way, Golton (1997) relates residential obsolescence to sustainability, distinguishing four types of obsolescence: structure, economic, utility and social obsolescence. Golton's model is useful for case studies, but the interrelational effects of the distinguishable factors are hard to trace. The TOBUS software of Allehaux and Tessier (2002) assesses the functional performance of office buildings using five criteria: flexibility, divisibility, maintainability, compliance with user needs and with regulations. In the property valuation domain, obsolescence is more or less synonymous to discounting and depreciation (Baum, 1991; Deakin, 1999; Dunse and Jones, 2005), using - as far as they refer to causes - similar factors.

From these sources, the most acknowledged and widely applied causal distinction is between physical factors, related to material processes, and behavioural factors, related to human actions, and the interactions between them. The latter is nowadays acknowledged as decisive for most processes of residential obsolescence (van Kempen et al., 2006). The effects are commonly divided in technical and economical obsolescence (Iselin and Lemer, 1993).

Regarding scale, obsolescence can appear separately or combined on the level of building materials, parts and elements, building construction systems (structure, fabric, mechanical & electrical, etc), separate buildings, blocks, quarters and neighbourhoods. It can be regarded as a range of diseases, spreading over and mutually affecting different levels of scale, i.e. timber decay and lack of maintenance can corrode the market position of dwellings and trigger filtering processes. Conversely, the inflow of more vulnerable residents can, for example, seriously hamper maintenance investments.

Within the building category, there are essential differences between residential and non-residential buildings. Apart from differences in purpose, use, funding, management and legislation, housing is a rather stable function with long life cycle expectancy. In contrast, non-residential functions like office, retail, leisure, trade and industry often have a shorter cycle of usage and adaptation and consequently have a different vulnerability for obsolescence. Building types, shapes and functions are often interrelated, sometimes very strongly (e.g. water towers and churches) posing strong restrictions for reuse and transformation. Sometimes these factors are less restrictive or facilitate a wide range of functions (e.g. manor houses converted in offices and then back again into residences, and warehouses converted in apartments which of course is the origin of lofts). The main determining factors in these cases are space and structure (Markus et al., 1972).

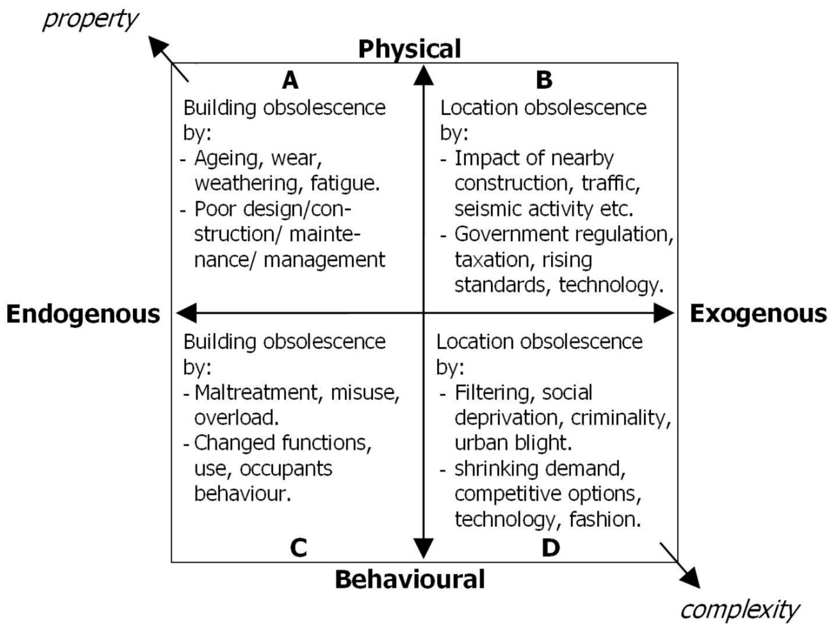
Tenure is decisive for property management and control. There are essential differences between rented and owned property, as well as between profit and non-profit and between single and joint ownership. (Itard and Meijer, 2008). This holds in particular for residential property, as social and institutional landlords are (as a rule) organisations with skilled professionals but have limited control on usage and care. Single owner-occupiers generally lack any proficiency, but have (in principle) full control on usage and care. Small landlords and condominium owners take a middle position, with limited control on usage and care and often lacking professional support. Similar relations can be found in non-residential property like shopping centres.

