Obsolescence – the underlying processes

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Abstract

Obsolescence, defined as the process of declining performance of buildings, is a serious threat for the value, the usefulness and the life span of housing properties. Thomsen and van der Flier (2011) developed a model in which obsolescence is categorised on the basis of two distinctions, namely between endogenous and exogenous cause-effect relationships and between physical and behavioural cause-effect relationships. In this way, the model presents a classification of underlying factors of obsolescence. However, these underlying factors, more specifically the underlying cause-effect relations, are still a black box. In this paper we try to disclose this. Based on a review of related models concerning the process of declining performance of built property, we present several hypotheses on cause-effect relationships underlying obsolescence of dwellings and discuss their relevance and appropriateness for future research on the topic.

Keywords: obsolescence, decay, housing stock, property value, portfolio analysis

1. Introduction

1.1. Conceptual model of obsolescence

Obsolescence, defined as the process of declining performance of buildings, is a threat for the value, the usefulness and the life span of housing properties. Knowledge about obsolescence and about ways to stop or prevent it is therefore important. The on-going paradigm shift from new construction to maintenance of the existing housing stock also calls for better knowledge of the ageing processes going on in the building stock and for a comprehensive approach of these processes. To that end Thomsen and van der Flier (2011) developed a model to detect and analyse obsolescence. Obsolescence is categorised on the basis of distinctions between:

- endogenous and exogenous cause-effect relationships. This distinction regards the origin of the relation: from the building itself (endogenous) or from the environment (exogenous).
- physical and behavioural cause-effect relationships. This distinction regards the character of the relation: related to the built entity (physical) or to the behaviour of the main stakeholders, i.e. owners and residents (behavioural).

Combined the two distinctions result in a model with four quadrants that typify various ageing processes c.q. types of obsolescence. The quadrants are characterised by the underlying cause-effect mechanisms and not by their physical appearance. E.g. quadrant A regards decline of performance of

buildings by physical cause-effect processes within the building, e.g. poor or substandard initial quality resulting in defects (fig. 1).

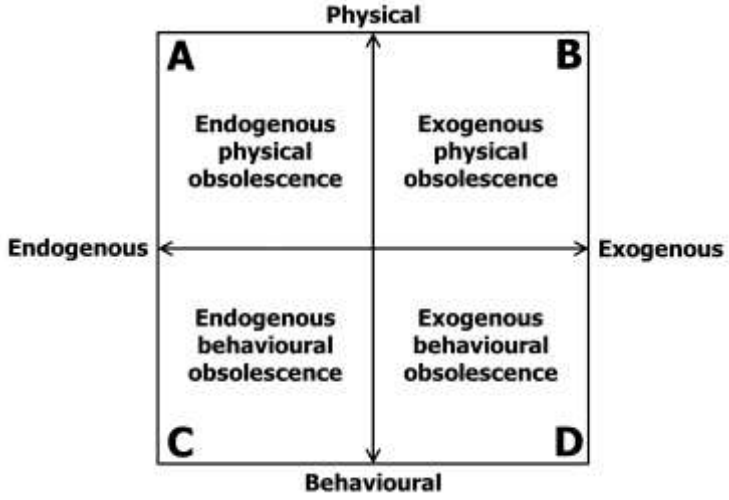

Fig. 1, Conceptual model of obsolescence

The objectives of the model are twofold.

- To serve as a theoretical framework to trace, analyse, understand and model processes of ageing and decline of performance of buildings;
- To serve as a diagnostic framework to investigate the probability and/or future risk of performance decline of buildings by ageing and/or obsolescence and potential remedial actions.

1.2. Approach

In previous stages of the research we have reported about the further development of the model, the search for indicators and instruments to trace and measure different types of obsolescence and the testing of the model (Thomsen and Van der Flier, 2013; Nieboer et.al. 2014; Thomsen et.al. 2015). The results so far showed that the model is useable and further development is feasible and promising, but not in an odd moment. There are still a number of difficulties to be resolved though, missing information to be gained and complexities to be tackled, all related to the core dynamics of obsolescence - cause-effect processes, resulting in declining performance of buildings -, the 'black box' of obsolescence.
This paper is dedicated to these difficulties. To solve them three options are conceivable: an extended search for findings from sources in a wider domain, in particular similar and/or related models concerning the process of declining performance and a laborious time and resources consuming search by means of systematic cause-effect analyses in a detailed series of case studies. In between these two it may also be worth to search for logic relations by hypothetic reasoning.
This paper reports about the first option, the search for reachable existing fruit that was not harvested in our previous reviews, followed by the third option: answering some tentative hypothetic questions.
For practical reasons the scope is narrowed to residential buildings.

