OBSOLESCENCE AND THE END OF LIFE PHASE OF BUILDINGS

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Abstract
What is obsolescence? Numerous older housing blocks have been knocked down because of being obsolete. There is a general understanding that buildings, like machinery and durable consumer goods, should be replaced when they become obsolete. But is this true?
Obsolescence is a serious threat for built property. Given its immobile, long lasting and capital intensive character and its societal and cultural significance on the one hand and the high uncertainty about their future lives on the other, minimizing obsolescence is indispensible for the up keeping of the physical, economical and societal investments involved.
This article explores the characteristics and symptoms of obsolescence, how can they be diagnosed and when and to what extent is demolition an unavoidable consequence?
Due to the limited availability of empirical sources, the approach is mainly inventory and conceptual, based on literature search supported by previous empirical work.

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

INTRODUCTION

What is obsolescence? Numerous older housing blocks have been knocked down because of being obsolete. The recent discussion about the demolition of Ringo Starr's birthplace illustrates on the one hand the emotional character of the subject, but also that there is a 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 true? Not for monuments and other structures with heritage or other intrinsic values that may not be demolishes, not 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 love it and it does not harm its environment. Even if obsolescence is defined as a condition that justifies demolition, there are other solutions like renovation, reuse and transformation to extend the service life of buildings. On the other hand, obsolescence is not a necessary condition for demolition, and pretended obsolescence is not necessary always the true reason for pulling down existing building (Thomsen and van der Flier, 2009b).

Obsolescence is a serious threat for built property. Given its immobile, long lasting and capital intensive character and its societal and cultural significance on the one hand and the high uncertainty about their future lives on the other, minimizing obsolescence is indispensible for the up keeping of the physical, economical and societal investments involved.

Since the awareness of the fundamental paradigm change from the massive new construction in the 20th century to the sustaining of the existing stock, the significance of careful maintenance and adaption is undisputed but still often ignored (Thomsen, 2010). The awareness of the huge ecological burden and the consequential need for physical and social sustainable improvement of the built environment further underpins the significance of useful life cycle extension of the building stock.

Obsolescence is not a natural phenomenon but a function of human action. Buildings are complex man-made artefacts and can only survive by means of regular reinvestments during its long service life. 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.

However, the available knowledge about the prevention and management of obsolescence is scarce. Libraries are filled with publications about the initial phase of building; resources on the service life are scarce and on the terminal phase almost inexistent. Bibliographic search machines show an abundance of hits on obsolescence and demolition, but they are mainly casuistic and descriptive. The available theoretical knowledge is limited, empirical data are scarce and evidence based applicable expertise is hardly present nor accessible.

This article explores the characteristics and symptoms of obsolescence. Based on the available literature and following previous research, 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 extend can it be avoided, diagnosed and cured?
3. What is the relation to end of life phase of buildings, and to what extent is demolition an unavoidable consequence?

Goal is an inventory of usable and evidence based knowledge to prevent unwanted, unnecessary obsolescence and to optimize the sustainable use of building stock by life cycle prolongation and reduction of demolition.

Due to the limited availability of empirical sources, the approach is mainly inventory and conceptual, based on literature search supported by previous empirical work.
The structure follows the research questions and concludes with recommendations for further research.

OBSOLESCENCE AND THE END OF LIFE PHASE, A THEORETICAL APPROACH

What is obsolescence?

The Oxford 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 specific ‘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, but of the first 250 none about buildings (GoogleScolar, 2010). Housing and property obsolescence is nonetheless a significant design and management issue. The degradation over time should be regarded as the fourth dimension in building as it largely determines the 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 is thus an essential professional skill of designers, developers and facility managers.

Obsolescence of building stocks

Obsolescence can have a wide range of causes. The fact that buildings are composed of a multitude of elements and materials with different life cycle characteristics makes an extra confusing complication. This is mirrored in the available literature, showing a confusing variety of categorisations like physical, economic, financial, functional, locational, environmental, political, market, style and control obsolescence, all focussing on a specific causal factor and subsequent explanatory and problem solving concept.
One main causal factor, inherent to the word obsolete, is overall acknowledged: the factor time i.e. age. 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 age old houses still very popular while others are demolished before the 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.
Most categorisations of obsolescence are based on the nature of causes and/or on the effects.
Regarding the causes the most acknowledged and widely applied distinction is between physical factors, related to material processes, and behavioural factors, related to human actions, and the interactions between them. Where most of the attention was originally pointed at the physical decay of the buildings and building parts, the awareness of the behavioural and environmental impact has gradually grown (Nutt et al., 1976) and is nowadays acknowledged as decisive for most processes of obsolescence (van Kempen et al.,