Building type (when compared to building category and tenure) has a stronger influence on the usage and the appreciation of property. Detached, terraced, multi-storey, high-rise etc. have a significant influence on the property value. The inventory above is not exhaustive; real estate agents will immediately add size, location, situation, architecture, services and facilities (Isaac and Steley, 1999), illustrating the complex influences on property value development as itself a determining variable of obsolescence.

2.1.3. A conceptual model of obsolescence

The often used categorisations of obsolescence distinguish on the one hand internal and external factors (Iselin and Lemer, 1993) and on the other hand physical and behavioural factors (Nutt et al., 1976). When assembled into a quadrant matrix, similar to the one used for building evaluations (Leaman, Stevenson, and Bordass, 2010) the results can be clearly conceptualized as shown in Figure 1.

Figure 1 Conceptual model of obsolescence.



Internal or endogenous factors are related to processes typical for the building itself, resulting in what Baum calls building obsolescence (Baum, 1991). The processes can be physical, like degradation and deterioration over time, caused by ageing, wear and weathering or fatigue of materials and structures, or by poor design, construction, a lack of maintenance and adaptation (quadrant A in Figure 1). They also can be behavioural, like damage by maltreatment, overload, and misuse or by changes in functions, use and occupants behaviour (quadrant C in Figure 1). External or exogenous factors are related to influences from outside, resulting in what Baum calls location obsolescence. These can have physical effects, like the impact of changing conditions in the environment by nearby buildings or infrastructure, traffic, pollution, noise, seismic activity etc., or by changes in government regulations, building codes and fiscal conditions, rising standards and functional requirements and new technologies (quadrant B in Figure 1) They can also have behavioural effects like filtering down and social deprivation processes in the neighbourhood, criminality, urban and planners blight, or like depreciation and loss of market position and value as a result of new technology, changing fashions and user preferences, the availability of better alternatives or simply a shrinking demand (quadrant D in Figure 1).

The diagonal line from quadrant A to D also depicts the increase of complexity regarding scale and participants and in the opposite direction increase of property based control. The physical factors in quadrant A are relatively uncomplicated and can be well controlled and managed by the proprietor. The mainly use-related factors in quadrant C are more complex and less easily controlled, while the mainly environmental factors in quadrant B are generally beyond control of the proprietor, as well as the highly complex factors in quadrant D. From the opposite direction, threats coming from the exogenous behavioural corner can have very serious negative effects. Where direct control fails, proprietors' (often, but not always the owner) responses have to be found in timely anticipation and intervention.

Many of the aspects in Figure 1 are interrelated (Golton, 1997; Grigsby et al., 1987; Prak and Priemus, 1986). The interrelation can be demonstrated by looking at the actual environmental challenge of energy efficiency. The energy performance of buildings is on the one hand determined by the energy quality of the physical design and construction (quadrant A) as measured in the EPBD (European Commission, 2002) (quadrant B), but on the other hand, also depends on the users' behaviour (quadrant C). A low EPBD rating and high energy bill can weaken the market position (quadrant D) and consequently have either have a negative impact on the chances for improvements in the direction of C, B and A, resulting in increased obsolescence, or be a stimulant for improvement actions. A similar reasoning can be applied on social deprivation, being another major contemporary threat.

As is typical for all models, this model is a simplification of the reality. It does not pretend to be all-embracing, but simplifies and condenses the major variables and its relations.

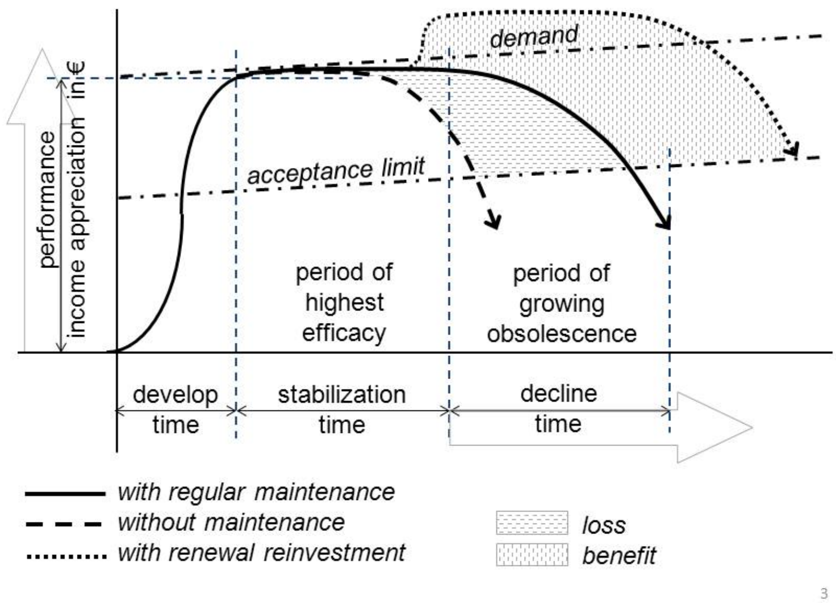
2.2. Obsolescence and the life cycle of buildings.