1.3. Research questions

The paper is structured by the following research questions:

1) What are the main difficulties and missing links found so far on the way to further development of the model?
2) What knowledge resources and /or models about similar problems and solutions can be found in the literature and what are their basic characteristics?

3) What factors are mentioned in these resources and models and what (causal) relationships are found or assumed between them?
4) What hypotheses are - regarding the objectives of the model - most relevant for future research?

These questions will be answered in the next paragraphs. After detailing the difficulties in paragraph 2, the available sources concerning the process of declining performance will be reviewed in paragraph 3 to identify the factors they distinguish and the assumed relationships between the factors. From this review several hypotheses on cause-effect relationships regarding obsolescence will be distilled and answered in paragraph 4. Their relevance and appropriateness will be discussed for future research with the aim to develop a tool to determine and compare the performance of estates and housing stocks. Based on the answers paragraph 6 draws conclusions and presents an outline for future research on obsolescence.

2. Main difficulties and missing links

This paragraph answers the first research question.

2.1. Cause-effect processes

The model is based on the hypothesis that the core dynamics of obsolescence consists of a series of complex interrelated recurrent cause-effect processes between the distinguished factors, resulting in the eventual performance decline of buildings. The advance of these cause-effect processes within and between the quadrants: by nature highly interdisciplinary, is still a black box.
As change-processes basically consist of recurrent chains of causes and effects, cause-effect analysis is a basic research approach in a wide range of knowledge fields e.g. process- and quality-management, planning, ICT and medical pathology. A well-known tool in the management domain is the fishbone diagram originally developed as a causal diagram to depict problems in the manufacturing industry (Ishikawa, 1976, fig. 2) and since widely used for cause-effect analyses in the marketing and service industry.

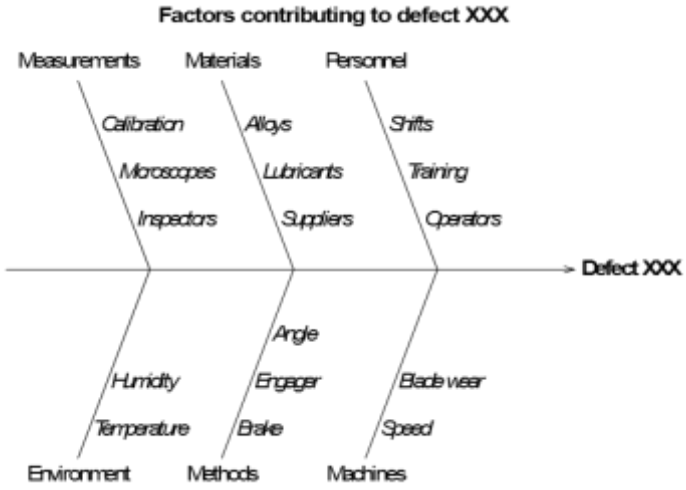

Fig. 2, Fishbone diagram

For more complex interrelated multifactor cause-effect processes the fishbone diagram and similar methods result in a confusing multitude of interrelated diagrams. That might be feasible with the help of digital means but is presumably very laborious. Applying methodical and statistical approaches as e.g. multifactor analysis and epidemiologic research as used in the medical domain may be more fruitful. The difficulties we faced for further development of the model are related to these cause-effect processes: their complex multifaceted, interrelated nature; their wicked problem character; the lack of knowledge about their functioning and the shortage of indicators for its occurrence and of instruments to measure its effects.

2.1.1. *Wicked problem character*

The assessment of building performance is to some extent a wicked problem. Contrary to tame problems - as conventionally used in beta sciences -, wicked problems - as inherent in policy science and planning - are difficult or impossible to solve because of incomplete, contradictory, and changing requirements that are often difficult to recognize (APSC 2007; Rittel and Webber, 1973). Though this only partly refers to the analysis of cause-effect processes in this paper, building performance is a subjective variable and the assessment of building performance as a result of behavioural cause-effect processes wears the characteristics of a wicked problem. As the APSC concludes, wicked problems can be tackled by an array of requirements, such as a flexible holistic approach, discourse based accountability and effective stakeholders and citizens engagement.

