

REAL ESTATE MARKET SYSTEM - PHASE SPACE THEORY APPROACH

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Abstract

The real estate market poses a topic of research in the theoretical sense, as well as encouraging researchers to search for new methods/tools/platforms which would help to understand, manage and undertake all kinds of activities (decisions) within its realm. The process of globalization, need to constantly gather information (create extensive registers), data management, implementation of complicated computing procedures (which only seemingly provide solutions), and awareness and knowledge of market participants are supposed to lead us to "ultimately understand" the structures of the real estate market. However, in most cases, the decisions made in the real estate market realm are not rational.

Market participants do not always act accordingly to the (economic) presumptions of the market and many of their behaviors can easily be viewed as chaotic and impulsive. Owing to this fact, it seems justified to invoke mathematical and physical concepts, and apply them to the real estate market.

This article describes the concept of how the real estate market is perceived according to the phase space theory. Phase space is understood as a multidimensional space of market events where the transfer of rights to real estate takes place and decision-making processes occur. Transaction prices, on the other hand, indicate market development and are an emanation of decision-making processes.

The goal of this article is to provide proof for the hypothesis that the real estate market is a system existing in multidimensional phase space and that the complexity of this space affects the unit price of real estate.

Keywords: real estate system, decision processes, theory of phase space.

JEL Classification: C01.

Citation: Radzewicz A., (2013), "Real estate market system theory approach phase space", *Real Estate Management and Valuation*, vol. 21, no. 4, pp. 87-95.

DOI: 10.2478/remav-2013-0040.

1. Introduction

The real estate market (REM) is a very important element in the development of a country and market driven economy, as well as a factor influencing society's prosperity and satisfaction. It is a background for professional activity, and fulfills the fundamental needs of human beings connected with, among others, the need for safety and housing.

In this article, the real estate market is perceived in the system approach as a set of mutual relations and connections between its participants (entities), objects (real estate) and the market environment - which takes into account the internal as well as external conditions of the market. The strength and quality of mutual connections and relations between these elements of the system most frequently appears in the price of real estate.

Systemic conceptualization is, therefore, a blanket (complex) approach to the real estate market, taking into consideration the elements of the market system, and keeping in mind its specificity and

influence. This influence cannot always be easily assessed, nor can all its components be indicated. Nevertheless, we must remember that each element of the system has an effect on others, thus remaining strongly connected. The participants of the REM are entities who take up activities and make decisions pertaining to real estate within a specific market. These entities (e.g., through their preferences) influence the market (e.g., by transforming or creating new buildings or premises).

Price is a certain objectivized value which specifies the level of development and quality of the real estate market. The activity of market participants creates not only market conditions, but also the means of price formation. Unit price applies to property. Real estate satisfies the needs of potential buyers by the transfer of the right to a given piece of real estate. Consequently, it is a desirable, standardized good, and constitutes an object of trade.

Even though the exact location of a given piece of real estate remains constant, its external conditions or surroundings change. The real estate market should, therefore, be examined as a whole, together with its surroundings and complex, often reflexive relations between the elements of the market and its environment. This environment can simplify or hinder, activate or suspend activities, as well as direct them irrespective of the system's condition.

Behaviors on the real estate market are subject to change due to the impact of changing internal and external determinants, thus leading to changes in the individual elements of the system. These changes, as well as the environment itself, constitute a multidimensional plane in which uncertainty occurs. The environment of the real estate market is determined by economic, spatial, social-economic and other surroundings. Even the smallest of changes may result in a random change in other elements of the system, completely altering the relations and dependences occurring in the market (RADZEWICZ, RENIGIER-BIŁOZOR, WIŚNIEWSKI, 2011).

2. Real market decision processes

2.1. The real estate market system (REMS)

The whole of processes and relations on the real estate market is identified for a property (P), which is the smallest basic unit of the real estate market (fig. 1). The objects within the real estate market system are: land (LP), buildings (BP) and premises (HP), characterized by different main features which are important to entities responsible for their management. Market participants are all the people appearing and/or doing business in the market space. This includes all natural persons, legal persons, and all kinds of companies and institutions present within a specific real estate market.

