What's Wrong with Pittsburgh?

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Abstract

I show how investor composition in the commercial real estate (CRE) market determines how frequently an asset trades and its illiquidity premium. Unlike many other Over-the-Counter (OTC) markets, geography clearly demarcates CRE markets making the interplay between investor composition and liquidity easier to observe. I first document that institutional CRE investors are concentrated in cities with the most liquid CRE. While more liquid cities offer investors lower dividend yields (cap rates) than more illiquid cities, the differences are quite modest. I then calibrate a search model with investor heterogeneity in liquidity preference.

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1 Introduction

As Table 1 shows, institutional commercial real estate (CRE) investors don't find Pittsburgh attractive. While the institutional share of CRE purchases averages 54% across US cities, it is a mere 46% in Pittsburgh. Furthermore, as Figure 1 shows, CRE in Pittsburgh trades less frequently than in almost any other US city. On average, only 2.3% of the stock of CRE in Pittsburgh transacts in a given year while the average turnover across major US cities is 5.5%. More generally, why are institutional investors drawn to some cities and not others? Furthermore, what are the consequences of different investor bases for liquidity?

The goal of this paper is to document and explain key facts about the relationship between investor composition and trade frequency across markets. I start from the observation that some investors trade frequently while others are essentially buy-and-hold investors. Cherkes et al. (2009), Hanson et al. (2015), and Chodorow-Reich et al. (2016) show how these different investment horizons affect portfolio allocation. I build on this insight to understand the implications of investor heterogeneity in liquidity preferences for investor composition, trade frequency, and asset prices across different markets. The key intution is that investors that value liquidity the most, because they trade more frequently or cannot weather short-term fluctuations in asset prices, concentrate their investments in the most liquid markets. Thus, concern for liquidity segments markets by investor. The market segmentation in turn makes the most liquid markets even more liquid because the main asset owners are those that trade relatively more frequently. In essence, liquidity begets liquidity.

In the next section of the paper, I document several key empirical facts about CRE investor composition, dividend yields, and trade frequency consistent with this intuition. In the CRE market, non-institutional investors that play the role of buy-and-hold investors.

Table 1: Average Share of Purchases by Institutional Investors by MSA, 2001-2015

msa	msalabel	instsh_all
DC Metro	DC	65.8
Boston	BOS	65.0
Baltimore	BWI	63.0
San Francisco	SFO	61.7
Seattle	STL	60.2
Orlando	MCO	60.2
Austin	AUS	60.1
Atlanta	ATL	59.4
Cincinnati	CIN	59.1
Chicago	CHI	59.0
Denver	DEN	57.7
Memphis	MEM	57.0
Houston	HOU	56.4
Tampa	TPA	56.1
San Jose	SJC	55.7
Jacksonville	JAX	55.4
Minneapolis	MSP	55.3
Dallas	DFW	54.6
Portland	PDX	54.5
Oakland	OAK	54.3
Kansas City	KC	53.5
Philadelphia	PHL	53.1
Charlotte	CLT	53.0
Indianapolis	IND	52.6
Columbus	CMH	52.4
Los Angeles	LA	52.1
San Diego	SAN	51.8
NYC Metro	NYC	51.4
San Antonio	SAT	50.4
Nashville	BNA	50.0
Orange County	OC	48.4
Phoenix	PHX	46.8
Cleveland	CLE	46.4
Pittsburgh	PIT	45.9
Riverside	RIV	45.2
Sacramento	SAC	43.8
Salt Lake City	SLC	43.6
Las Vegas	LAS	42.2
Detroit	DTW	35.2
Average		53.5
Median		54.3

Figure 1: Institutional Investor Share and Trade Frequency are Positively Related

Institutional investor shares for each MSA are averaged over 2001-2015. Source: Real Capital Analytics (RCA) and author's calculations.

The largest category of these investors are developer/owner/operators. Consistent with institutional investors having relatively more need for liquidity, institutional investors' share of CRE is lowest during periods of market turmoil when the value of liquidity is highest. Furthermore, the share of institutional investors is higher in markets with more trade frequency. While I show that institutional investors also focus their investments in high value cities and cities in which they can more readily deploy a large amount of capital on a single building, the relationship between the share of institutional investors and trade frequency is robust. Finally, dividend yields (cap rates) are lower in markets with more trade frequency. However, there is less dispersion in cap rates across markets than there is in trade frequency.

I then calibrate the model of Vayanos and Wang (2007), which features investors that are heterogenous in the frequency with which they receive valuation shocks, to the US CRE market. Given the difficulties in measuring CRE returns because of selection in which properties transact (see Sagi (2017)), the model is necessary to properly quantify an illiquidity premium. The model illustrates how market segmentation by liquidity preference amplifies cross-market differences in liquidity. The model can replicate the large differences in trade frequency across cities but modest difference in cap rates.

