THE EFFECT OF MARKET EXPECTATIONS ON HOUSE PRICES: A SPATIO-TEMPORAL MODELLING APPROACH
Presentation outline

- Introduction
  - General question/topic
  - Advances in the literature

- Research context
  - Conceptual issues / spatial data pooled over time.
  - Decomposition of the (spatial) effects through weights matrix

- Hedonic price model
  - Isolating the spatial (spillover, dynamic and anticipation) effects.

- Empirical application
  - Data, Estimation process, Discussion.

- Conclusion;
Introduction

- **Spatial spillover effect and HP model:**
  - Spatial autocorrelation is a matter of concern in empirical application:
    - Introduces bias on estimated coefficients, or
    - Introduces imprecision of the estimated variance.
  - Correction can be based on spatial econometric models:
- It is almost impossible, by now, to ignore the problem of spatial dependence among residuals (Anselin, 2007).
- **Real estate transactions → spatio-temporal data:**
  - One transaction → specific location at a distinct moment in time
    - Neither cross-sectional nor panel data
  - Essential in numerous fields
Advances in the Literature

Many studies ignore the temporal dimension in HP

- Bateman et al., 2004; Theebe, 2004; Day et al., 2007; Hui et al., 2007; Salvi, 2008; Cohen and Coughlin, 2008; Dekkers and Van der Straaten, 2009; Chalermpong, 2010; Conway et al., 2010; Andersson et al., 2010.

Recent advances:

- The development of adapted methods to correctly address the spatial dimension for spatial data pooled over time
  - Smith and Wu, 2009; Huang et al., 2010; Dubé et al., 2011; Thanos et al., 2012; Dubé and Legros, 2013a, 2013b.

- Temporal dimension can provide some additional information, such as:
  - Spatial multidirectional effect for the same time period (Dubé and Legros, 2013a)
  - Spatial dynamic effect relate to the previous time period (Thanos et al., 2012; Dubé and Legros, 2012, 2013b)
Conceptual Issues

- Ignoring the temporal dimension (cross-sectional assumption):
  - Previous house sales are taken to affect current house prices, but so do future house sales.

- However
  - Arrow of time (unidirectional relation): information does not travel backwards in time.
  - Theoretical impossibility of future prices affecting current/past prices.

- Possible effects:
  - Overestimation of spatial dependence (Dubé and Legros, 2013a) and over connection bias (Smith, 2009).
Spatial vs Spatio-temporal data

Legend:
- Future observations (period $r+q$)
- Present observations (period $r$)
- Past observation ($r-p$)

First law of geography (Tobler, 1970):
“Everything is related to everything else, but closer things more so”.

\[ d_{ij} = \sqrt{(X_i - X_j)^2 + (Y_i - Y_j)^2} = d_{ji} \]

\[ s_{ij} = f(d_{ij}) \]

If time is not accounted for:
Future observations are taken to influence current and past observations.
Pooled spatial data layers

Legend:
- **Future observations (period \(r+q\))**
- **Present observations (period \(r\))**
- **Past observation (\(r-p\))**

General notation

\[ N_r \] Number of observations in period \(r\)

\[ N_T = \sum_{r=1}^{R} N_r \] The total number of observations in simply the sum of the number of observations in each time period

\( r = 1, 2, \ldots, R \) Time periods

\( r; p; q \) Time indices

\[ N_1 \neq N_2 \neq \ldots \neq N_R \] Number of observations is different in each time period
(Spatial) effects within the same period

Legend:
- Future observations (period $r+q$)
- Present observations (period $r$)
- Past observation ($r-p$)

Spatial relations for the dependent variable:
The temporal dimension is unidirectional: the spatio-temporal relations should take it into account.

Incorporate constraints on spatial relations:
- Multidirectional relations is possible only for the same time period.

This is the real spatial spillover effect.
(Spatio-temporal) effects over time

- Dynamic effect on the dependent variable:
  Sale price occurring in the surrounding one period before can affect price determination process.

- Spatial unidirectional relation:
  Past observations can affect actual price determination, but the inverse is impossible.

- Spatio-temporal relations:
  \[ w_{ij} = s_{ij} \times t_{ij} \]

Legend:
- Future observations (period \( r+q \))
- Actual observations (period \( r \))
- Previous observation (\( r-p \))

Possible spurious relations
Over-connexion bias (Smith, 2009)
(Spatio-temporal) effects over time?

