The Negative Externalities of Structurally vacant offices

An exploration of externalities in the built environment using hedonic price analysis
By Philip Koppels, Hilde Remøy and Sabira el Messlaki

Introduction
It is often assumed that a spatial concentration of structurally vacant offices results in a degradation of an area (Remøy 2010). It is argued that this has a negative influence on the attractiveness of a location for office accommodation, so that the "willingness-to-pay" of office organisations further decreases. The relationship between vacancy rate (market rate) at regional and national levels and price indexes has been extensively studied. The negative externalities of structural vacancy however are often assumed, but not quantified. This study explores the possibility of quantifying externalities by hedonic price analysis.

Background
Figure 1 shows the evolution of the location and number of structurally vacant offices in Amsterdam, in the period 2003-2007. The number of structurally vacant offices is increasing sharply and is roughly in line with changing market conditions in the Amsterdam office market. The spatial dimension is also evident: structural vacancy is concentrated at certain locations in the city. The negative impact of structural vacancy on the actual rent distinguishes itself from the normally assumed vacancy – rent-level relationship (rental adjustment equation) based on the fact that the effect is assumed "local" and considers "visible" and "long lasting" vacancy. This study attempts to distinguish the negative externalities of structural vacancy from the effects related to changing market conditions. The supposed negative externalities are measured by a spatially weighted (lagged) structural vacancy variable: the SWSVV.

The specification of the SWSVV is based on a series of assumptions. In this study an office building is considered structurally vacant if the building was at least 50% vacant for a period of three or more consecutive years. In addition, the impact of structural vacancy is assumed to depend on the building size (m² GFA). A structurally vacant office building of 10,000 m² probably has a greater negative impact than an office building of just 2,500 m². Besides these two assumptions, the specifications used differ in type of distance-relationship (constant or linear), the maximum distance of the effect (250, 500, 750m) and in whether the applied (spatial) weighting depends on the office density of the location (relative impact). By specifying the SWSVV in different ways, this paper attempts to understand the negative externalities associated with structural vacancies and the underlying spatial process.
Figure 1: Structural Vacant Offices (2003-2007)
Data and Operationalization

GIS applications (Geographic Information Systems) offer extensive possibilities to efficiently identify location and building characteristics (e.g. the distance to railroad-stations and motorways) for a large number of buildings, but also facilitate the construction of a spatially weighted (lagged) variable, like applied in this study. Furthermore, this study makes use of several secondary datasets and fieldwork. This has resulted in a database that contains detailed information about both the building and the location. Table 1 shows the definitions of the variables included in the hedonic price-analysis, excluding the spatially weighted structural vacancy variable (SWSVV) and descriptive statistics.