In contrast to other Over-the-Counter (OTC) markets, where the line between certain markets must be drawn somewhat arbitrarily by criteria such as credit ratings, the definition of a market in CRE arises naturally due to the physical segregation of markets. In addition to being interesting in its own right, CRE is thus a good laboratory for studying market segmentation. CRE thus provides an excellent illustration of the relevance of the concept of liquidity begetting liquidity. While I focus on the model of Vayanos and Wang (2007), the intuition that liquidity begets liquidity appears in other theories of OTC markets. For example, the models of Admati and Pfleiderer (1988) and Pagano (1989) generate such a prediction and Biais and Green (2007) discusses how endogeneous liquidity has led to bonds usually trading OTC since the mid-20th century. More recently, Chang (forthcoming) presents a model where submarkets with different trade frequencies arise endogenously as a result of heterogeneity in traders' holding costs. The heterogeneity I document in liquidity across CRE markets is also related to the concept of latent liquidity introduced by Mahanti et al. (2008). Latent liquidity describes the idea that some markets are natually more liquid than others, regardless of measures of liquidity such as bid-ask spreads, because the investor base trades more frequently. In the CRE context, cities that have a higher share of institutional investors have more latent liquidity.

This paper also contributes to our understanding of the implications of investors with different investment horizons. Cella et al. (2013) show that stock market investors with shorter trading horizons are more likely to dispose of their assets during periods of market turmoil which creates larger price drops and subsequent reversals for stocks held by short-term investors. A longer literature studies how the investment horizon of a firm's shareholders affects corporate decisions and control.[1] More generally, this paper contributes to our understanding of how the presence of institutional investors affects asset prices. Using data from publicly traded equity markets, Gompers and Metrick (2001) show that the preference of institutional investors for large-cap stocks increased the price of those stocks. Several papers study the asset pricing implications of insitutional investors being benchmarked against an index.[2] This paper instead studies how differences in their liquidity needs affect trade frequency and asset prices.

[1] See, for example, Bushee and Noe (2000), Bushee (2001), and Gaspar et al. (2005). Ambrose and Megginson (1992) and Stulz et al. (1990) study how institutional ownership affects corporate control although they do not explicitly link it to investment horizons.

[2] See, for example, Cuoco and Kaniel (2011), Basak and Pavlova (2013), Basak and Pavlova (2016), Breugen and Buss (2017)

Finally, the paper adds to a body of work that explains facts about real estate markets using search and matching models. While a number of papers have used search and matching models to understand the housing market[3], to my knowledge the only other paper that studies the CRE market using a search and matching model is Sagi (2017). While Sagi (2017) explains the returns on individual properties with a search model, the current paper aims to explain heterogeneity across cities in CRE trade volumes and investor composition.

2 Empirical Facts about Trade Frequency and Investor Composition

2.1 Data and Variable Construction

The data covers 2001-2015 for 39 US MSAs. 2001 is the first year for which Real Capital Analytics (RCA) has data on total transactions by MSA. I use all cities for which I have data on investor composition, transactions, and the stock of CRE. In addition to providing the data on total transactions, RCA provided data on investor composition and capitalization rates. CBRE provided the data on the stock of commercial real estate by MSA. I combine office, industrial, and retail existing squre footage by MSA into $stock_{i,t}$ where i indexes the MSA and t indexes the year. Combining different property types mitigates the influence of differences in industry composition across MSAs although the results are broadly similar when I use data from only one property type at a time. I measure trade frequency as the number of square feet transacted divided by the stock (also measured in square foot). To measure MSA-level cap rates, trade frequency, and institutional ownership shares for

[3]See, for example, Arnott (1989), Wheaton (1990), Krainer (2001), Piazzesi and Schneider (2009), Ngai and Tenreyro (2014), Albrecht and Vroman (2016), Han et al. (2017), and Arefeva (2017).

combined property types, I value-weight the cap rates for each property type in each year. I proxy for the average property size in an MSA using the transactions-level RCA data. In particular, I construct $avgsize_i$ by dividing the total square footage transacted by the number of transactions and average across all years. I average across all years to mitigate the influence of any cyclical trends in which size properties transact in an MSA.

I measure the amount of purchases made by institutional investors as the dollar volume of transactions in an MSA and year made by the following types of investors: banks, endowment funds, equity funds, insurers, investment managers, listed funds, REITs (both traded and non-traded), open-ended funds, pension funds, and sovereign wealth funds. I categorize the following purchaser types as non-institutional investors: Cooperatives, Corporate, Education (excludes endowment funds), Finance, Government, High Net Worth, Non-Profit, Developer/Owner/Operator, Other/Unknown, Religious, and REOC. RCA defines the investor types.