What about anticipation affecting house prices?

Anticipation effect of future prices \((r+q)\) on current \((r)\) observations. Future prices as a good proxy?

However, expectations/anticipation are based only on current/past information, NOT information travelling back in time.

**Intuition:**
Is the effect of anticipation (asking price) internalize in house prices?

**Question:**
How can we capture anticipation effects, without disregarding the arrow of time?
Research context

- **Research question:**
  - Is there an anticipation effect of future price movements that can influence current houses prices?
    - Accounting for the decomposition of the spatial effect.

- **Quantitative feature/requirement:**
  - Need to test for a (short-run) market expectations effect:
    - the degree to which the expectations of sellers and market intermediaries (e.g. agents, lawyers, and surveyors) affect the final house price.
  - Measure the information effect on potential house buyers from **asking price** setting in the market?
    - Use of spatio-temporal data to exploit information from both spatial and temporal dimensions.
Decomposing the effects

Weights matrix structure (dependent variable)

The square spatio-temporal weights matrix can be obtained through the creation of a spatial weights matrix and a temporal weights matrix.

\[
W = S \otimes T
\]

Express the spatial links between the observations collected in period \( r \)

Express the spatial links between the observations in period \( r \) and those collected in period \( r-p \) (define only for \( p > 0 \)) penalized by a factor \( (\kappa_{r-r-p}) \) accounting for the “temporal” distance.

Express the spatial links between the observations in period \( r+q \) and those collected in period \( r \) (define only for \( q > 0 \)) penalized by a factor \( (\kappa_{r+r+q}) \) accounting for the “temporal” distance. However, the negative temporal distance between future and present/past observations is problematic.
Asking price, not time-machine

- Thanos and White (2013) noted that the asking prices setting is influenced by the expectations of sellers with regard to future price movements.

- We develop a temporal weights matrix $T^*$, based on the date a house is put on the market ($\tau^*_i$):
  - the temporal distance between the time/period house $i$ was put on the market and the time house $j$ was put on the market.

$$t^*_{ij} = \tau^*_i - \tau^*_j \quad \forall i, j$$

- This takes positive values when house $i$ is put on the market before house $j$.

- This way we can include weights in the upper triangle of the weights matrix if $t^*_{ij}$ is positive, while $t^*_{ij}$ is negative.
Decomposing the effects

- **Weights matrix structure (dependent variable)**

\[
W = \begin{pmatrix}
W_{11} & W_{12} & W_{13} & \cdots & W_{1R} \\
W_{21} & W_{22} & W_{23} & \cdots & W_{2R} \\
W_{31} & W_{32} & W_{33} & \cdots & W_{3R} \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
W_{R1} & W_{R2} & W_{R3} & \cdots & W_{RR}
\end{pmatrix}
\]

- **An upper triangular block component:**
  - Anticipation effects of future observations/prices $(r+q)$ on current $(r)$ and past $(r-p)$ observations.
  - Our asking price specification forgoes the negative sign of temporal distance.
  - Hence, we can capture the **anticipation** effect without bending the laws of physics.

- **A lower triangular block component:**
  - Control for unidirectional spatial relations.
  - Isolate the **dynamic** effect of past realizations $(r-p)$ on actual $(r)$ realizations.

- **A spatial block-diagonal component:**
  - Control for multidirectional spatial (spillover) effect among observations in a given time period.

**Possibility of isolating different effects**
- Effects can be obtained through a decomposition of the $W$ weights matrix.
- Eliminating the bias related to over-connexion of the weights matrix (Smith, 2009).
Hedonic pricing (HP) models

- **Typical HP model:**
  \[ y_{ir} = \delta D_{ir} + \beta Z_{ir} + \epsilon_{ir} \]
  
  Where:
  - \( y_{ir} \): Nominal sale price (in euros) of house \( i \) in time \( r \)
  - \( D_{ir} \): Matrix of dummy variables indicating the period (\( r \)) of sale
  - \( Z_{ir} \): Matrix of the descriptors (\( k \)) of the house \( i \) at time \( r \)

- A Spatial autoregressive HP model
  \[ y_{ir} = \rho S y_{ir} + \delta D_{ir} + \beta Z_{ir} + \epsilon_{ir} \]
  