Obsolescence is commonly regarded as the beginning of the end-of-life phase of buildings. Sources about the life cycle of buildings show a variety of terms. The building and property development communities commonly refer to the development cycle, consisting of the development phase, including the design and the construction phase, and the usage phase, consisting of the actual use and the reuse or end-of-life phase (de Jonge and Arkesteijn, 2008). Sources regarding the life span, building pathology and mortality of buildings more often refer to the physical life or real life, being the period of physical existence, including the usage and end-of-life phase. This is in line with most national building stock statistics that in general only state withdrawal from the residential stock, in some countries subdivided by withdrawal by demolition and/or disaster, merging with other buildings and loss of function (Dol and Haffner, 2010).

The usage phase has now a formal definition: the service life, being ‘the period of time during which a building or its parts meet or exceed performance requirements’ (ISO, 2000). Bradley and Kohler (2007) state that the end of the service life can be the end of the physical life. However, it can also be just the indication of the expected time horizon.

They also refer to the economic life, being 'an assumed period of time over which the costs and benefits of buildings are assessed for purposes of making decisions about design and management', adding that this term when used for accounting or fiscal or other legal requirements is not necessary related to the likely service life time (Bradley and Kohler, 2007).
Analysing the influence of decay, several authors depict the life cycle as a function of a building's performance capacity over time (Awano, 2006; Iselin and Lemer, 1993; Markus et al., 1972; Miles, Berens, and Weiss, 2007; Nutt et al., 1976; Vroman, 1982). Following Markus et al., Iselin and Lemer illustrate obsolescence as the extending divergence over time between the declining performance and the steadily rising expectations. Miles et al. more specifically look at the economic performance of buildings, from the first investments in the development phase, the regular operation in the stabilization phase, the growing obsolescence in the decline phase through the final end of life. Combining these concepts results in Figure 2, showing the effects of maintenance and reinvestment.

Figure 2 Obsolescence and service life (not to scale)



Maintenance is required to maintain a building's initial performance capacity. Without maintenance, the performance will not meet the demand and eventually drop below the limit of acceptance of users or residents and the expected service life will not be reached, resulting in serious loss of efficacy.

In practice, both the demand and the limit of acceptance will gradually rise over time as a result of improved technology, rising standards and growing prosperity. Improvement and renewal are required to answer the accordingly rising expectations. By adding performance capacity the period of highest efficacy can be considerably extended and the service life prolonged. Assessment of the loss and benefits of alternative interventions in this way is part of current professional property and facility management (Boussabaine and Kirkham, 2004).

Apart from proficiency, financial ability and insight of urgency play a decisive role. For some building categories and functions with a short life cycle (e.g. retail and industrial facilities), regular refurbishment and adaptation are accepted preconditions to uphold its market position and/or accommodate changing needs. But in many other cases renewal and improvement is less obvious, due to a lack of financial means and/or urgency. For example in the residential sector, typically non-profit landlords maintain and improve their stock in a regularly planned way; most private landlords lack the means for substantial reinvestment, institutional landlords lack the urgency as they generally will sell their dwellings before they need major improvements, while the majority of owner-occupiers lack both means and urgency (Meijer and Thomsen, 2006; Oxley, 2004). As a result, major improvements in the owner-occupied sector are generally combined with the purchase and financing by a new owner.

In the last decade, sustainability and more particularly energy efficiency is of growing importance for the market position of built property. Improving the energy performance has become a strong rationale for additional investment in structural improvement of buildings and dwellings, imposing threats as well as opportunities for the existing older stock (Thomsen and Van der Flier, 2010).