Table 1: Descriptive Statistics of the sample

<table>
<thead>
<tr>
<th>Variables</th>
<th>Description</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min.</th>
<th>Max.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rent per square meter</td>
<td>Real rent per square meter (price level = 2007)</td>
<td>182.8</td>
<td>57.8</td>
<td>61.0</td>
<td>370.9</td>
<td>272</td>
</tr>
<tr>
<td>Building age</td>
<td>Building age: transaction year - year built or renovated</td>
<td>9.3</td>
<td>6.5</td>
<td>0.0</td>
<td>30.0</td>
<td>272</td>
</tr>
<tr>
<td>Travel time to highway entry/exit</td>
<td>Travel time to nearest highway entry/exit (minutes)</td>
<td>2.0</td>
<td>1.6</td>
<td>0.1</td>
<td>7.4</td>
<td>124</td>
</tr>
<tr>
<td>Distance metro/tram stop</td>
<td>Distance to nearest train station (meters x100)</td>
<td>4.51</td>
<td>4.27</td>
<td>0.28</td>
<td>26.53</td>
<td>124</td>
</tr>
<tr>
<td>Number of amenities</td>
<td>Number of shops for daily essentials and restaurants/pubs (r=500m)</td>
<td>18.57</td>
<td>44.04</td>
<td>0.00</td>
<td>258.00</td>
<td>124</td>
</tr>
<tr>
<td>Employment industry &amp; logistics</td>
<td>Number of jobs industry &amp; logistics (x1000, r=500m)</td>
<td>1.02</td>
<td>0.84</td>
<td>0.02</td>
<td>3.61</td>
<td>124</td>
</tr>
<tr>
<td>Employment financial &amp; business services</td>
<td>Number of jobs F&amp;B (x1000, r=500m)</td>
<td>3.73</td>
<td>2.82</td>
<td>0.08</td>
<td>11.54</td>
<td>124</td>
</tr>
<tr>
<td>Parking ratio</td>
<td>Inverse parking ratio (1:LFA, x100)</td>
<td>1.27</td>
<td>0.87</td>
<td>0.00</td>
<td>4.76</td>
<td>124</td>
</tr>
<tr>
<td>Entrance surface %</td>
<td>Entrance size as percentage of building size (LFA)</td>
<td>0.02</td>
<td>0.02</td>
<td>0.00</td>
<td>0.12</td>
<td>124</td>
</tr>
<tr>
<td>Categorical variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercity location</td>
<td>No intercity station location (r=250m)</td>
<td>116</td>
<td>93.55</td>
<td></td>
<td></td>
<td>124</td>
</tr>
<tr>
<td>Covered deck parking</td>
<td>Covered deck parking facilities</td>
<td>48</td>
<td>62.9</td>
<td>124</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Façade material</td>
<td>Composite/bricks/syntactical cladding</td>
<td>85</td>
<td>68.55</td>
<td>124</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Company logo</td>
<td>Company logo present</td>
<td>60</td>
<td>48.39</td>
<td>124</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No company logo</td>
<td>64</td>
<td>51.61</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The variables above are used as control variables in this study and are related to the main rent price determining factors. Based on transaction databases of real estate consultants, 272 rental transactions from the period 2003-2007 were linked to a total of 124 inspected offices. For each building that was investigated, at least one and maximum twelve transactions were identified. The transaction might relate to the total rentable floor area (single-tenant buildings) or business units (multi-tenant buildings).

Table 2: Number of transactions per building
Besides the dataset created from fieldwork, this study uses an office inventory database that contains information about the total Dutch office building stock (Bak, 2011). Based hereupon, combined with the supply database of DTZ, the structural vacancy of the Amsterdam office building stock was determined. The supply-data for Amsterdam contained 1205 office buildings with a total of 5.635.000 m² in 2007\(^1\).

**Spatially Weighted Structural Vacancy Variable (SWSVV)**
The stock dataset was combined with the supply data to compile the SWSVV. This variable serves as a proxy for the supposed negative externalities of structurally vacant offices. To construct the SWSVV, the distance to all offices within a certain radius around the identified offices was determined, but only the structurally vacant buildings were "weighted" in the SWSVV variable.

**Figure 2: Constructing the SWSVV**

![Figure 2: Constructing the SWSVV](image)

The house number of a number of office buildings was missing so that the X and Y coordinates could not be determined. These buildings were not included in the analysis.

<table>
<thead>
<tr>
<th>Numb. Transactions</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>59</td>
<td>33</td>
<td>15</td>
<td>7</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Percentage</td>
<td>47.6</td>
<td>26.6</td>
<td>12.1</td>
<td>5.6</td>
<td>2.4</td>
<td>.8</td>
<td>1.6</td>
<td>1.6</td>
<td>.8</td>
<td>.8</td>
</tr>
</tbody>
</table>

\(^1\) The house number of a number of office buildings was missing so that the X and Y coordinates could not be determined. These buildings were not included in the analysis.
expected (negative) effect: what is the maximum range of the effect \((r = 250-750m)\), the type of distance relationship (linear or constant ) and whether or not the impact is "relative" compared to the office density of the location. The following formula demonstrates how the value of the variable is determined for building \(i = 1\) in 2007.

\[
SWSVV_{r.i,j;2007} = \sum_{j=2}^{4} w_{i,j} \times GFA_j = w_{i,1,j=2} \times 10.000(GFA)_{j=2} + w_{i,1,j=4} \times 10.000(GFA)_{j=4}
\]

The term \(w_i\) is the "weighting term" and is determined by the assumptions just discussed. Figure 3 illustrates this "spatial weighting".

