Integration of Funding and Market Liquidity in Real Estate: International Evidence

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Idea and contribution

- Regional private real estate markets move in tandem
- This holds for returns as many studies show
- But to what extent does this apply to liquidity?
- And is the integration stronger or weaker?
- And are there differences across asset classes and countries?
Idea and contribution

• We estimate investor demand and supply indexes for eight different asset-country combinations (Van Dijk, Geltner, and van de Minne, 2018)
• We compare the degree of integration of both returns and market liquidity for different countries and asset classes
• We examine one particular driver behind this commonality: funding liquidity
• Prices are determined by both space and capital markets and liquidity more by capital markets (which are more integrated than space markets)
• Implications for aggregate portfolio liquidity risk and policy regarding capital markets
Main findings

• Market liquidity within a country and asset class shows strong co-movements
• Market liquidity shows stronger commonalities than returns in almost all markets
• Reservation prices lie closer together in residential markets than in commercial markets
• Residential markets are more integrated
• Funding liquidity is an important driver of the commonality in market liquidity
Reservation prices and liquidity: normal market

Reservation Prices

Normal market

Demand

Supply

\( P_0 \)

Reservation Prices
Reservation prices and liquidity: booming market
Reservation prices and liquidity: crashing market

![Diagram showing the relationship between bust and reservation prices. The diagram illustrates the concept that as prices change (P₀, P₁, P₂), the market experiences a 'bust' event. The graph highlights the area where prices converge, indicating a critical point in the market's lifecycle.]
Econometric strategy

- Estimate supply and demand indexes for regional commercial and residential real estate markets in the US, UK, and The Netherlands (Van Dijk et al., 2018), model here.
- Calculate midpoint prices and liquidity metrics:

\[
\beta_t = \frac{\beta_t^b + \beta_t^s}{2} \quad (1)
\]

\[
Liq_t = \frac{\beta_t^b - \beta_t^s}{\beta_t} \quad (2)
\]
dvandijk.shinyapps.io/AppLiqInt_HH2019/
Econometric strategy

- Measure integration of prices and liquidity based on two measures: “$R^2$”-measures and PCA
- PCAs are estimated for each country-asset combination, degree of integration is determined the explanatory power of the first factor
- $R^2$ measures are calculated as follows: (Roll, 1988; Morck et al., 2000; Karolyi et al., 2012)

\[
\begin{align*}
    r_{i,t} &= \alpha_i^{Ret} + r_{m,t} \beta_i^{Ret} + \varepsilon_{i,t} \\
    Liq_{i,t} &= a_i^{Liq} Liq_{i,t-1} + D_\tau + \omega_{i,t}^{Liq} \\
    \hat{\omega}_{i,t}^{Liq} &= \alpha_i^{Liq} + \sum_{j=-1}^{1} \hat{\omega}_{m,t+j}^{Liq} \beta_{i,j}^{Liq} + \varepsilon_{i,t}^{Liq}
\end{align*}
\]
Data

- Indexes are estimated for 8 CRE markets in the US (RCA), 7 CRE and RES markets in the UK (RCA/HMLR), and 4 CRE and RES markets in NL (RCA/Kadaster)
- In total more than 110K and 22MLN RES transactions
- Assumption of model is that whole property universe is observed (capture rate RCA 2000–2018 > 90%, capture rates RES ≈ 100%)
- Data on (national) credit conditions from Fed SLOOS, BoE CCS, ECB BLS
US CRE liquidity commonality
US CRE price commonality

- Prices seem less correlated across MSAs
Degree of integration ($R^2$)

- Returns show less commonality than changes in liquidity
- RES markets more integrated than CRE markets
Degree of integration (PCA)

- US CRE: 40%
- UK CRE: 50%
- NL CRE: 60%
- UK RES: 90%
- NL RES: 90%

- Returns
- Market Liquidity differences

- Similar results
US CRE market liquidity and credit conditions of US CRE loans

![Graph showing US CRE market liquidity and credit conditions](image-url)
Funding liquidity and market liquidity in VARs (1/4)