In some specifications, I control for the MSA-level occupancy rate. I construct MSA-level occupancy rates from TREPP property-level data. I exclude data from multifamily housing, manufactured housing, lodging, securities, and coop housing in constructing MSA-level occupancy rates from the TREPP data. The resulting average occupancy rates are value-weighted by property type similar to the combined cap rates, trade frequency, and institutional ownership shares. While the property-level data in TREPP skews towards properties that are financed by CMBS loans, comprehensive property-level data are not available for the universe of commercial properties. See Downs and Xu (2015), Ghent and Valkanov (2016), and Black et al. (forthcoming) for a comparison of the properties financed by CMBS with those financed with portfolio loans. I also measure lagged revenue growth using the property-level data in TREPP. I winsorize revenue growth at the 1% level.

I construct the number of publicly traded firms in an MSA in each year from Compustat. I also construct a variable that is the aggregate amount of assets these firms have using the Compustat data. Because the Compustat data is available only through 2014, these variables are not available for 2015. I take the natural log of these to get $lognfirms$ and $logfirmassets$.

Table 2 provides summary statistics on the data. On average, institutional investors account for 54% of purchases. There is substantial variation, however, with institutions accounting for just 1.7% of purchases of property in Pittsburgh in 2009 and 92% of purchases of property in 2003 in Pittsburgh. On average, 5.5% of the property stock transacts in an MSA in a year but less than one percent changed hands in several cities in 2009. The average cap rate is 7.6%, roughly 400 basis points above the 10-year Treasury over this time period. Cap rates exhibit far less volatility over both time and across MSAs; the standard deviation is just 0.9 percentage points. The average price per square foot is $152. The average MSA population is 3.7 million and ranges from 1.1 (Salt Lake City) to 19.6 million (New York City Metro).

2.2 Trade Frequency and Investor Composition

Table 1 aggregates our data to show how institutional investor shares range across MSAs. The Table presents the average institutional investor share of purchases in each MSA over the 2001-2015 period. Institutional investors comprised 66% of purchases in the DC Metro area but only 35% of purchases in Detroit. Perhaps surprisingly, institutional investors accounted for less than the median share in the NYC Metro area. While institutional investors do seem to concentrate their purchases in coastal cities, Austin and Cincinnati also have high shares of institutional investment.

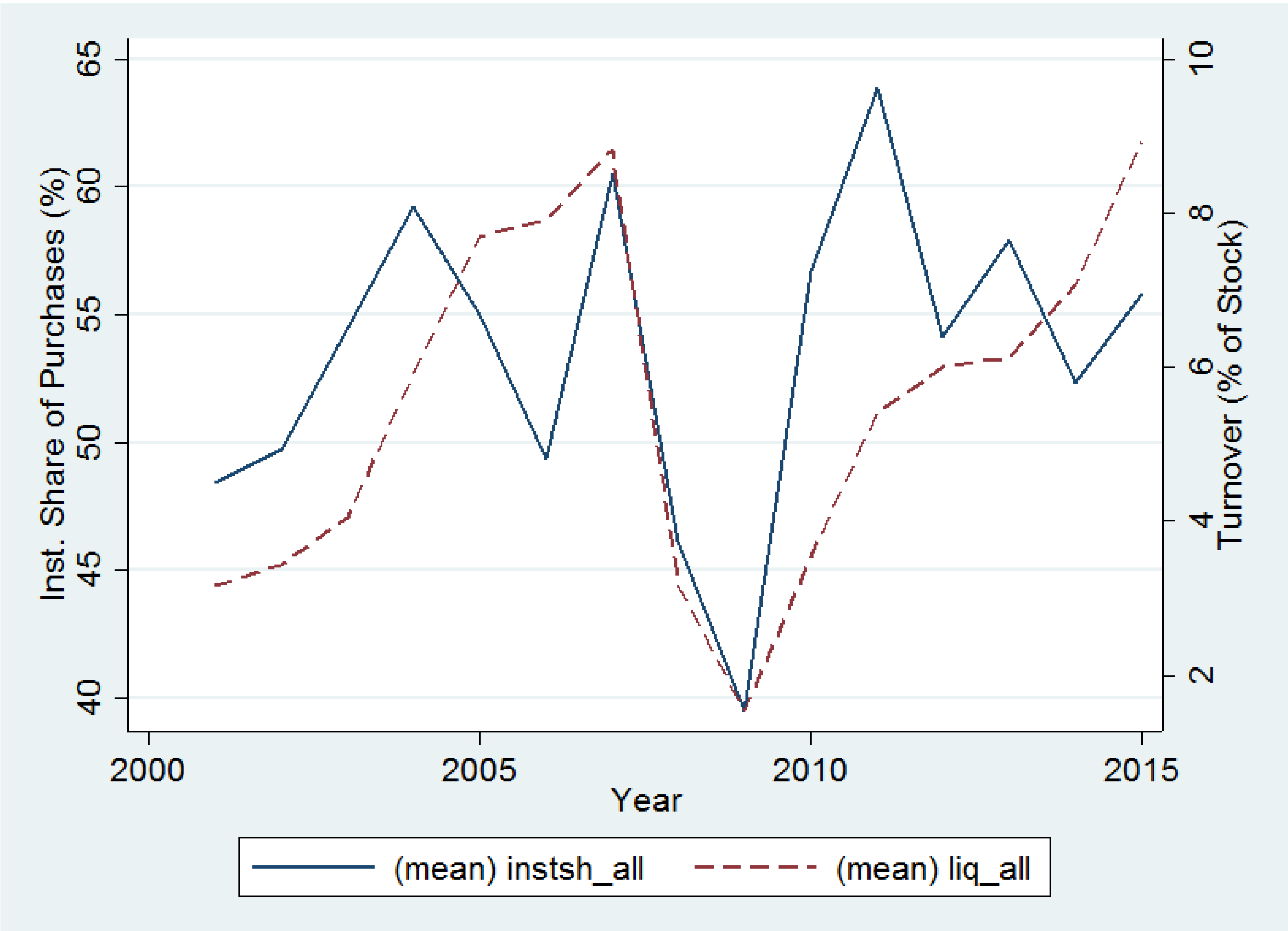
Table 2: Summary Statistics: US Commercial Real Estate in 39 MSAs, 2001-2015