Figure 3: Distance Relationships

The first specification assumes that the impact applied within the radius \((r = 250-750m)\) is constant, each structurally vacant building has a weighting of "1". The second specification assumes that the "impact" of negative externalities decreases linearly with distance. The office building \(J = 4\) now only has half the impact of the office building \(J = 2\). Additionally, there are versions of the SWSVV specified in which higher office density results in a lower weighting of the structurally vacant buildings. Conceptually this can be imagined as a "third axis" in Figure 3, where the weighting decreases with an increase of the number of offices within the radius specified. This is done by applying a standardized weighting factor. The individual weightings for each office, a "1" in the first specification, are divided by the sum of the row, in this case "5" (five office buildings are located within \(r = 500m\)). This specification still implies that both office buildings have similar impact, but the strength of the effect is partly dependent on the density of office buildings.

For this study four different SWSVV variables were specified. The specifications can all be explained intuitively and theoretically. The distribution of the variable shows a very skewed pattern: "zero" values
prevail. This is as expected because not all inventoried buildings are located in a location with structural vacancy. The following table reports the frequency of "zero" values for each radius.

Table 3: Frequencies SWSVV Specifications

<table>
<thead>
<tr>
<th>SWSVV: r=...m</th>
<th>150m</th>
<th>250m</th>
<th>500m</th>
<th>750m</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWSVV = 0</td>
<td>93.80%</td>
<td>85.30%</td>
<td>69.50%</td>
<td>57.70%</td>
</tr>
<tr>
<td>SWSVV &gt; 0</td>
<td>6.20%</td>
<td>14.70%</td>
<td>30.50%</td>
<td>42.30%</td>
</tr>
</tbody>
</table>

Method

The effect of structurally vacant offices on the rent levels of nearby offices is determined using the hedonic pricing method. In the Dutch context, the method was recently used to measure the value of the office working environment, image-effects and sustainability (2009 Koppels, Weterings, 2009, Kok 2011).

The hedonic pricing method is applied using actual rents (rental transactions), in order to identify the implicit price influence of individual building- and location-characteristics. The hedonic equation for this study has the following formula:

\[
\ln R_i = \beta_0 + \sum_{k=1}^{2} \beta_k \times X_i + \beta \times RGWSLV_i + \alpha_i + \delta_i + \epsilon_i
\]

in which the index i denotes a building from the sample (124 buildings), and the index t refers to the year of the transaction (2003-2007). The \( \beta \)'s are the implicit prices of building- and location-characteristics, \( X_i \). The dependent variable, the transaction rent per m², and the continuous independent variables are in this model logarithmically transformed. This simplifies the interpretation; the coefficients can be interpreted as price elasticity. The variables on the right side of the equation are the operationalized variables describing the location and building. The coefficients - the implicit rent prices of the attributes - are in the model logarithmically transformed. This simplifies the interpretation; the coefficients can be interpreted as price elasticity. The variables on the right side of the equation are the operationalized variables describing the location and building. The coefficients - the implicit rent prices of the attributes - are in the model statistically determined by maximum likelihood. Besides this cross-sectional dimension the dataset used requires that the time dimension is specified. The time dimension is important because the sample includes several years (2003-2007) making an adjustment for market conditions desirable. Traditionally, this is often done in hedonic price analysis by incorporating dummy variables for the total number of years considered, minus 1 period. For this study, a random effects specification was used for the economic trend, \( \delta_i \).

The term \( \alpha_i \) represents the random building-effect - a building-specific constant term - and corrects for missing building- and location-characteristics. In hedonic pricing models for real estate it is not so much a question whether the model is misspecified – because variables that affect the price are missing - but whether despite this incomplete specification reliable parameters (coefficients) can still be estimated.