- Market liquidity responds negatively to a shock in funding liquidity
- Based on VAR with $\Delta CC$ and $CF_{\Delta Liq}$
Funding liquidity and market liquidity in VARs (2/4)

- Also in UK commercial
Funding liquidity and market liquidity in VARs (3/4)

- And in UK commercial
Funding liquidity and market liquidity in VARs (4/4)

- And (a bit) in Dutch residential
Conclusions

- We examine co-movements in residential and commercial real estate returns and market liquidity across the world.
- Market liquidity co-moves stronger than real returns.
- Residential markets are stronger integrated than commercial markets.
- Buyers in RES are more similar (and usually simultaneously buyer and seller) and thus reservation prices are closer to each other.
- Funding liquidity drives market liquidity in both commercial and residential markets.


Reservation price model (short)

- Adapt Heckman selection model for repeat sales developed by (Gatzlaff and Haurin, 1997)
- Estimate probability of sale:

  \[ S_{i,t}^* = \gamma_t + X_i \omega + \eta_{i,t}, \quad \eta_{i,t} \sim N(0, 1). \]
  \[ = Pr(S_{i,t} = 1|X_i) = \Phi(\gamma_t + X_i \omega) \]

- Estimate the repeat sales model:

  \[ P_{i,t} - P_{i,s} = \beta_t - \beta_s + \sigma_{\varepsilon,\eta}(\lambda_2 - \lambda_1) + \nu_i, \quad \nu_i \sim N(0, \sigma_v^2) \]
  \[ \Delta \beta_t = \rho \Delta \beta_{t-1} + \xi_t, \quad \xi_t \sim N(0, \frac{\sigma^2_\xi}{1 - \rho^2}). \]

- \( \lambda \) are the "inverse Mills Ratios" from the probit

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Reservation price model (short)

- Combine probit and RS results to obtain investor demand/supply indices (FGGH):

\[
\hat{\beta}_t^b = \hat{\beta}_t + \frac{1}{2} \hat{\sigma} \hat{\gamma}_t
\]

\[
\hat{\beta}_t^s = \hat{\beta}_t - \frac{1}{2} \hat{\sigma} \hat{\gamma}_t
\]

- Identification of \( \hat{\sigma} \) makes uses of the fact that residuals of repeat sales model are equivalent to residuals of hedonic model with pair fixed effects

- Identification of \( \lambda \) requires no correlation error terms of the first selection (sale) equation and the second sale (selection) and correlation between the first sale and first selection=correlation of the second sale and second selection

- Complete model [here](#).

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Reservation price model (long)

Starting point are the reservation prices:

\[ R_{p_i,t}^b = \beta^b_t + X_i\alpha^b + \varepsilon^b_{i,t}, \]

\[ R_{p_i,t}^s = \beta^s_t + X_i\alpha^s + \varepsilon^s_{i,t}. \]

Normal hedonic model estimates the following:

\[ E(P_{i,t}) = \frac{1}{2}(\beta^b_t + \beta^s_t) + \frac{1}{2}X_i(\alpha^b + \alpha^s) + \frac{1}{2}E((\varepsilon^b_{i,t} + \varepsilon^s_{i,t})|R_{p_i,t}^b \geq R_{p_i,t}^s), \]

\[ E(P_{i,t}) = \beta_t + X_i\alpha + E(\varepsilon_{i,t}|R_{p_i,t}^b \geq R_{p_i,t}^s). \]

We observe \( S_{i,t} = 1 \) if a transaction is consummated:

\[ S_{i,t}^* = R_{p_i,t}^b - R_{p_i,t}^s = (\beta^b_t - \beta^s_t) + X_i(\alpha^b - \alpha^s) + (\varepsilon^b_{i,t} - \varepsilon^s_{i,t}). \]