Variable	Obs	Mean	Std. Dev.	Min	Max
$instsh_{all}$	585	53.5	14.3	1.7	92.5
liq_{all}	578	5.5	3.2	0.5	20.6
cap_{all}	530	7.6	0.9	5.1	10.3
$logpop$	585	14.9	0.6	13.9	16.8
$occrate_{all}$	585	93.9	2.3	81.8	100
$revgrowth_{all}$	1.8	2.9	-2.2	6.9	
$lognfirms$	546	4.56	0.91	2.48	6.95
$logfirmassets$	546	12.6	1.5	8.9	17.0
$logtransize_{all}$	576	16.9	0.4	15.7	18.6
$logpsf$	576	4.89	0.49	3.60	6.73

Notes: 1) $instsh_{all}$ is the share of purchases made by institutional investors; liq_{all} is the percent of the property stock (in square feet) transacting; cap_{all} is the average cap rate on properties in that market; $logpsf$ is the log of the average price per square foot in \$; *logpop* is the log of the population of the MSA in 2010; *occrate* is the average occupancy rate in that market from TREPP in %; $revgrowth_{all}$ is the average lagged revenue growth in that market from TREPP in %; $lognfirms$ is the log of the number of publicly traded firms in the MSA; $logfirmassets$ is the log of the combined assets of all publicly traded firms in the MSA; *logtransize* is the average size of a transaction in the MSA averaged where the property size in square feet is averaged across all years to mitigate the influence of which properties are transacting over time. 2) Each observation represents an MSA-year although *logpop* does not change across years. 3) $lognfirms$ and $logfirmassets$ are not available for 2015. 4) Property types included are office, industrial, and retail.

Figure 2 illustrates the time series variation in trade frequency and the share of purchases made by institutional investors. Institutional investors exit the market when liquidity is scarce. In contrast to the attributes Chodorow-Reich et al. (2016) describe an insulator having, they do not weather fire sales but instead stop buying during the financial crisis of 2008-2009.

Figure 2: Institutional Investor Share over Time



Notes: 1) Institutional investor shares for each year are averaged over 39 major US MSAs. 2) Source: Real Capital Analytics (RCA) and author's calculations.

Consistent with institutional CRE owners valuing liquidity more highly than non-institutional owners, figure 1 illustrates that there is a positive relation between institutional ownership and trade frequency. Figure 1 does not control for any covariates. While an exhaustive empirical analysis of the determinants of institutional ownership in CRE is beyond the scope of this paper, it is worth considering a few potential confounding factors that come quickly to mind when considering figure 1.

I consider four possible alternative explanations: First, one might suspect that institutional investors focus their investments on the largest markets where there is more information and more liquidity. Second, as is known from the bond market (see, for example, Edwards et al. (2007) and Green et al. (2007)), lower-risk assets are usually more liquid. It is thus possible that the relationship between institutional ownership shares and trade frequency merely reflects institutional owners preferring less risky assets and those assets also being more liquid. A related idea is that institutional investors prefer what is known as "credit tenants". Credit tenants are generally nationally known publicly traded firms and institutional investors may have a preference for such tenants because they can readily show measures of credit-worthiness to their investment boards. The argument is similar to the 'prudent-man' laws Del Guercio (1996) shows affect the choice of equity holdings of institutional investors. Third, institutional investors may herd into markets where rents are growing quickly. Finally, institutional investors, who often need to deploy large amounts of capital and have limited resources to carefully examine many properties, may focus their investments on the most expensive markets or markets with large properties where they can deploy a large amount of capital on a single property.

To consider whether the relationship between liquidity and institutional investor share is driven solely by these covariates, Table 3 explores the robustness of the relationship between institutional investor share to these factors in a variety of specifications. While the coefficient on turnover is about a third lower after controlling for covariates, the coefficient remains statistically significant at the 1% level in all specifications. Overall, the magnitude of the relationship is such that a 1 percentage point increase in transaction volume is associated with an approximately 1.3 percentage point increase in the share of purchases from institutional investors.