2.1.2. *Complex multifaceted, interrelated nature*

In the course of ageing processes the distinguished factors can be both cause and effect and the reverse. For instance, obsolescence can be attributed to poor initial quality of the respective building (type A), but in turn the choice of the initial quality can be expected to be a deliberate human action of the that time designer and/or principal of the building (type C); or it can be attributed to physical decay (type A) related to rude climatic conditions (type B) insufficiently anticipated by the designer and/or principal, and/or cared for by the resident (type C). If not properly solved (type C), the physical decay (type A) subsequently attributes to loss of market value (type D) and subsequently to erosion of as well the financing capacity (type D) and the satisfaction of the residents (type C) while the vulnerability for exogenous physical corrosion (type B) increases and so on.

2.1.3. *Recurrence of processes*

Ageing processes of buildings are by nature cyclic and recurrent. They consist of a series of interrelated processes that evoke successive processes. The course of these processes can only be studied in time by longitudinal comparative research: successive diagnoses where ageing and decay are the difference in performance ΔP between two or more moments t_1, t_2, t_x

$$\Delta P = Pt_1 - Pt_2 - Pt_x \qquad (1)$$

Previous survey (Nieboer et.al., 2014) learned though that earlier data are barely readily available and - as far as obtainable from archives - require time-consuming search and/or conversion as the data available are most often registered in variables, parameters or quantities.

2.1.4. Lack of knowledge and shortage of data and indicators

Our previous research disclosed the lack of knowledge of and insight in the black box of cause-effect processes that result in obsolescence. The existing knowledge turned out to be incomplete, fragmented and insufficient to cover the analytical model and the same goes on for instruments and indicators for the disclosure of the cause-effect processes.

These shortcomings are not evenly spread over the four quadrants of the model:

- Quadrant A - Endogenous physical obsolescence - is rather sufficiently covered by available knowledge from the field of building and construction physics and technology, accessible data from both public sources and professional property owners and relevant general applicable indicators, standards and instruments.
- Quadrant B - Exogenous physical obsolescence - shows a range of insufficiencies; being covered by a variety of knowledge domains, from earth sciences as meteorology, seismology and geology through urban planning, transportation and public health sciences with an accordingly fragmented knowledge and lack of accessible data, indicators, standards and general applicable instruments.
- Quadrant C - Endogenous behavioural obsolescence - is potentially covered by a sufficient source of property management data in the social and economic domain from professional proprietors, but case studies showed a shortage of accessible and useable data, in particular of incomparable data in different years and a lack of indicators, standards and general applicable instruments.

- Quadrant D - Exogenous behavioural obsolescence - shows a limited but relevant coverage of accessible data in the social and economic domain, from public statistics trough semi-public sources and instruments to intermediate sources from the national union of real estate agents and related indicators, standards and instruments.

In addition to these shortcomings and at least as important is:

- The unavailability of longitudinal data sources, enabling analyses of changes in time.
- The lack of knowledge about the relative relevance and appropriateness of the different cause-effect processes.

3. Related models and similar sources

In this paragraph, findings from related models and similar sources are reported that also contain the interplay between physical and human/behavioural factors regarding the performance of buildings. The search was limited to the relevant main scientific literature.

Most of the models found concern entire neighbourhoods rather than individual buildings. As a consequence application in our model means adaption of the geographical scale from the neighbourhood level to the building or dwelling level. Fortunately, our model includes locational factors facilitating this step. Moreover, as Grigsby *et al.* (1987) state, neighbourhood decline is reinforced by the fact that in neighbourhoods generally consist of individual homes of a certain type – thus to some extent relating neighbourhood and dwelling level.