The real estate system

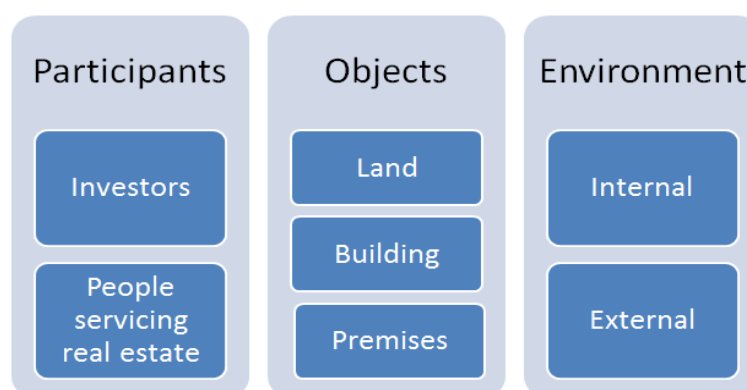


Fig. 1. Integrant elements of the real estate market. Source: own study.

Real estate (REMS objects) which is isolated from a specific space is, theoretically, stable in time and place. The real estate market, as a natural place for the occurrence of real estate, is under constant change depending on the behavior and activities of market participants, as well as the influence of the surrounding elements. A given piece of real estate is influenced by its environment (neighborhood) as well as by the environment of the specific real estate market. The variability of real estate market systems is strictly connected with the passing of time, increasing awareness of people (as a result of

globalization or social transformations - an aspiration to be an informational society), changing of categories and/or types of P, specificity of their description, and conditions (features/attributes) of real estate. Although real estate is a product that is constantly on the market, it changes qualitatively. It conforms to different requirements (buyer preferences), even though it may continue to realize the same needs.

2.2. Decision processes

The real market system and decision processes are quite complex, determined by many factors which vary in terms of their nature and degree of influence. The participants' activities, objects of observation and environment (immediate as well as more distant) all create specific relations and dependences, including aleatory factors. The activities assumed by market participants are an essential, causative factor in economic systems (REM). It is the participants of the REM who establish rules as to how the market functions and real estate turnover, as well as creating suspense. Human activity is quite often characterized as being irrational and actions are taken despite the lack of fundamental information from an investor's point of view. The range of these activities covers real estate and distinguished space, along with circumstances which are characteristic for their type and location. People are the ones who, using the available tools, decide about market activities and seek to (theoretically) maximize their own benefits.

The participants of the real estate market shape it by means of the market game in which they, hypothetically, want to make conscious decisions which, from their point of view, are most profitable. Decision making processes are influenced by many factors, including economic, social or aleatory ones, which also presuppose the final decision. While making a decision, individuals take their own preferences, motives, traditions, ethic rules and financial capabilities under consideration. The interaction of market conditions (price and conditions of exchange) is also not without influence on the final decision.

However, decisions and market stipulations are encumbered with uncertainty. Humans are not able to factor into account all the circumstances which influence free market behaviors and predict all the risks connected with investing on the real estate market. Decision processes should be based on solid information. It is assumed that information from the outside or from within the system should be reflected by how well a market functions (RENIGIER-BILOZOR, WISNIEWSKI, 2012). However, we must not forget that it is the participants who are responsible for recording and processing information about the real estate market system. The means of obtaining and recording information are not homogenous for the whole market. Information is, therefore, oftentimes piecemeal. Participants make decisions which are doubtful from the very beginning, and lead them to take improper courses of action.

The decisions made are a result of the influence of objective conditions but also the subjective feelings of buyers. The most significant problem of decision-making processes seems to be the identification of activities which occur as a result of human action. People are the key element of the real estate market due to their intellectual, emotional and physical activities connected with real estate selection, and procurement and use of real estate and services connected with it in order to satisfy their needs (WILKIE, 1994). In connection with the above, real estate market analyses should consider such variables as: the subjective aims, needs and expectations of people making specific consumer decisions. This causes a lot of problems, such as defining consumer behaviors on the real estate market.