Large Cities

In columns (2) to (5) of Table 3, I control for the population of the MSA. The coefficient is negative, indicating that institutional investors are more likely to invest in smaller cities, but is usually only marginally significant. Other things equal, institutional investors appear to be indifferent to the size of the MSA.

Risk and Tenant Quality

In column 2, I include the occupancy rate in the MSA. The coefficient on the occupancy rate is positive but far from statistically signficant. I consider two different measures of tenant quality. First, I control for the number of publicly traded firms in the MSA (column 3). Similar to the occupancy rate, the coefficient on the log of the number of publicly traded firms is far from statistically significant. In columns (4) and (5), I control for the total assets of publicly traded firms. The coefficient is positive in both specifications and statistically significant at the 10% level in column (5). I thus find modest support for the idea that institutional investors prefer credit tenants.

Herding

In columns (2) through (5), I control for lagged revenue growth and find no support for the notion that institutional investors crowd into markets with rapidly increasing revenue.

Asset Size

In columns (2) through (4), I control for the log of average transaction size (in \$). Since the goal is to proxy for the types of properties in the MSA, I average the physical transaction size across all years to mitigate the influence cyclical factors may have on which properties transact. The coefficient is positive and statistically significant at the 1% level in all thre specifications. In column (5), I instead control for the log price per square foot; the coefficient on log price per square foot is positive and statistically significant at the 10% level. Taken together, the results support the hypothesis that institutional investors prefer markets in which they can deploy a large amount of capital in a single transaction.

Within Property Types

Table 4 shows that the relationship between institutional investor share and transaction frequency also holds within the three property types in our sample (office, industrial, and retail). The relationship is statistically significant at the 1% level for office and retail and at the 5% level in industrial. The magnitude is highest in industrial with a one percentage point increase in turnover being associated with a 1.7 percentage point higher share of institutional investment. The coefficient on the log average transaction size is positive for all three property types but is not statistically significant for office property and is statistically significant at only the 10% level for industrial.

2.3 Trade Frequency and Cap Rates

Figure 3 shows that, in general, cap rates are lower in MSAs in which trade is least frequent. This is consistent with there being an illiquidity premium for CRE. However, cap rates do not vary as much across MSAs as turnover does.

Table 3: Institutional Investor Share and Trade Frequency: Multivariate Correlations

	(1)	(2)	(3)	(4)	(5)
Dep. Var.	$instsh_{all}$	$instsh_{all}$	$instsh_{all}$	$instsh_{all}$	$instsh_{all}$
% of Property Stock Transacting	1.70***	1.33***	1.35***	1.35***	1.41***
	(0.31)	(0.28)	(0.29)	(0.27)	(0.29)
Log of 2010 Population		-1.73	-1.73	-2.21	-2.43
		(1.68)	(2.37)	(1.92)	(1.91)
Occupancy Rate		2.63			
		(1.75)			
Lagged Revenue Growth (%)		-2.37***	0.33	0.33	0.16
		(0.79)	(0.48)	(0.49)	(0.49)
Log Avg. Transaction Size ($)		9.75***	9.64***	8.74***	
		(2.61)	(2.49)	(2.51)	
Log No. Publicly Traded Firms			-0.0049		
			(1.47)		
Log Assets of Public Firms				0.52	1.61**
				(0.80)	(0.73)
Log Price per Sq. Foot ($)					2.82
					(2.09)
Constant	44.1***	-330*	-90.0	-74.2	47.9*
	(2.45)	(189)	(56.1)	(51.3)	(25.0)
Observations	578	570	531	531	531
R^2	25.1%	30.9%	30.7%	30.9%	27.9%
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Std. Errors Clustered by MSA	Yes	Yes	Yes	Yes	Yes