  Where
  - \( S \): is a general spatial weights matrices for the same time period
Our Spatiotemporal HP Approach

- The dynamic spatial HP:

\[ y_{ir} = \psi W y_{ir-p} + \rho S y_{ir} + \delta D_{ir} + \beta Z_{ir} + \varepsilon_{ir} \]

- The dynamic spatial HP with anticipation effect:

\[ y_{ir} = \psi W y_{ir-p} + \theta W y^*_{ir+q} + \rho S y_{ir} + \delta D_{ir} + \beta Z_{ir} + \varepsilon_{ir} \]

- Where

  \( y^*_{ir+q} \) The asking price, in period \( r \), of a house \( i \) sold in \( r+q \)

- And the parameters of interest are:

  \( \rho \) Spatial spillover effect of price determination process

  \( \psi \) The dynamic effect of price determination process

  \( \theta \) The anticipation effect of price determination process
Data

- Aberdeen, Scotland:
  - Transactions (nominal sale price) occurring between 2004 and 2007.
    - 18,758 observations, but leaves 18,283 observations for estimation
  - Total of 47 descriptors (independent variables).
    - 19 intrinsic amenities.
      - Number of rooms, floor, detached house, garage, garden, ...
    - 13 extrinsic amenities.
      - Distance to airport, distance to train station, socio-economic status of the neighbourhood, ...
    - 15 temporal variables (price evolution).
      - Controlling for quarter variation.
Data

Total number of transactions according to the time period

Number of transactions

Time periods
Data

Evolution of the mean price of houses, Aberdeen (Scotland), 2004-2007

- 2004: 90,000
- 2005: 110,000
- 2006: 130,000
- 2007: 150,000

Prices in nominal £
Estimation process

- Two important considerations:
  - The underdiagonal spatio-temporal weights matrix contains $N_1$ elements set to zero
    - The first period(s) cannot be used since $y_{ir-p}$ is not defined.
  - The overdiagonal spatio-temporal weights matrix contains $N_R$ elements set to zero
    - The last period cannot be used since $y_{ir+q}^*$ is not defined.

- Total sample size:
  - Eliminate some time periods (Cochrane-Orcutt).
    - Total sample: $N_{T^*} = N_T - (N_1 + N_2 + N_R)$
### Results (1)