Classic explanations of (locational) obsolescence can be found in Grigsby *et al.* (1987) and earlier American authors such as Park (1936), where the term 'neighbourhood succession' plays a central role. In these models neighbourhoods gradually decline as a consequence of "filtering" (Grigsby *et al.*, 1987: 25-26), meaning that incoming households in an area have on average a lower socio-economic status than those already living in it. The assumption is that this kind of 'filtering' diminishes the attractiveness of neighbourhoods, reinforcing out-migration of the better-off and leaving homes behind for income groups that are not able to rent or buy relatively expensive homes.
Until several decades ago, the reason for this filtering was mainly sought in the physical deterioration ('wear and tear') of the dwelling and its immediate surroundings. Social problem developments, in particular in several American and European high-rise estates, made clear however that obsolescence could not only be attributed to the physical state itself, but also to changes in appreciation of these characteristics (e.g. Turkington *et al.*, 2004; Wassenberg, 2013; Iselin and Lemer, 1993) – which Van Kempen *et al.* (2006) regard as the distinction between "physical obsolescence" and "social obsolescence". They state: "Physical obsolescence is associated with the physical failure of the fabric and materials of the dwelling. (…) Social obsolescence is associated with changing technologies and expectations – as a result dwellings that were once considered adequate are seen as deficient" (Van Kempen *et al.*, 2006: 98). Especially in the 1980s and 1990s, when lettability problems did not only occur in technically poor, but also in well-maintained buildings, it became clear that the economic life span of some (types of) dwellings was shorter than the technical life span, an unprecedented phenomenon at that time.

Although Turkington *et al.* (2004) do not specifically address obsolescence, their factors influencing the position of high-rise housing estates can be used to identify several causal mechanisms regarding the (declining) performance of buildings. These scholars distinguish micro and macro factors. Micro factors are related to the building or the neighbourhood; examples are indicators of housing demand and supply, such as household characteristics and initial physical quality, and the presence and quality of local services. Macro factors consist of government policy and regulations (e.g. rules for housing allowance and housing allocation) and so-called "megatrends", such as globalisation, welfare state developments, sustainability and demographic trends).
In mentioning both micro and macro factors, Turkington *et al.* take what Lupton and Power (2004: 4) call a "middle position", meaning that neighbourhoods are seen "as related elements within urban and regional systems, focusing on the changing functions of types of neighbourhoods and the relationships between them, within a broader context of societal change." This "middle position" is to be seen in

contrast with the two extremes, namely, as Lupton and Power (2004: 4) state, on the one hand "theorists [who] focus very much on localised explanations, on within-neighbourhood causal links; emphasising issues such as levels of social capital, local economic development, and the effectiveness of services" – and on the other hand those who "play down the local and see neighbourhood change as a manifestation of much wider social and economic movements, such as changes in economic structure, or in ideology and taste, or patterns of racial discrimination."

Kintrea (2007: 324) presents a bit more refined classification of factors, namely:
1. "The nature of the *housing stock*, its physical attributes, adaptability and cultural value;
2. The *expectations of households* about what is a socially acceptable housing package, with the observation that expectations have constantly risen through time;
3. The *location* including the influence of local markets and neighbourhoods;
4. Finally, there is the role of *housing and urban policy*. On one hand, setting higher standards may accentuate tendencies towards obsolescence; on the other, maybe policy can compensate by improving the quality of neighbourhoods."

In all this literature, obsolescence is treated as a dependent variable, and the factors are presented as independent, potentially causal variables. This is true, but the argument that we want to make here is that they do not adequately reveal the underlying cause-effect mechanisms. For instance, it can be argued that government policy, housing market developments or the above-mentioned 'filtering' do not *directly* lead to obsolescence, but that there are other, intervening factors in play.
Such possible intervening factors can be found in a model for the analysis of declining estates by Prak and Priemus (1987). Although this model is nearly 30 years old, we hardly found more recent models of a similar nature. In their model the authors relate several groups of variables, namely: estate¸ landlord/housing providers (especially regarding financial and maintenance policies), operating costs, tenants (e.g. socio-economic and demographic characteristics), government (e.g. rent and building regulations), and demographic/economic/technological developments.

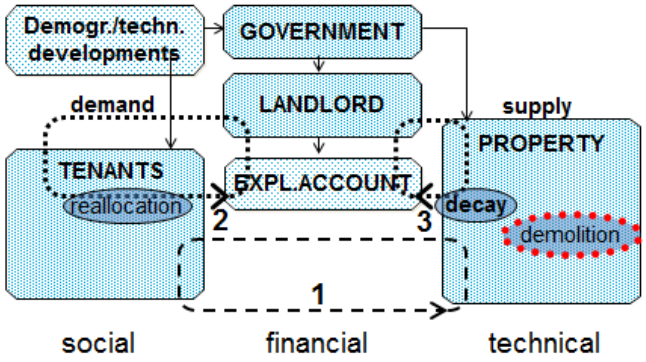

Fig. 3. Decay model by Prak and Priemus (1986, edited)

An added value of the model is that is explicitly recognises the role of the main actors in the maintenance and the quality of housing, namely the owners (landlords/housing providers) and the users (tenants). Although the model concentrates on the rented sector, this can hardly be regarded as a drawback, because the model can be easily adapted to be applicable to the owner-occupied sector as well.