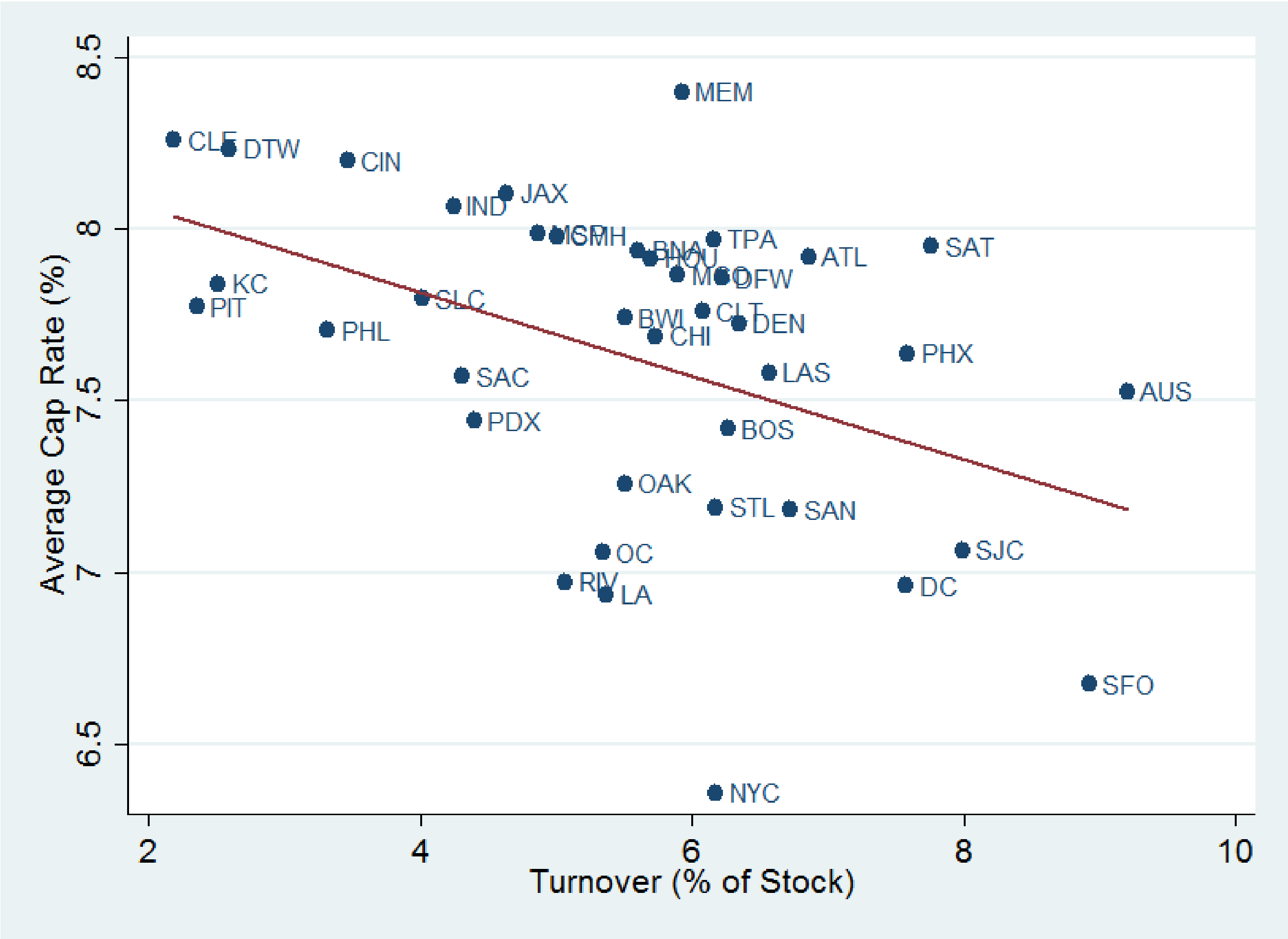
Notes: 1) Robust standard errors in parentheses. 2) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. 3) Dependent variable is share of purchases in MSA in a given year by institutional investors in %.

Table 4: Institutional Investor Share and Trade Frequency Within Property Type

	(1)	(2)	(3)	(4)	(5)	(6)
	Office		Industrial		Retail	
% of Property Stock Transacting	1.08***	0.90***	2.29***	1.67**	1.60***	0.97***
	(0.20)	(0.26)	(0.58)	(0.70)	(0.29)	(0.25)
Log of 2010 Population		1.41		-2.24		1.37
		(2.15)		(2.15)		(2.00)
Occupancy Rate		1.54***		0.018		0.47
		(0.56)		(0.54)		(0.70)
Lagged Revenue Growth (%)		-0.095		0.12		0.028
		(0.12)		(0.19)		(0.16)
Log Avg. Transaction Size ($)		6.59		5.45*		14.7***
		(5.31)		(3.23)		(3.58)
Constant	43.6***	-194**	45.6***	20.3	32.5***	-211*
	(3.71)	(84.9)	(3.95)	(74.1)	(4.56)	(109)
Observations	585	453	576	395	583	458
R^2	19.9%	27.5%	20.3%	27.0%	20.5%	31.5%
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Std. Errors Clustered by MSA	Yes	Yes	Yes	Yes	Yes	Yes

Notes: 1) Robust standard errors in parentheses. 2) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. 3) Dependent variable is share of purchases in MSA in a given year by institutional investors in %.

Figure 3: Cap Rates and Trade Frequency are Inversely Related



Notes: 1) Cap rates for each MSA are averaged over 2001-2015. 2) Source: Real Capital Analytics (RCA) and author's calculations.

3 Explaining the Facts

We first consider how well a search model with heterogeneous investors can explain the facts above. To do so, we calibrate a simplified version of Vayanos and Wang (2007) to the US CRE Market. We then ask whether a model with heterogeneity in search technologies, rather than investors, can explain the data.