3. The theory of phase space

From a philosophical point of view, the real estate market would not be able to function if it were not isolated, naturally or artificially, from space (the cosmos, world, country, region or town) by market participants, evaluating it according to the standard of usefulness and serviceableness for a given purpose. Space is understood as a primary concept which will not be defined here. References to the space within this article concern the multidimensional space of the real estate market, from which specific markets have been distinguished. The real estate market system is, therefore, a spatial pattern which occurs in a specified space at a strictly indicated time. The smallest element of this system is a piece of real estate, the spatial borders of which are determined by the socio-economic assignment of the land, taking into consideration that the ownership of land extends above as well as below its

surface (KODEKS CYWILNY, 1964). Therefore, the definition provided by the Code indicates that real estate is treated as a **spatial object**. Following this line of thought, the real estate market is a place where the transfer of rights to real estate takes place, and consists of infinite amounts (due to the possibility of division) of individual pieces of real estate, which also makes it a spatial object. According to its definition, a real estate market is a **multidimensional space of events**, occurring as a result of the mutual interaction of participants, objects and the REM (RADZEWICZ, WISNIEWSKI, 2011).

In light of the above-mentioned deliberations, the REMS can be defined as a multidimensional, spatial pattern **set in phase space**. The term "phase space" exists in math as well as physics, and signifies the space of all possible states in which the analyzed pattern (REMS) can appear. Phase space of the dynamical system is an abstract space with orthogonal co-ordinates, each of which presents a variable needed for defining the state of the system. ADAMCZEWSKI (2011) emphasizes that real estate is a real object which exists in a specific time and space. The utilization of a trend allows for the behavior of a piece of real estate in time to be determined and, with the help of a vector or generalized coordinate, it is possible to define its localization in a given space.

Phase space is normally multidimensional and each degree of freedom (i.e., minimal amount of independent variables unanimously describing its state) of this system is represented as its separate dimension (D). The combination of system parameters at a given time is equivalent to the position of a point (referred to as its microstate) within this space. If the evolution of the system is fully determined by these parameters, a trajectory, composed of subsequent states that the system will be in, can be identified in space. The shapes of these trajectories allow us to precisely describe various attributes of the system. In the case of the REMS, the price, which is a characteristic microstate, is the emanation the state of the market. Transaction price noted on the REM is a derivative of anthropogenic factors connected with market participants, objects and the real estate market itself. It leaves its mark in the structure of the entire system, posing as a point of reference for later transactions. BELEJ (2011) believes that variability of real estate transaction prices is unambiguously spatially replicated. Owing to this suggestion, we can assume that in a phase space system, this replication will be visible in subsequent microstates (prices) of real estate and/or the REM.

In the system theory, the real estate market can be written down as a Cartesian product of its elements: participants (Pd), objects (Pdr) and the environment, understood to be the place of the events (Mz), in accordance with formula no. 1.

$$SRN = Pd_i \times Pdr_i \times Mz_i \quad (1)$$

The foregoing definition, even though it had originally concerned the whole real estate market system, is also accurate for a single property existing in this system. Thereupon, presumptions that the REMS and P are to be treated as fractal objects which are described in the same incomplete space exist. Fractals are geometric figures which can be divided into parts where each will constitute a reduced copy of the whole, thus becoming self-similar (Bajerowski, 2003). Fractals cannot be described by mathematical patterns, only by recursive dependencies.

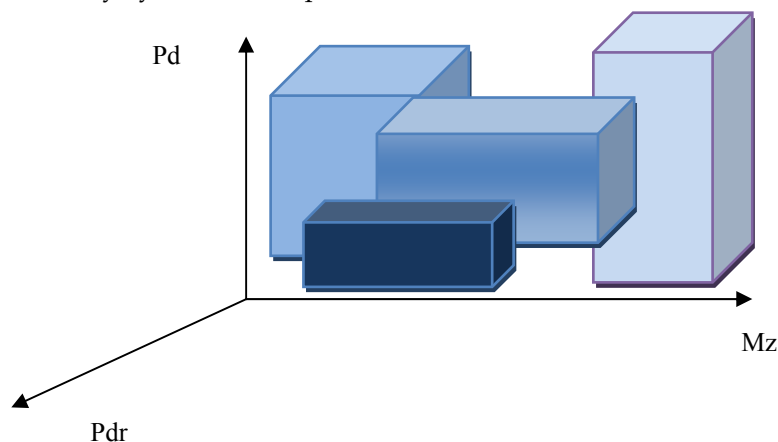


Fig. 2. The real estate market system in phase space. *Source:* own studies.