2006). The effects are commonly divided in technical and economical obsolescence (Iselin and Lemer, 1993).
Regarding the scale, obsolescence can appear separately or combined on the level of building materials, parts and elements, constructions, 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 blight and lacking maintenance can corrode the market position of dwellings and trigger filtering processes, while reversely the inflow of more vulnerable residents can seriously hamper maintenance investments.
Regarding 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 a long life cycle expectancy, where non-residential functions like office, retail, leisure, trade and industry often have a short cycle of usage and adaptation and consequential different vulnerability for obsolescence. Building types, shapes and functions are often interrelated, sometimes very strong as e.g. water towers and churches, posing strong restrictions for reuse and transformation; sometimes less curbing or in contrary facilitating a wide range of functions, like manor houses converted in offices and back again in residences, and warehouses converted in apartments, the origin of lofts, space and structure being the main determining factors (Markus et al., 1972).
Tenure is decisive for property management and control. In this regard 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 limited control on usage and care, whereas 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.
In relation with building category and tenure, building type has a strong 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.

Obsolescence, a conceptual model.
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). Assembled in a quadrant matrix, similar to the one used for building evaluations (Leaman, Stevenson, and Bordass, 2010) results in figure.1.

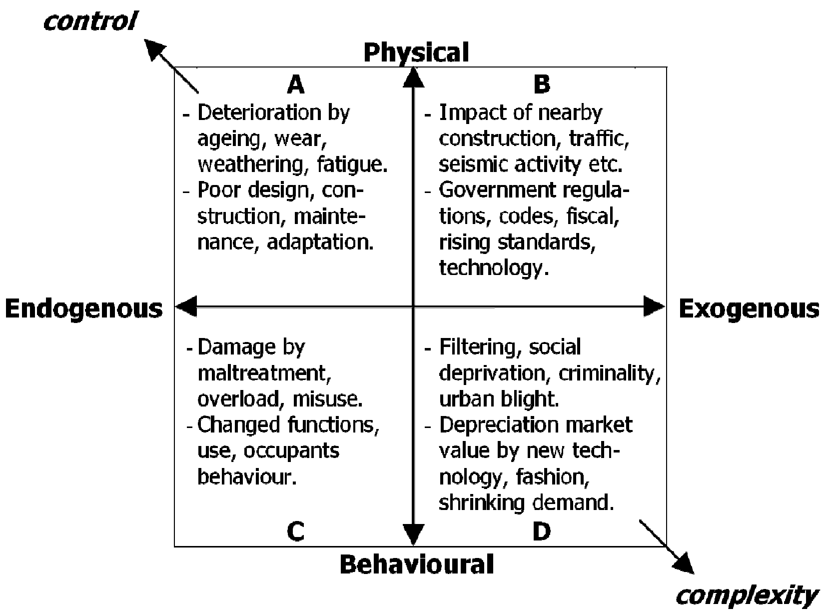

Figure 1 Obsolescence, conceptual model

Internal or endogenous factors are related to processes typical for the building itself. 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, lacking maintenance and adaptations (quadrant A in figure 1). They also can be behavioural, like damage by maltreatment, overload, 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. They can have physical effects, like the impact of changing conditions in the environment by nearby constructions, 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 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 the corresponding decrease of 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 effects. Where direct control fails, proprietors answers have to be found in timely anticipation and intervention.

Many of the aspects in figure 1 are interrelated (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 energetic quality of the physical design and construction (quadrant A)as measured in the EPBD (quadrant B), but on the other depending of 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.

1.1. 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 development trade commonly refers 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 state that the end of the service life can be the end of the physical life but 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 cs., Iselin and Lemer illustrate obsolescence as the extending divergence over time between the declining performance and the steadily rising expectations. Miles cs. 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.