Thefe are are two assets, 1 and 2, traded in markets 1 and 2. Both assets pay a dividend of 1 per period and are in supply s. The two markets are *ex ante* identical.

Investors are risk-neutral and have a rate of time preference of r. Each period, there is an inflow of new agents into the economy. Investors are born into the market without the asset and enjoying a high valuation of the asset, i.e., their per period benefit is the full dividend of 1. Their valuation of the asset can switch to $1-x$ and the intensity with which investors become low valuation agents is κ. In contrast to Duffie et al. (2005) and Duffie et al. (2007), once an agent becomes a low valuation agent, he remains a low valuation agent until he sells the property. Once he has sold the property, he exits the economy.

Agents differ in the likelihood that they will receive a valuation shock. Valuation shocks arrive at Possion rate κ. If an investor switches to a low valuation type, he receives only $1-x$. The density of investors that enter the economy is $f(\kappa)$ which we take as the uniform distribution over the interval $[\underline{\kappa}, \overline{\kappa}]$. Investors must commit to searching in only one market at any given time. In the context of CRE, one may interpret such a restriction as a high cost of acquiring information about a particular city's property market that prevents an investor from searching simulataneously in all possible markets.

These assumptions in turn imply that the density of all high valuation agents in the economy (rather than that of new entrants to the economy) is

$$g(\kappa) = \frac{1}{\kappa} \tag{1}$$

such that D_h, the measure of high-valuation ages is $\frac{log(\overline{\kappa})-log(\underline{\kappa})}{\overline{\kappa}-\underline{\kappa}}$. We focus on the case where there is neither excess demand nor excess supply such that

$$S = \frac{D_h}{2} = 0.5 * \frac{log(\overline{\kappa}) - log(\underline{\kappa})}{\overline{\kappa} - \underline{\kappa}} \tag{2}$$

When a buyer (a newly born agent) meets a seller (an agent that had bought the asset as a high valuation agent but who now only gets $1 - x$ from owning the asset), the use bilateral bargaining to split the gains from trade. In particular, one party is randomly selected to make a take-it-or-leave-it offer. The probability that the buyer is selected to make the offer is $\frac{z}{1+z}$.

Equilibrium

We focus on the clientele equilibrium in which low κ agents choose to enter the high liquidity market which we take as market 1 without loss of generality. We denote by $\mu_B^i(\kappa)$, $\mu_O^i(\kappa)$, and $\mu_S^i(\kappa)$, the density of agents with valuation shock frequency κ in market i that are looking to buy the asset, that own the asset and remain high valuation, and that own the asset but have become low valuation such that they are looking to sell the asset. We have

$$\int_{\underline{\kappa}}^{\overline{\kappa}} \mu_B^i(\kappa) d\kappa = \mu_B^i \tag{3}$$

$$\int_{\underline{\kappa}}^{\overline{\kappa}} \mu_O^i(\kappa) d\kappa = \mu_O^i \tag{4}$$

$$\int_{\underline{\kappa}}^{\overline{\kappa}} \mu_S^i(\kappa) d\kappa = \mu_S^i \tag{5}$$

Given our assumptions, by Lemma 1 of Vayanos and Wang (2007), there is a unique value of κ, κ^*, such that all investors with $\kappa > \kappa^*$ choose to enter market 1 and all investors with $\kappa < \kappa^*$ go to market 2. Given this fact, to determine μ_B^1 (for example), we use the fact that the inflow into buyers is $\frac{1}{\underline{\kappa}, \overline{\kappa}} d\kappa$ for $\kappa > \kappa^*$ for market 1, 0 for $\kappa < \kappa^*$ while the outflow is $\lambda \mu_B^1(\kappa) \mu_S^i d\kappa$. This gives us an equation for $\mu_B^i(\kappa)$ in terms of μ_S^i and the parameters. We similarly set the inflow into owners equal to the outflow for a given κ to solve for μ_O^i in terms of μ_S^i and the underlying parameters. Finally, we impose that the mass of owners and sellers must equal total supply in each market (i.e., $\mu_O^i + \mu_S^i = S$).

The equilibrium of the model then requires the following three equations to be solved for the three unknowns μ_S^1, mu_S^2, and κ^*:

$$\frac{1}{\overline{\kappa} - \underline{\kappa}} \int_{\kappa^*}^{\overline{\kappa}} \frac{\lambda \mu_S^1}{k(k + \lambda \mu_S^1)} dk + \mu_S^1 = S \tag{6}$$

$$\frac{1}{\overline{\kappa} - \underline{\kappa}} \int_{\underline{\kappa}}^{\kappa^*} \frac{\lambda \mu_S^2}{k(k + \lambda \mu_S^2)} dk + \mu_S^2 = S \tag{7}$$

$$\begin{aligned} \mu_S^1 - \mu_S^2 + \mu_S^1 \frac{1}{2(r + \kappa^*)(\overline{\kappa} - \underline{\kappa})} \int_{\underline{\kappa}}^{\kappa^*} \frac{\lambda(r + \kappa^* + 0.5\lambda \mu_S^2)}{(k + \lambda \mu_S^2)(r + k + 0.5\lambda \mu_S^2)} dk \\ + \mu_S^2 \frac{1}{2(r + \kappa^*)(\overline{\kappa} - \underline{\kappa})} \int_{\kappa^*}^{\overline{\kappa}} \frac{\lambda(r + \kappa^* + 0.5\lambda \mu_S^1)}{(k + \lambda \mu_S^1)(r + k + 0.5\lambda \mu_S^1)} dk = 0 \end{aligned} \tag{8}$$

Trading volume in the model is determined entirely by the parameters $\underline{\kappa}$, $\overline{\kappa}$, and λ.