In harmony with the introduced definition of the real estate market system and understanding of REM structures, this system was placed in Cartesian-space, which is shown in figure 2. The Cartesian scheme of the REM consists of three axes: the axis of participants, axis of objects, and axis corresponding to the place of an event (Pd, Pdr, Mz). In other words, we could call it a multidimensional space of market events, understood as the phase space of the market. In the picture below, the REM is presented for different sizes and strengths of influence of its elements. Depending on which element of the system exerts a stronger effect on the formation of the market, that dimension will be greater.

Each of the presented phase space axes consists of further n-dimensional subspaces. Each axis consists of other (further) axes, which are distinguished in subsequent iterations shown in table 1. For example, market participants can be divided into: natural persons, legal persons, and companies and institutions. Each of them can be defined as persons selling, buying and servicing real estate or transactions. If we take a closer look at this division, it turns out that family, friends, acquaintances and the place of work can influence each of these parties (second iteration), determining a particular behavior. Thus, we can see that there are various participants (direct and indirect) on the REM, who, though not always aware of their participation, play a major part in its formation.

The space of objects on the REM is also multidimensional. First of all, according to the division imposed by the Civil Code, real estate is comprised of land, buildings and premises. Nevertheless, irrespective of the type of real estate, it will be perceived and assessed due to its physical features, performed functions and legal base, which determines the scope of the ordinance and receiving benefits from a given piece of real estate. Additionally, we can determine further qualities of real estate by assigning it to individual spaces.

Table 1

Phase space of the real estate market accounting for individual n-dimensions

Main axis	First iteration	Second iteration	Third iteration
Participants (Pd)	Natural persons	Seller	Family
	Legal persons	Customer	Friends and acquaintances
	Companies and institutions	People servicing RE and transactions	Workplace
Objects (Pdr)	LP	Physical features	Plot shape Hypsometry Land use
	BP	Functions	Residential Agricultural Commercial and business
	HP	Law	Property Perpetual usufruct of land Limited property rights
		Demography	Age of population Education „Growth rate“
Environment (Mz)	Social	Economy	„Production of goods“ „Consumption of goods“ „Distribution of goods“
		Psychology	Instincts Culture Cognitive processes
		Legislative acts	Acts and ordinances MPZP/SUiKZG
	Legal regulations		Decisions and rulings
		Technical procedures	Creating the law Respecting the Law Changing the law

		Impositions
Consequences		Fines
		Profits
Geographical	Location	Global
		General localization
	Specific localization	
	Internal determinants	Location
		Neighborhood
	External determinants	Communication
Geographical determinants		
Local law		
		Climate and water conditions

Source: own studies.

The last equally important, though a bit more "developed", axis in the space of the REMS is the environment, understood as the place where real estate occurs and trade transactions are registered. The environment has been divided into 3 dimensions: social, legal and geographical. In the following iterations, new dimensions of this space are indicated in a way that enables the conditions and place of the exchange to be determined as precisely as possible.

4. Application of the theory of phase space

The theory of phase spaces, despite being perfectly suited for physical phenomena, has never been adapted (not yet been noticed) to the real estate market. The multidimensionality of occurrences appearing on the REM was strongly emphasized by WISNIEWSKI (2007, 2012), suggesting the utilization of phase space.