Results

The analyses (Table 5) show that the base model corrects well for the economic trend and the time-independent spatial dimension of the data. As expected, only a small fraction of the price variance appears to be related to economic trend. None of the estimated trend-coefficients are significantly different from zero. The short analysis-period and relatively constant market conditions contribute to this. Although only a small fraction of the price-variance appears to be related to economic trends, according to a "likelihood ratio" test a model with a random effects specification for economic trends explains more price-variance than a model without this specification. From a spatial analysis of the residues of the basic
model, no spatial autocorrelation is found (Global Moran's I) and no clear "hot" or "cold" spots can be observed (Local Moran's I). This implies that the specified model corrects well for spatial relations. The results of the various specifications show a changing pattern (Table 4).

### Table 4: Comparison SWSVV Specifications

<table>
<thead>
<tr>
<th>Type SWSVV</th>
<th>Spatial relationship</th>
<th>Max. distance</th>
<th>Office density</th>
<th>Base model + SWSVV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specification 1</td>
<td>Constant</td>
<td>250</td>
<td>No</td>
<td>-0.004 0.018 0.831</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>500</td>
<td>No</td>
<td>-0.016 0.009 0.078</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>750</td>
<td>No</td>
<td>-0.004 0.007 0.588</td>
</tr>
<tr>
<td>Specification 2</td>
<td>Constant</td>
<td>250</td>
<td>Yes</td>
<td>0.007 0.128 0.960</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>500</td>
<td>Yes</td>
<td>-0.210 0.196 0.286</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>750</td>
<td>Yes</td>
<td>-0.093 0.351 0.791</td>
</tr>
<tr>
<td>Specification 3</td>
<td>Linear</td>
<td>250</td>
<td>No</td>
<td>0.151 2.017 0.941</td>
</tr>
<tr>
<td></td>
<td>Linear</td>
<td>500</td>
<td>No</td>
<td>-1.538 1.801 0.394</td>
</tr>
<tr>
<td></td>
<td>Linear</td>
<td>750</td>
<td>No</td>
<td>-0.794 1.743 0.649</td>
</tr>
<tr>
<td>Specification 4</td>
<td>Linear</td>
<td>250</td>
<td>Yes</td>
<td>-0.006 0.107 0.954</td>
</tr>
<tr>
<td></td>
<td>Linear</td>
<td>500</td>
<td>Yes</td>
<td>-0.107 0.189 0.573</td>
</tr>
<tr>
<td></td>
<td>Linear</td>
<td>750</td>
<td>Yes</td>
<td>-0.090 0.245 0.713</td>
</tr>
</tbody>
</table>

Though in general the observed coefficients are negative as expected, only one of the specified SWSVV variables is significant at a liberal significance norm of 92%. This variable assumes a maximum radius of 500m, a constant distance relationship and is independent of the office density. It is striking that for all four specifications the partial specifications that assume a maximum radius of 500m perform best in terms of significance and according to the AIC. The short maximum distance of the impact probably also partly explains the detected constant distance-relationship: a constant distance-relationship is more realistic for short distances than for long ones. Possibly the effect is characterised by a "zone of indifference" where the weighting is constant at short distances and then starts to rapidly decrease. The detected relatively good performance of the inverse distance-relationship provides an indication for this (specification 3, r = 500m). The current specified relationship possibly assumes a too rapid decline with distance. Weighting scheme that take account of the urban structure and physical barriers (e.g. highways) might provide a further way to enhance the spatial weighting scheme. Table 5 shows the results of the basic model compared to the extended model. Here the first specification with a radius of 500m is used. The interpretation of this coefficient is simple: an increase of 10,000 m² of structural vacancy within 500m leads to a price reduction of 1.6%.
Adding the SWSVV to the model explains relatively little additional price-variance, but the variable is significant and demonstrates the expected relationship: an increase of structural vacancy leads to a reduction in rents of nearby offices. The question remains whether the variable is actually measuring what we think we are measuring - the negative externalities of structural vacancy - or that another unknown effect is measured. The SWSVV shows sufficient variance within one year so that the economic trend-effect can be well separated from the assumed negative externalities. Furthermore, the specified random building-effects corrects for the not included but relevant building- and location-characteristics. However, on average only two transactions per office building were known and could be used to estimate this effect. The specified random building-effects therefore probably includes some of the negative externalities and other specified consequences. The reported coefficients and significance levels may
therefore be regarded as conservative estimates. The model performance improves by the addition of the SWSVV, and this improvement is significant at a 94% norm.