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Estimate the following probit:

\[ S_{i,t}^* = \gamma_t + X_i \omega + \eta_{i,t}, \quad \eta_{i,t} \sim N(0, 1). \]

\[ = \Pr(S_{i,t} = 1|X_i) = \Phi(\gamma_t + X_i \omega), \]

The coefficients are estimated up to scale factor \( \sigma \):

\[ \hat{\gamma} = \gamma / \sigma = (\beta^b_t - \beta^s_t) / \sigma, \]

\[ \hat{\omega} = \omega / \sigma = (\alpha^b_s - \alpha^s_s) / \sigma. \]

Calculate IMRs and plug these in the two sales equations:

\[ E(P_{i,s}|S_{i,s} = 1) = \beta_s + X_i \alpha + E(\varepsilon_{i,s}|S_{i,s} = 1), \]

\[ = \beta_s + X_i \alpha + \sigma_{1,3} \lambda_1 + \sigma_{2,3} \lambda_2, \]

\[ E(P_{i,t}|S_{i,t} = 1) = \beta_t + X_i \alpha + E(\varepsilon_{i,t}|S_{i,t} = 1), \]

\[ = \beta_t + X_i \alpha + \sigma_{1,4} \lambda_1 + \sigma_{2,4} \lambda_2. \]
This results in the following repeat sales equation:

\[ P_i^t - P_i^s = \beta_t - \beta_s + (\sigma_{1,4} - \sigma_{1,3})\lambda_s + (\sigma_{2,4} - \sigma_{2,3})\lambda_t + \nu_i. \]

We estimate the following restricted version:

\[ P_{i,t} - P_{i,s} = \beta_t - \beta_s + \sigma_{\epsilon,\eta}(\lambda_2 - \lambda_1) + \nu_i, \quad \nu_i \sim N(0, \sigma_\nu^2). \]

The conditional expected variance of the pricing errors \((\epsilon_{i,t}^2)\) is:

\[
E(\epsilon_{i,t}^2 | S_i,t = 1) = \sigma_{\epsilon}^2 - \sigma_{\epsilon,\eta}^2(\gamma_t + X_i \omega)\lambda_{i,t},
\]

where \(\sigma_{\epsilon}^2 = \text{Var}((\epsilon_{i,t}^b + \epsilon_{i,t}^s)/2) = (\sigma_b^2 + \sigma_s^2)/4 = \sigma^2/4.\)

Rewriting yields:

\[
\hat{\sigma}_{\epsilon}^2 = (1/N) \sum_{i=1}^N \left[ \hat{\epsilon}_{i,t}^2 + \hat{\sigma}_{\epsilon,\eta}^2(\hat{\gamma}_t + X_i \hat{\omega})\hat{\lambda}_{i,t} \right],
\]

\[ \hat{\sigma} = 2\hat{\sigma}_{\epsilon}. \]
From the probit we have $\hat{\gamma} = (\hat{\beta}_t^b - \hat{\beta}_t^s)/\hat{\sigma}$, we also have

$$\hat{\beta}_t = \frac{1}{2}(\hat{\beta}_t^b + \hat{\beta}_t^s) \rightarrow \hat{\beta}_t^s = 2\hat{\beta}_t - \hat{\beta}_t^b:$$

$$\hat{\gamma} = (\hat{\beta}_t^b - 2\hat{\beta}_t - \hat{\beta}_t^b)\hat{\sigma},$$

$$\hat{\beta}_t^b = \hat{\beta}_t + \frac{1}{2}\hat{\sigma}\hat{\gamma}_t.$$

Similarly:

$$\hat{\beta}_t^s = \hat{\beta}_t - \frac{1}{2}\hat{\sigma}\hat{\gamma}_t.$$

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Estimation

- Two-step approach (Heckman, 1979)
- Probit is estimation by Maximum Likelihood
- Repeat sales model is estimated in Bayesian framework (Francke, Van de Minne, and White, 2017)
- MCMC methods, NUTS in RStan (Hoffman and Gelman, 2014)
- Chains=4, Iterations per chain=6000, Warmup=3000
Liquidity in Amsterdam residential real estate