A fairly recent model of neighbourhood decay, including the role of investors, is presented by Skifter Andersen (2002: 62), who combines three main factors in his model for neighbourhood decay, namely:
1. "the composition of residents in the neighbourhood;
2. the economic conditions of the properties;
3. the physical condition of buildings and the neighbourhood as a whole".

The author depicts his model as a "succession cycle" (Skifter Andersen, 2002: 63, see Fig. 4), in which "succession", in the sense of the above-mentioned neighbourhood succession, leads to "lower demand" and "falling values" and, as a consequence, to a deteriorated "economic condition". This, in turn, causes "smaller investments", which leads to a deteriorated "physical condition". This means a diminished attractiveness of the neighbourhood, which leads to further "succession". It must be noted that, conversely, a "gentrification cycle" can be drawn, in which an influx of more affluent residents leads to an improved economic condition, which in turn leads to an improved physical condition, which consequently attracts other better-off households. As a fourth main factor government intervention can be mentioned, in the sense that this type of action can help to prevent or to stop a negative succession cycle and even to turn it into a gentrification cycle.

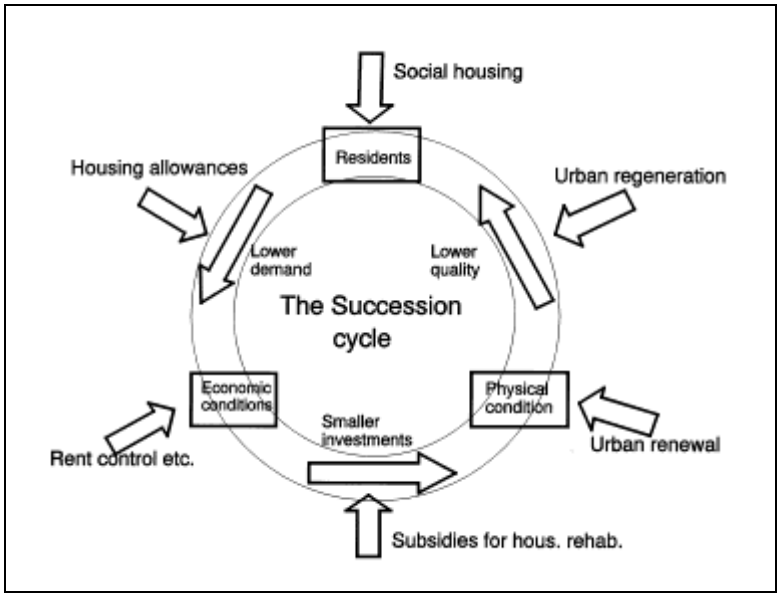

Fig. 4. Succession cycle, by Skifter Andersen (2003)

Based on the literature discussed research questions 2) and 3) can be answered as follows:

- The number of models regarding obsolescence is limited. Most of the models do not concern the individual building level but the level of entire neighbourhoods. However there appears to be a close correlation between the two levels due to the often large amount of dwellings of the same type in declining neighbourhoods. On the other hand conversion to and deduction in endogenous and exogenous factors in accordance with our model is not straight forward possible.
- The factors mentioned in the models can be divided in two groups:
  - factors that have to do directly with the performance of the building and neighbourhood and with the behaviour of the involved stakeholders: owners and residents. This group is potentially suitable to include in our model;
  - factors regarding the wider context ranging from megatrends that impact on preferences and expectations of (future) residents to changing regulations and norms as a result of changing policies. These 'contextual' factors do not directly lead to obsolescence but only via factors from the first group, e.g. a changing housing policy does not directly impact on the performance of buildings but through the behaviour (appreciation and activities) of owners and residents. This group is of importance for the exogenous cause-effect processes as distinguished in our model but not straightforward useful.
- The relation between the factors on the level of the building and the neighbourhood can be conceptualized as a cyclical process. It is characterized by interaction between the behaviour of the main stakeholders, owners and residents, and the declining performance of buildings in physical and economic sense. This is in accordance with the recurrent cause-effect processes underlying our model as discussed before in 2.1.3.
- On the level of the building a number of 'intervening' factors play a part. Some of the factors impact on the behaviour of owners. Examples are management motives related with tenure