Trading volume does not depend on the discount from a liquidity shock, x. x matters only for price determination.

Transactions prices are heterogeneous in each market. While transactions prices have closed form solutions, in the interests of space, we do not reproduce the expressions for them from Vayanos and Wang (2007). We present the average cap rates in markets 1 and 2 as these are the analogues to the empirical MSA averages. See Vayanos and Wang (2007) for additional details on the model solution.

Calibration

Given that the model has no role for heterogeneity in liquidity needs or technologies over time, I collapse the data to the means for each of the 39 MSAs. I then split the sample of cities into two sets high turnover and low turnover cities. High turnover cities are the top half of cities by turnover while low turnover cities are those with turnover below or equal to the median. Table 5 shows that the most liquid cities have turnover of 6.85% while the least liquid cities have turnover of just 4.30%. The difference in turnover between the two sets of cities is more than 45% of the mean level of turnover. By comparison, the difference in the average cap rates across the two sets of cities is a mere 13 basis points or less than 2% of the average cap rate.

I fix z to 1 such that buyers and sellers have equal bargaining weight. I fix r at 3.5% which is the approximately the average yield on the 10-year US Treasury over 2001-2015. Given the moments in the data, we can fit the data relatively well by setting $\underline{\kappa}$, $\overline{\kappa}$, λ, and x to 0.035, 0.09, 3.0, and 0.57. The midpoint of the range of κ is such that each high valuation agent faces a 6.25% chance of getting a liquidity shock in any given year and thus becoming a low valuation agent.

Table 5: Search Model with Investor Heterogeneity

	Data: US Cities			Model	
	All	High Turnover	Low Turnover	High Turnover Market ($\kappa > \kappa^*$)	Low Turnover Market ($\kappa \leqslant \kappa^*$)
Avg. Cap Rate	7.63%	7.51%	7.74%	7.62%	7.68%
Turnover	5.54%	6.85%	4.30%	6.80%	4.28%
Inst. Share	53.5%	56.2%	51.0%		
N	39	19	20		
μ_B				0.45	0.34
μ_O				8.15	8.23
μ_S				0.43	0.36
Mos. to Sell				8.92	11.65

Notes: 1) κ^* is the unique value in the distribution of κ such that investors with values of κ above that choose to search in market 1 (high turnover) and investors with values of κ below that choose to search in market 2 (low turnover). 2) Mos. to sell is the expected number of months a seller expects to wait before finding a buyer. 3) The data from US cities covers 2001-2015.

For these parameter values, the value of κ that separates the two sets of agents is $\kappa^* = 0.056$. As Vayanos and Wang (2007) point out, there are both more buyers and more sellers in the more liquid market. Furthermore, there are The equilibrium masses of buyers in markets 1 and 2 are 0.44 and 0.33 such that the equilibrium times on the market ($\frac{1}{\lambda \mu_B^i}$) are approximately 9 and 12 months. I am not aware of empirical estimates of the time required to sell in the commercial real estate market but these numbers seem within the plausible range for commercial real estate.[4]

4 Conclusions

We have shown that, empirically the composition of the investor base in CRE differs markedly across cities. Institutional investors, who are more likely to have shorter holding periods, are more prevalent in the more liquid markets. From the perspective of an institutional investor's

[4]See Carrillo (2013) and Carrillo and Pope (2012) for a discussions of time on the market as a measure of liquidity in the residential market.

perspective, the problem with the Pittsburgh CRE market, and the CRE market of similar cities, is that it lacks liquidity. The low share of institutional investors' in markets like Pittsburgh is itself a reason that Pittsburgh lacks liquidity. We also found that institutional investors are more prevalent in markets with larger average transaction sizes consistent with their being a minimum deal size necessary for them to invest.

We show that a simple search model with heterogeneity in the frequency with which investors get liquidity shocks can explain these facts. In the model, CRE markets are *ex ante* homogeneous and yet one market emerges as having substantially more liquidity than the other. In practice, there are likely some initial differences across CRE markets that give one set of cities an edge in attracting investors that have a greater need for liquidity. Empriically, we find that the average transaction size is corrlated with the share of institutional investors. We leave to future research other reasons for heterogeneity in investor composition across markets.

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