2.3. Obsolescence and life cycle management: prevention, diagnosis and cure

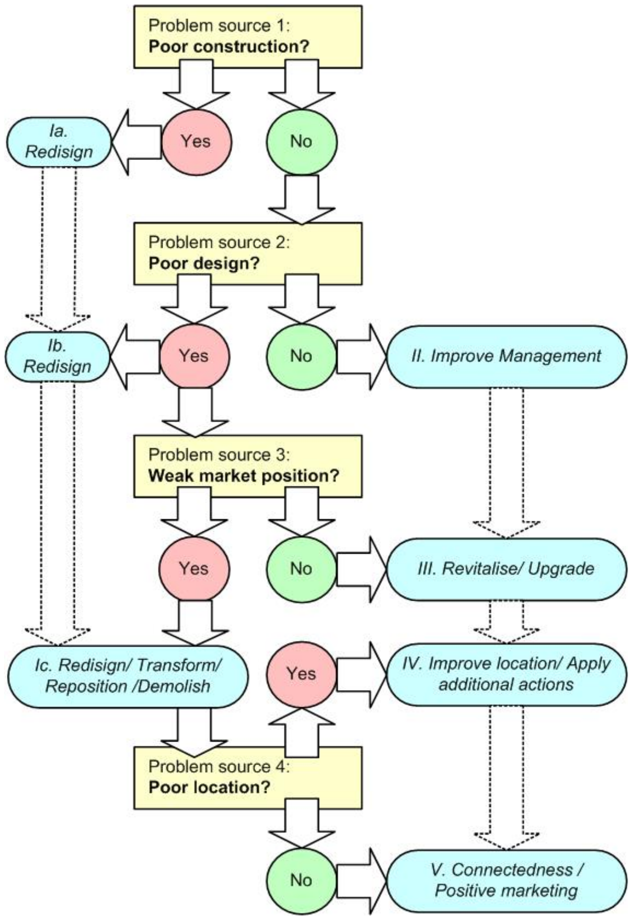
Although highly theoretical, the conceptual models of Figures 1 and 2 provide a succinct summary of the basic ingredients to analyse, avoid and cure obsolescence. In practice, the development of obsolescence is much more complicated and the range of methods and instruments to avoid and cure obsolescence likewise broad.

Given the long life and capital-intensive character of buildings, prevention is the most effective and efficient approach to avoid obsolescence. Prevention consists of systematic periodic analytical anticipation on all influences that are potential threats to the performance of buildings. Lijbers et.al. found four circumstantial factors for decay and obsolescence in the Dutch early post-war housing stock: design, construction, use and management, of which the design was by far the main causal factor (Lijbers, Thijssen, and Westra, 1984). A variety of surveys on different stock in different countries came to the same conclusion. They emphasize the importance of on the one side appropriate functional and circumstantial analyses underlying the functional program, including future developments (Iselin and Lemer, 1993), and on the other the building's spatial and structural flexibility to accommodate future changes (Brand, 1994; Maver, 1979; Till, 2009; van Nunen, 2010). Prevention should thus start in the earliest initial stage with an open eye to anticipating on changes, but should in fact never stop.

The diagnosis of obsolescence follows prevention as the next step in the systematic periodic analyses of stock performance. In the same way as prevention it requires in the first place an open eye for early symptoms and trends that may foster negative effects on all quadrants of Figure 1, being the base of systematic maintenance and management. This implies in quadrant A the systematic periodical inspection of the property, to be implemented in maintenance schemes (Harris, 2001; Straub, 2008; Watt, 2007), but also in quadrant B, C and D as indications for possible improper use, changing circumstances and conditions, and last but not least evaluated and fed back as preventive input to be used when programming new development.

Apart from physical decay, obsolescence is increasingly related to exogenous factors on a larger scale like unattractiveness of the neighbourhood and/or the availability of more attractive alternative options (Wassenberg, van Meer, and van Kempen, 2007). In their analysis of housing obsolescence, Nutt et.al. (1976) paid particular attention to the allocation and movement of residents. In the rented housing sector, but also in the retail, leisure and hotel sector, regular market analyses are necessary both for assessing the core business as for monitoring the buildings as main capital assets (Gruis and Nieboer, 2004). Based on an international comparative evaluative survey of the regeneration of larger social rented housing estates, Van Kempen et.al. (2006) developed a comprehensive framework for the diagnosis and cure of decay and obsolescence. Although based on residential property, it gives a clear basis for housing as well as for non-residential property management.