To get a good impression of the potential impact of structural vacancy on the rent, based on the estimated model the following example shows the calculated rent-level in two different situations in 2007. The adopted values of the variables are typical of a relatively "low grade" office building located in Amsterdam South East (Paalbergweg, Paasheuvelweg, ...).

Table 6: Building- and location-type of a fictional building in Amsterdam Southeast (Paalbergweg, Paasheuvelweg, ...)

<table>
<thead>
<tr>
<th>Location- and building characteristics</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building age</td>
<td>5 years</td>
</tr>
<tr>
<td>Travel time to highway entry/exit</td>
<td>1.7 minutes</td>
</tr>
<tr>
<td>Intercity train station location</td>
<td>No</td>
</tr>
<tr>
<td>Distance metro/tram stop</td>
<td>600 meter</td>
</tr>
<tr>
<td>Number of amenities</td>
<td>None</td>
</tr>
<tr>
<td>Employment industry &amp; logistics</td>
<td>800 jobs</td>
</tr>
<tr>
<td>Employment financial &amp; business services</td>
<td>2400 jobs</td>
</tr>
<tr>
<td>Parking ratio (1:LFA)</td>
<td>1 pp. per 50m2 LFA</td>
</tr>
<tr>
<td>Covered deck parking</td>
<td>No</td>
</tr>
<tr>
<td>Façade material</td>
<td>Composite/bricks</td>
</tr>
<tr>
<td>Company logo</td>
<td>Yes</td>
</tr>
<tr>
<td>Entrance surface %</td>
<td>1%</td>
</tr>
</tbody>
</table>

Table 7: Predicted rent-levels Amsterdam Southeast (Paalbergweg, Paasheuvelweg, etc.)

<table>
<thead>
<tr>
<th>Structural vacancy (m2)</th>
<th>Rent price (euro's per m2)</th>
<th>Percentage change compared to no structural vacancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>142.97</td>
<td>n.v.t.</td>
</tr>
<tr>
<td>10000</td>
<td>140.70</td>
<td>1.59%</td>
</tr>
<tr>
<td>20000</td>
<td>138.46</td>
<td>3.15%</td>
</tr>
<tr>
<td>30000</td>
<td>136.26</td>
<td>4.69%</td>
</tr>
<tr>
<td>40000</td>
<td>134.10</td>
<td>6.20%</td>
</tr>
<tr>
<td>50000</td>
<td>131.97</td>
<td>7.69%</td>
</tr>
</tbody>
</table>

**Conclusion**

The vacancy problem lately gets much attention in the Netherlands: from market parties, research institutes / universities and national and local politicians. All parties seem aware of the need of solving this problem, but there's a tendency of pointing the finger at each other. This study delivers quantitative evidence that not only the owners of structurally vacant office buildings suffer financially, but also the owners of nearby (yet) leased buildings: An increase of structural vacancy with 10.000m2 leads to a decrease of 1.6% of the rent-level within a radius of 500m. Possibly, this creates a negative spiral in which a location is becoming less attractive as office accommodation. The neighbour's problem becomes everybody's problem.

The revealed constant distance-relationship with a maximum distance of 500m is intuitively and theoretically easy to explain, but so is a decreasing distance-relationship too. Analyses that apply (spatial) weighting are conditional to the weighting matrix used, as is demonstrated in this study. By analysing the different specifications, it became clear that the effect of structural vacancy is limited to approximately
500m. The results give rise to further research about the exact spatial process. Possibly the effect is characterised by a "zone of indifference" where the weighting is constant at short distances and then rapidly decreases.

**Bibliography**