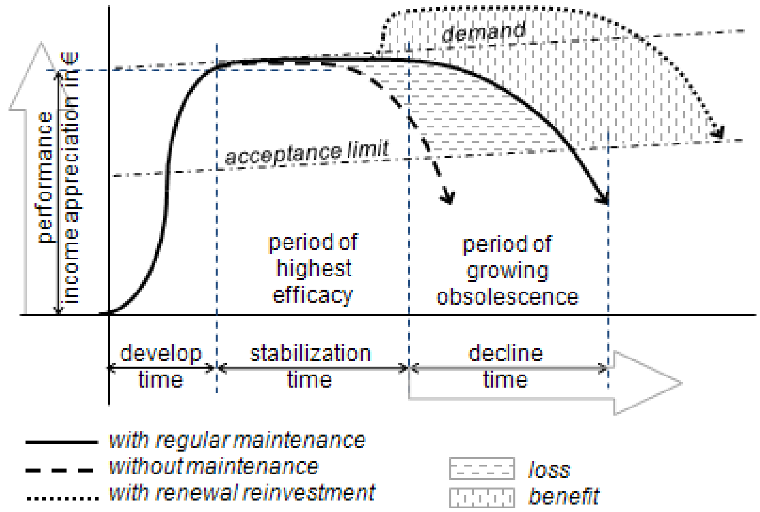

Figure 2 Obsolescence and service life (not to scale)

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 nowadays 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 like retail and industrial facilities, regular refurbishment and adaptation are accepted preconditions to uphold its market position respectively accommodate to changing needs. But in many other cases renewal and improvement is less obvious, due to lacking means and/or urgency. For example in the residential sector, only 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 (Oxley, 2004; Thomsen and Meijer, 2007). 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 energetic 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).

Obsolescence and life cycle management: prevention, diagnosis and cure

Though highly theoretical, the conceptual models of figure 1 and 2 give in a nutshell 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 analytic anticipation on all influences that are potential threats for 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 more and more 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). Nutt et.al. paid in their then breaking analytic models for housing obsolescence much attention to the allocation and movement of residents (Nutt et al., 1976). 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. developed a comprehensive framework for the diagnosis and cure of decay and obsolescence (van Kempen et al., 2006). Though based on residential property, it gives a clear basis for housing as well as for non-residential property management.