<table>
<thead>
<tr>
<th></th>
<th><strong>OLS Estimation method</strong></th>
<th><strong>SAR Estimation method</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HPM</td>
<td>Dynamic HPM</td>
</tr>
<tr>
<td></td>
<td>Coeff.  t-stat</td>
<td>Coeff.  t-stat</td>
</tr>
<tr>
<td><strong>Constant</strong></td>
<td>11,5006 841.50</td>
<td>11,0857 31.15</td>
</tr>
<tr>
<td><strong>Distance to airport in kilometres</strong></td>
<td>0.0140 15.78</td>
<td>0.0140 15.78</td>
</tr>
<tr>
<td><strong>Distance to central train station (km)</strong></td>
<td>-0.0365 -35.08</td>
<td>-0.0364 -35.07</td>
</tr>
<tr>
<td><strong>Detached houses</strong></td>
<td>0.1132 9.76</td>
<td>0.1131 9.75</td>
</tr>
<tr>
<td><strong>Terraced or semi-detached house</strong></td>
<td>0.0250 2.92</td>
<td>0.0249 2.91</td>
</tr>
<tr>
<td><strong>Main floor flat</strong></td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td><strong>2nd floor flat</strong></td>
<td>0.0074 0.81</td>
<td>0.0073 0.80</td>
</tr>
<tr>
<td><strong>3rd floor flat</strong></td>
<td>0.0776 2.83</td>
<td>0.0778 2.84</td>
</tr>
<tr>
<td><strong>4th floor flat or higher</strong></td>
<td>0.1652 3.43</td>
<td>0.1658 3.44</td>
</tr>
<tr>
<td><strong>Missing information on the floor #</strong></td>
<td>-0.0315 -5.86</td>
<td>-0.0315 -5.86</td>
</tr>
<tr>
<td><strong>Houses with 1 bedrooms</strong></td>
<td>-0.5102 -70.87</td>
<td>-0.5102 -70.87</td>
</tr>
<tr>
<td><strong>Houses with 2 bedrooms</strong></td>
<td>-0.1526 -25.32</td>
<td>-0.1526 -25.32</td>
</tr>
<tr>
<td><strong>Houses with 3 bedrooms</strong></td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td><strong>Houses with 4 bedrooms</strong></td>
<td>0.2064 21.80</td>
<td>0.2066 21.82</td>
</tr>
<tr>
<td><strong>Houses with 5 bedrooms</strong></td>
<td>0.4033 25.67</td>
<td>0.4034 25.68</td>
</tr>
<tr>
<td><strong>Houses with 6 bedrooms or more</strong></td>
<td>0.6394 25.88</td>
<td>0.6395 25.89</td>
</tr>
<tr>
<td><strong>Missing bedroom number</strong></td>
<td>-0.8332 -42.30</td>
<td>-0.8333 -42.30</td>
</tr>
<tr>
<td><strong>3 or more public rooms</strong></td>
<td>0.2697 31.43</td>
<td>0.2697 31.43</td>
</tr>
<tr>
<td><strong>2 or more bathrooms</strong></td>
<td>0.1530 12.71</td>
<td>0.1528 12.70</td>
</tr>
<tr>
<td><strong>House with garage(s)</strong></td>
<td>0.2041 31.71</td>
<td>0.2040 31.70</td>
</tr>
<tr>
<td><strong>House with gas central heating</strong></td>
<td>0.1286 24.67</td>
<td>0.1285 24.66</td>
</tr>
<tr>
<td><strong>House with garden</strong></td>
<td>0.0257 4.33</td>
<td>0.0258 4.34</td>
</tr>
<tr>
<td><strong>&gt; 50% detached houses</strong></td>
<td>-0.0217 -1.64</td>
<td>-0.0216 -1.63</td>
</tr>
<tr>
<td></td>
<td>OLS Estimation method</td>
<td></td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>-----------------------</td>
<td>------------------</td>
</tr>
<tr>
<td></td>
<td>HPM</td>
<td>Dynamic HPM</td>
</tr>
<tr>
<td></td>
<td>Coeff.</td>
<td>t-stat</td>
</tr>
<tr>
<td>asterisk</td>
<td>HPM</td>
<td>Dynamic HPM</td>
</tr>
<tr>
<td></td>
<td>Coeff.</td>
<td>t-stat</td>
</tr>
<tr>
<td>&gt; 50% terraced or semi-detached houses</td>
<td>-0.0464 -6.33</td>
<td>-0.0465 -6.33</td>
</tr>
<tr>
<td>Not dominated from a specific house type</td>
<td>0.0639 7.04</td>
<td>0.0639 7.04</td>
</tr>
<tr>
<td>&gt; 50% of social rented houses</td>
<td>-0.1955 -23.13</td>
<td>-0.1955 -23.14</td>
</tr>
<tr>
<td>&gt; 50% of privately rented houses</td>
<td>-0.0907 -6.13</td>
<td>-0.0905 -6.12</td>
</tr>
<tr>
<td>&gt; 20% of vacant household spaces</td>
<td>-0.0213 -2.44</td>
<td>-0.0214 -2.44</td>
</tr>
<tr>
<td>&gt; 40% of the population over 60</td>
<td>0.1044 10.94</td>
<td>0.1043 10.93</td>
</tr>
<tr>