and capacity of owners. Other factors influence the behaviour of residents, e.g. income level and place in the household cycle. There are also factors that impact on the performance of buildings. Examples are building type and initial quality. Contextual factors often impact on obsolescence trough these 'intervening' factors and vice versa. These factors are also is in accordance with the recurrence of the cause-effect processes underlying our model as discussed before in 1.2.1.

- The literature does not give a definite answer to the question where the process starts. But it can be assumed that any decay is a lifetime process that starts at the very beginning.

Overlooking these finding the receipts do only incompletely and to a limited extent cover the shortcomings and missing links form paragraph 2. The expectation that the answers and solutions could be found in related models and similar sources is all in all insufficiently fulfilled.

4. Hypothetic reasoning

After this short review of the literature on obsolescence models, questions can be asked that can be answered hypothetically by means of our model and its four types of obsolescence. The questions below are not complete; they illustrate ways to search for the nature, relative relevance and appropriateness of the distinguished cause-effect processes.

4.1. Questions and hypothetic answers

1) What is the relative importance of the different groups of factors or what is the *relative importance of each type of obsolescence*?

It can be argued that type C and D are more important than type A for the start of an on-going ageing process. Type A does not have to lead to such an ageing process if the appreciation of the building remains the same due to a tight market or increasing appreciation of 'older' buildings of a certain type. However, if the appreciation of buildings decreases an ageing process - e.g. the departure of better off residents - may start even if the performance of the building in the physical sense remains (almost) the same. So: A0 + C↓ + D↓ -> C↓-> A↓ but A↓ + C↑ + D↑ -> C↑ -> A↑. This kind of hypotheses is of importance to determine the risk of an on-going ageing process when certain types of obsolescence appear in growing defects or changing behaviour.

2) What (*combinations of) intervening factors* regarding buildings (building type, structure etc.), owners (motives and capacities) and residents (income, social economic status) can be distinguished and how do they *lead to an on-going ageing processes*?

It can be argued that the ageing process of single family dwellings (type) of housing associations (tenure) is different from the ageing process of apartment blocks. The appreciation of both types varies and depending on their capacities proprietors will react to this variation in their maintenance and improvement policy. Given the appreciation for single family dwellings they might invest in this type, while they only maintain apartment blocks on a very basic level. This policy may lead to an on-going ageing process in the apartment blocks. For single family dwellings the combination may be: (A)↓+ C↑ + D↑ -> C↑ -> A↑ and for apartment blocks the sequence may be (A)↓ + C↓ + D↓ -> C↓ -> A↓. These hypotheses are important to establish the (relative) importance of specific combinations of intervening factors like tenure and capacities as indicators for on-going ageing processes.

3) What *sequence in time* of types of obsolescence can be established?

Various sequences are possible often depending on variation in intervening factors. E.g. for owner occupiers the sequence may be A↓ -> C0 -> A↓ because they are not able or willing to invest in structural deficiencies. For commercial rented property the sequence may be C↓ + D↓ -> C↓-> A↓ because they are not willing to invest in property running risks with future lettability. These hypotheses are important to distinguish between the ageing processes in various property sectors.

4.2. Discussion: selection of most relevant hypotheses

The above mentioned hypotheses differ in theoretical relevance, in relevance for the practice of housing management and in the way they can be examined, depending on the availability of data and the research capacity needed. Table 1 shows the differences.

Table 1. Overview hypotheses

Relevancy etc. Hypothesis	Theoretical relevancy	Practical relevancy	Research approach
1.relative importance of types	+ Elaboration of model	0 Risks in general	By comparing a large number of ageing processes; given the limited number of factors quantitative research possible
2.impact combinations of intervening factors	+ Indicators for ageing processes	+ Risks related with specific combinations of factors	By comparing various sets of intervening factors; given the large number of factors case studies are appropriate
3.sequence of types in time	+ Elaboration of model	- Not important	By comparing a large amount of sets of intervening factors; (combination of 1 and 2?)