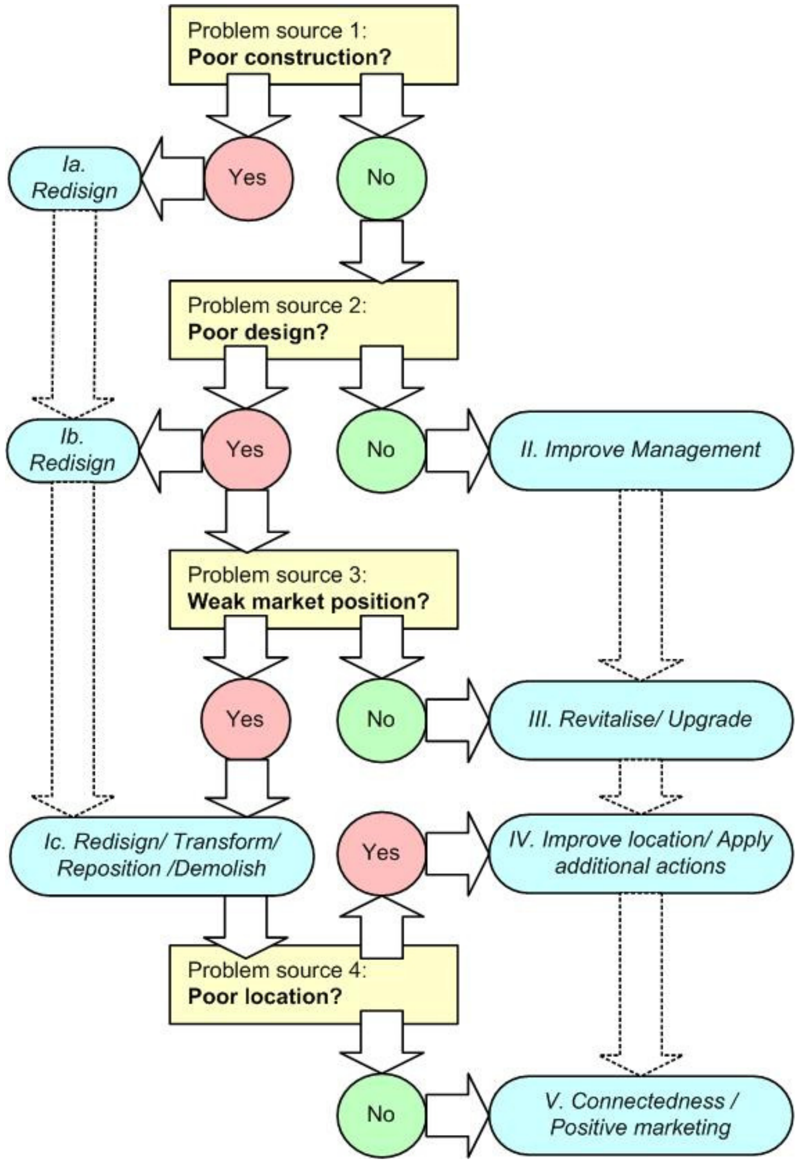

Figure 3 Managing housing obsolescence, analytical model (source: van Kempen 2006)

Obsolescence and demolition

The end of life phase is a normal part of the life cycle of buildings. Without adequate cure, obsolescence will eventually result in the end of the service life, generally by demolition. Exceptions are monuments and other structures with heritage or other intrinsic values that no one may demolish, and empty out of service structures on valueless land that no one will demolish. Even if obsolescence is defined as a condition that justifies demolition, there are other solutions like renovation, reuse and transformation to extend the service life of buildings. On the other hand, obsolescence is not a necessary condition for demolition, and pretended obsolescence is not necessary always the true reason for demolition. Apart from obsolescence, there can be many reasons to -or not to - demolish. To what degree these reasons become decisive motives depends on the interests and disposition rights and the capacities of the party involved.

Despite an abundance of case studies and descriptions (LibraryofCongress, 2010), empirical knowledge about the decision-making in the final phase of the life cycle of buildings and the underlying motives is scarce and fragmented. Data about demolition of non-residential property are generally not included in the statistics nor available from other resources. As a consequence, quantitative data are only available from the residential stock of the 19 out of the 27 EU members that supply any, of which only 9 on an a rather complete annual base, while the qualitative knowledge comes almost exclusively from the social rented stock and/or urban renewal areas of these 9 countries. Furthermore the definition of what is included in the records varies considerably.
Looking at the available data as shown in Figure 4, the rate of demolition differs considerably between countries, varying from 0,05% and below in France, the UK and Sweden to over 0,3% in the Netherlands.

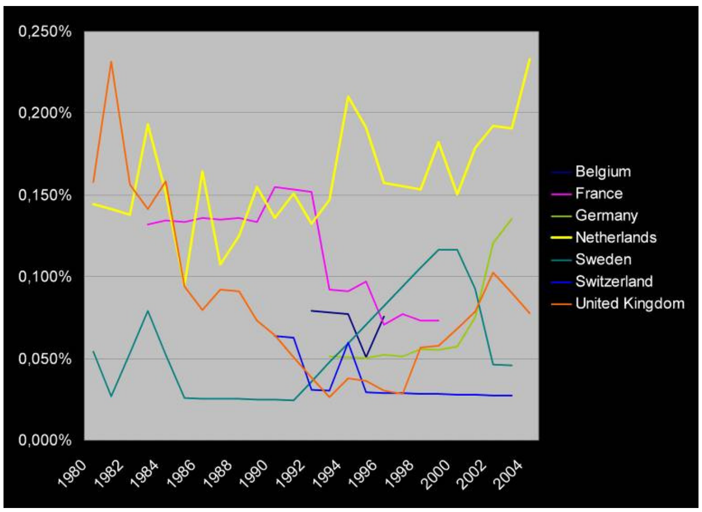

Figure 4 Demolition rate Western-Europe.