Figure 3 Managing housing obsolescence, analytical model (source: van Kempen 2006)



2.4. Testing the conceptual model

The conceptual model of obsolescence has been derived from the literature. To see if the model is useful and usable in research it should be tested in analyses of cases of obsolescence. In this paragraph the model is summarized and the steps are described that can be taken to conduct such case studies.

Obsolescence has been defined as ‘a process of declining performance resulting in the end of service life’. Accordingly an obsolete building can be defined as a building that does not meet the actual performance requirements. Obsolescence is the result of a variety of contextual processes, ranging from wear and weathering to changing levels of income or changing life styles. These processes have influence on two types of variables:

endogenous variables, related to the building itself, and exogenous variables related to the building at a specific place or in an area or market.
Lijbers et. al. (1994) mention as endogenous variables: design (including building type and building form); construction; maintenance (including tenure); management (including tenure) and use (including use, misuse and other than intended use). The first two variables are mainly physical. Maintenance and Management are the transition to behavioural variables and use is mainly behavioural. According to Lijbers et.al. design is the most important endogenous variable.
According to Miles et.al. (2007) the main exogenous variables are: site (the place as such); location / value (the place / value related to other places) and popularity / attractiveness.
The first variable is physical. Location is the transition to behavioural and popularity is mainly behavioural. In the literature there is no agreement about the relative importance of the exogenous variables.
The variables are interrelated. Grigsby et.al. (1987) and Prak and Priemus (1986) developed models showing the interrelation. These models are valuable but do not show how the process of obsolescence starts and the relations between physical and behavioural variables are hardly elaborated.

To test the model and to investigate the relation between the variables, case studies are proposed about concrete cases of demolition or improvement of residential buildings or estates. The assumption behind this method of working is that the decision to demolish or improve a building is motivated by obsolescence. It is of course possible to work the other way around and start with an old building and establish first to what extent it is obsolete. This can be done by confronting the actual state of the building with original or actual performance requirements. That procedure is probably more time consuming and difficult because the performance requirements are not always available.

The next steps are proposed for the test of the model:
- Selection of cases; the criterion for selection is projects in which the proprietor has decided to demolish or improve the building or estate. Proposed is to start with one category of buildings, residential ones, and to increase the complexity of the test step by step. In a next stage non residential buildings can be added. No further criteria are needed for selection.
- Description of the actual state of the building or estate using the endogenous and exogenous variables mentioned and description of the interrelation between the variables that can be found in the case.
- Analysis of the causes for the state of the building by relating the variables to contextual processes found or mentioned by participants.
- Description of the decision-making process that resulted in the decision to demolish or improve the building or estate.
- Analysis of the relation between the state of the building and the content and the course of the decision-making process.
- Comparison, after a number of case studies, of the results of the cases. The objective is to see if the selected variables are relevant, if variables are missing and to see if there are similar patterns in their relations and their relation to contextual processes.

The case study design is rather loose because of the exploratory stage of the research. Objective is to conduct and collect as much case studies as possible. Interested researchers are invited to participate in the testing and elaboration of the model by using it and by exchanging the results.

3. Conclusions

The diverse characteristics and many causes of obsolescence were explored and a conceptual model of causes of obsolescence and effects proposed. It distinguishes between on the one hand physical and behavioural factors and on the other endogenous and exogenous factors. It shows the often inverse relation between the increase of complexity of types of obsolescence and the decrease of the owner's / proprietor's possibilities to manage it. Obsolescence as a process is described as the growing divergence between the declining performance of buildings and the rising expectations of users and proprietors. Obsolescence is often regarded as the start of the end-of-life phase of buildings. However, obsolescence is not an inevitable natural phenomenon and does not necessary lead to demolition. Demolition is not always preceded by obsolescence.

As obsolescence is a serious threat to built property, further research on obsolescence and its causes and as well as the decision-making involving life cycle extension or demolition is required. The proposed conceptual model, derived from the present knowledge, is developed for that purpose.

To investigate and test the usefulness of the conceptual model a series of case studies is proposed. In these case studies concrete cases of obsolescence, e.g. obsolete buildings or estates should be investigated using the conceptual model. The outcomes should add to the understanding of the case, clarify the interrelation of causes and effects, test the usefulness of the model and help elaborating it.

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