This short exploratory hypothetic reasoning does not fully answer the question what hypotheses are most relevant for future research. The value of this kind of reasoning is that it on the one hand shows the prospect of entering the black box by experience based hypothetic cause-effect relations, but on the other hand the indispensability of empiric data to test the answers and of the resulting insight in the process development as fundamental conditions for the model's objectives.

5. Conclusions

This paper is dedicated to the further development of the conceptual model of obsolescence, more particularly to the solving of a range of problems and shortcoming as encountered so far and described in paragraph 2.
Based on the results as concluded below the further development and future research on obsolescence will be discussed.

5.1. Results

The answers to the research questions formulated in paragraph 1 are as follows.

1) What are the main difficulties and missing links found so far on the way to further development of the model?

As reported in paragraph 2, the main difficulties and missing links found so far are basically related to the black box of complex interrelated and recurrent cause-effect processes resulting in the performance decline underlying obsolescence. To unlock this black box two options are conceivable: an extended search for findings from sources in a wider domain, in particular similar and/or related models concerning the process of declining performance and - as far as this does not delivers sufficient content - a laborious time and resources consuming search by means of systematic cause-effect analyses in a detailed series of case studies. The research as reported this paper was directed at the first option.

2) What knowledge resources about similar problems and solutions can be found in the literature and what are their basic characteristics? and
3) What factors are mentioned in these recourses and what (causal) relations are found or assumed between them?
   - The extended search as reported in paragraph 3 produced the following findings:

- The number of models regarding obsolescence is limited and mainly directed at the level of entire neighbourhoods instead of individual buildings. Though useable to some extent conversion to and deduction in endogenous and exogenous processes is not straight forward possible.
- The factors mentioned in the models can be divided in factors that have to do directly with the performance of the building and neighbourhood and with the behaviour of the involved stakeholders, and contextual factors regarding ranging from megatrends to changing regulations and norms as a result of changing policies. Of these only the first is potentially suitable for our model; the latter is of importance for the exogenous cause-effect processes as distinguished in our model but not straightforward useful.
- The relation between the factors on the level of the building and the neighbourhood can be conceptualized as a cyclical process of interaction between the behaviour of the main stakeholders and the declining performance of buildings in physical and economic sense. This is in accordance with the recurrent cause-effect processes underlying our model.
- On the level of the building a number of 'intervening' factors play a part, some with impact on the behaviour of the stakeholders, some with impact on the performance of buildings and vice versa. These factors are also is in accordance with the recurrence of the cause-effect processes underlying our model.
- The literature does not give a definite answer to the question where the process starts. But it can be assume that any decay is a lifetime long process that starts at the very beginning.

These findings do not cover all of the shortcomings and missing links form paragraph 2. The expectation that the answers and solutions could be found in related models and similar sources is all in all insufficiently fulfilled.

4) What hypotheses are - regarding the objectives of the model - most relevant for future research?

Though the short exploratory hypothetic reasoning presented in this paper does not fully answer the question what hypotheses are most relevant for future research it shows on the one hand the prospect of entering the black box by experience based hypothetic cause-effect relations, but on the other hand the indispensability of empiric data to test the answers and of the resulting insight in the process development as fundamental conditions for the model's objectives.

5.2. Discussion: selection of most relevant hypotheses

This last conclusion represents more generally the overall conclusion of this development phase of the model. The results disclose barely new viewpoints and only limited new knowledge and most of all the difficulties and missing links as described in paragraph 2 remain largely unsolved. As argued in paragraph 2 this leaves the last option as required further step: a laborious time and resources consuming search by means of systematic cause-effect analyses in a broad series of detailed case studies of dwellings with different characteristics of obsolescence, applying methodical and statistical approaches as e.g. multifactor analysis and epidemiologic research as used in the medical domain.
Starting points of these case studies should be:

- As framework: the to be further completed hypothetical questions about the nature, the interrelations and relative relevance and appropriateness of the distinguished cause-effect processes;
- As field of search: the property sector(s) that may be expected to yield the best array of available data and support, both in spread and time, enabling inter-relational as well as longitudinal search;
- Cooperation with related scientists and institutions;
- And last but definitely not least: sufficient funding.

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