<td>&gt; 60% of one person households</td>
<td>-0.0178 -3.00</td>
<td>-0.0178 -2.99</td>
</tr>
<tr>
<td>&gt; 50% of the hh owning 2 or + cars</td>
<td>0.2192 21.15</td>
<td>0.2192 21.15</td>
</tr>
<tr>
<td>&gt; 50% of the hh owning no car</td>
<td>-0.1605 -25.58</td>
<td>-0.1604 -25.58</td>
</tr>
<tr>
<td>Dwelling density</td>
<td>-0.0008 -16.50</td>
<td>-0.0008 -16.50</td>
</tr>
<tr>
<td>2004 - Q2</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td>2004 - Q3</td>
<td>-0.0344 -3.44</td>
<td>-0.0355 -3.54</td>
</tr>
<tr>
<td>2004 - Q4</td>
<td>-0.0381 -3.68</td>
<td>-0.0386 -3.73</td>
</tr>
<tr>
<td>2005 - Q1</td>
<td>0.0244 2.28</td>
<td>0.0227 2.09</td>
</tr>
<tr>
<td>2005 - Q2</td>
<td>0.0968 9.69</td>
<td>0.0905 7.99</td>
</tr>
<tr>
<td>2005 - Q3</td>
<td>0.0989 9.85</td>
<td>0.0928 8.20</td>
</tr>
<tr>
<td>2005 - Q4</td>
<td>0.1241 12.13</td>
<td>0.1178 10.19</td>
</tr>
<tr>
<td>2006 - Q1</td>
<td>0.2095 18.88</td>
<td>0.2021 15.85</td>
</tr>
<tr>
<td>2006 - Q2</td>
<td>0.2995 30.25</td>
<td>0.2883 20.93</td>
</tr>
<tr>
<td>2006 - Q3</td>
<td>0.3604 37.12</td>
<td>0.3465 22.58</td>
</tr>
<tr>
<td>2006 - Q4</td>
<td>0.3971 38.55</td>
<td>0.3832 24.32</td>
</tr>
<tr>
<td></td>
<td>OLS Estimation method</td>
<td>SAR Estimation method</td>
</tr>
<tr>
<td>------------------</td>
<td>------------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td></td>
<td>HPM</td>
<td>Dynamic HPM</td>
</tr>
<tr>
<td></td>
<td>Coeff.  t-stat</td>
<td>Coeff.  t-stat</td>
</tr>
<tr>
<td>2007 - Q1</td>
<td>0.5414 49.84</td>
<td>0.5241 28.45</td>
</tr>
<tr>
<td></td>
<td>0.3969 37.08</td>
<td>0.3781 31.56</td>
</tr>
<tr>
<td>2007 - Q2</td>
<td>0.6416 66.18</td>
<td>0.6195 29.05</td>
</tr>
<tr>
<td></td>
<td>0.4552 48.93</td>
<td>0.4312 36.86</td>
</tr>
<tr>
<td>2007 - Q3</td>
<td>0.6164 63.97</td>
<td>0.5934 27.00</td>
</tr>
<tr>
<td></td>
<td>0.4392 47.25</td>
<td>0.4141 37.55</td>
</tr>
<tr>
<td>2007 - Q4</td>
<td>0.5854 53.23</td>
<td>0.5629 25.35</td>
</tr>
<tr>
<td></td>
<td>0.4147 38.66</td>
<td>0.3902 32.27</td>
</tr>
<tr>
<td>Dynamic Effect</td>
<td>0.0360 1.17</td>
<td>0.0392 1.27</td>
</tr>
<tr>
<td>Anticipation Effect</td>
<td>0.1203 5.07</td>
<td></td>
</tr>
<tr>
<td>ρ</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Moran's I</td>
<td>0.0958 12.90</td>
<td>0.0950 12.95</td>
</tr>
<tr>
<td>R²</td>
<td>0.7891</td>
<td>0.7891</td>
</tr>
<tr>
<td>R² - bar</td>
<td>0.7886</td>
<td>0.7886</td>
</tr>
<tr>
<td>N</td>
<td>18283</td>
<td>18283</td>
</tr>
</tbody>
</table>
Conclusions

- We are not using future prices as a proxy for the anticipation of future prices at the present time
  - contravening the laws of physics
- We specify a methodological framework that takes into account both spatial and temporal distance.

The novelty and significance of this research is underlined by:

- Finding significant spatial spillover effects within the same period and from previous periods (dynamic effect)
- Demonstrating (for the first time in spatial HP literature) that market expectations, captured in asking price setting, significantly affect the sale prices.
- Our methodology is applicable to other countries and markets:
  - A significant anticipation coefficient would underline the recent housing “bubble” phenomena in many markets including the US).
- Our methodological framework is applicable to all economic research fields that employ spatiotemporal data
  - Such as Innovation, business starts, crime, real-estate, non-market valuation
Acknowledgement

Fonds de recherche du Québec

Conseil de recherches en sciences humaines du Canada

Social Sciences and Humanities Research Council of Canada

Laboratoire d’économie et de gestion

UNIVERSITÉ DE BOURGOGNE & CNRS UMR 5118