According to a survey of demolition by housing associations in the Netherlands, over 60% of the demolitions were motivated by functional and structural obsolescence, in the pre-war stock even over 90%. Including economic motives and oversupply, 87% of the demolitions were attributed to a kind of obsolescence and 13% to urban planning (Thomsen and Andeweg-van Battum, 2004). Additional questioning and information showed though that the decision making was also strongly influenced by social problems and more hidden profit driven motives like the land value, urban and asset policy and deals with the municipality and was biased by prejudices about the quality and costs of renewal versus new construction (Thomsen and van der Flier, 2009b).
Empirical data about demolition motives in the private owned stock are almost absent. The available information shows that, apart from acquisition for urban redevelopment, almost all of the demolition in the owner-occupied sector concerns detached dwellings after purchase by a new owner. The explanation is simple: residing owners do not likely pull down their homes and accordance between multiple owners in apartment blocks to do that is a rare exception; this in contrast with new owners who either decide to replace instead of refurbish the original dwelling, or are just in search of land for new construction.
The conclusion is all together that obsolescence does not necessary lead to demolition, nor that demolition is necessary preceded by obsolescence. It can certainly be a motive or at least a trigger for the decision between demolition or life cycle extension, depending on the interests, motives and capacities of the proprietor.

Recent studies point at the unwanted environmental, social and economic impact of demolition and conclude that life cycle extension by improvement, renovation and renewal is a better and more sustainable solution (Itard, Klunder, and Visscher, 2006; Power, 2010; Thomsen and van der Flier, 2009b). Though based on housing, the outcomes for non-residential stock with regard to environmental sustainability, e.g. building waste and energy use, will probably not be different. The conclusion is as yet that the limited building replacement capacity, being anyhow insufficient for mass replacement (Thomsen, 2010) should be used for life cycle extension of the existing stock. This underpins on the one hand the need for appropriate life cycle management as described above, but also the relevance of careful decision-making before the execution of final destruction.
Knowledge about the decision-making in the final phase of the life cycle of buildings and the underlying motives is scarce and fragmented. It is generally regarded as a black box, in which a complex range of interrelated and often conflicting interests and expectations of different parties are blended with the interests, considerations and expectations of the proprietor, with the latter as decisive condition for the outcome. Following a more elaborated analysis of the decision process and underlying motives of proprietors, physical quality and market demand can be considered as the main decisive variables, with tenure and asset management as main conditional factors (Thomsen and van der Flier, 2009b). Though explanatory in the Dutch setting, comparative findings are not yet available and use for forecasting or influencing the outcome is as yet beyond reach.

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

This article explores the characteristics and causes of obsolescence resulting in a conceptual model of causes of obsolescence and effects. It distinguishes between on the one hand physical and behavioural factors and on the other endogenous and exogenous factors. It shows the inverse relation between the increase of complexity of types of obsolescence and the decrease of 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 but a function of human action, read decision making. It does not necessary lead to demolition as demolition is not always preceded by obsolescence.
Obsolescence is a serious threat for built property. Given its immobile, long lasting and capital intensive character, its societal and cultural significance, and the high uncertainty about its future lives, minimizing obsolescence is important for the preservation of the physical, economical and societal investments involved. However, facing the paradigm change from new construction to maintenance and adaptation and the resulting huge task to improve the performance of the existing stock, the knowledge about the management of obsolescence is insufficient. Further research about the causes of obsolescence and about decision making about life cycle extension or demolition is therefore required.
Concentrating on the residential sector different questions should be investigated about the owner occupied sector and about the non-profit rental sector and different research designs are appropriate. Although the causes for obsolescence in both sectors of the housing market can be the same the decision making in both sectors varies resulting from different objectives and capacities of owner occupiers and professional housing managers. The availability of knowledge and data about management and decision making in both sectors differs too, as relevant knowledge about the owner occupied sector is very scarce compared with the non-profit rented sector.

For the owner occupied sector a twofold research strategy may be appropriate. On the one hand the collection of basic quantitative data about numbers of demolition and possible causal factors by means of surveys using the model, depicted in this paper and on the other hand explorative case studies to elaborate a conceptual scheme about the decision making in this sector. Different from the non-profit sector the decision making by residents in the owner occupied sector seems to be related with their housing career: decisions are often related to change in household composition or to a move to another dwelling. The capacities of owner occupiers are also much more limited than the capacities of professional housing managers.
In the social rented sector more quantitative data are available so it is possible to start testing assumptions about causes and effects of obsolescence and about relations with interventions by housing managers. Different from the owner occupied sector the decision making in the non-profit sector seems to be mainly related to asset management and policy objectives. Starting from the knowledge about the structure of decision making in this sector it may be fruitful to compare decision making between non-profit housing providers in different housing markets or countries to test the effect of external factors like housing policy, housing culture and housing market. This could be achieved by international comparative research as described by (Thomsen and van der Flier, 2009a).

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