The concept of the theory of phase space appears to be placed in an abstract plane of thought when the REMS is concerned, though understanding it will facilitate an understanding of market-related issues. In accordance with the earlier presented assumptions, real estate markets (as well as individual pieces of real estate) are distinguished from a specific (physical) space as a result of the influence of features and elements of the REMS. We cannot, however, define and name all these factors because of the multiplicity of reactions and mutual interactions which occur within this system. Another obstacle is the uncertainty that occurs within the REMS, as well as the impulsive and chaotic behaviors of its participants.

Decision processes belong to a multi-faceted plane of the REM. They are a series of activities leading to the state of "reaching a decision" and take place at a given place and time, and under specified (by market participants) conditions. They are usually associated with reaching optimal (from the decision-makers' point of view) decisions.

The REMS is made up of an infinite number of decisions made continuously by its various participants and affecting the market to different degrees. The decision connected with determining (establishing) transaction price at a specific time/moment has the biggest influence on the REM. This price is a market fact, which means it is a direct resultant of a decision. The actual moment of making a decision can be understood as the sum or integral of products of the value of a specified random variable function and respective probabilities (ADAMCZEWSKI, 2011).

Decision processes are characterized by an individual nature and occur as a result of evaluating goals (and features of a transaction) as well as circumstances under which of the final decision was reached. The REM is full of market participants who vary from one another and are subject to constant changes in space and time. As a result of this, the participants of the market game are obliged to adequately diagnose and set precise goals (which a piece of real estate or the REM as a whole is to realize) and strive to make the best possible choice. The choice, as well as the decision by which it is followed, is the resultant of evaluating and comparing market objects. It is, therefore, helpful to determine the similarities of the REMS and/or property in such a case.

The similarity of the REMS is most often understood as choosing the same segment of the REM which is characterized by similar characteristics. Unfortunately, determining similarities is not an easy task because of the large number of elements that the system is comprised of and problems defining the relations that occur between them. ZYGA (2009) emphasizes that similarity reflects the strength and

amount of relations between two subjects and their features. This ascertainment can be easily transferred to the plane of the multidimensional REMS. The similarity of the REMS and/or P should also be understood as the similarity of an element of the REMS, which, at the same time, is one of the axes of phase space.

The definition of real estate market similarities is illustrated by figure 3, which presents two sample real estate markets, characterized by different phase dimensions. In multidimensional phase space, we can compare real estate markets and individual properties by assigning a specific position (pd_x, pdr_x, mz_x) to each of the comparable objects. In order to define the similarities of the REM (P), their phase dimensions (D) ought to be analyzed using the assigned coordinates, checking for similarities between each of them.

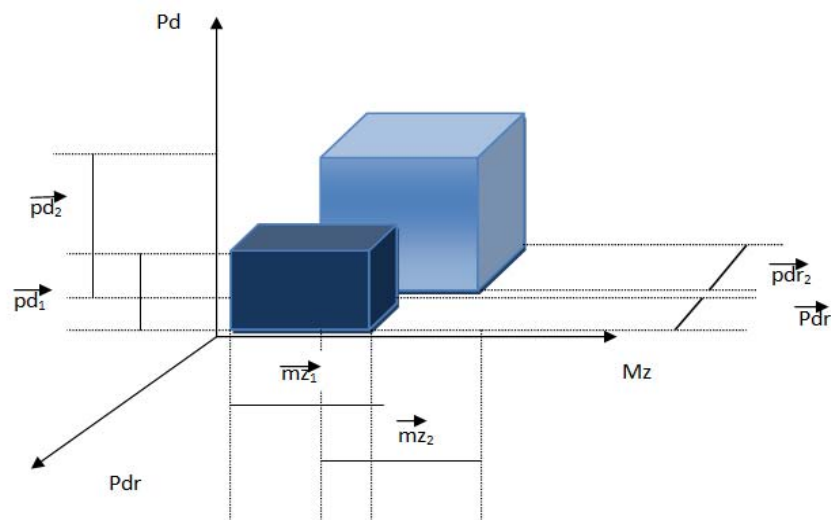


Fig. 3. Similarity of the real estate market using the phase space approach. *Source:* own studies.

$$\left. \begin{array}{l} \text{if } D(pd_1) \text{ and } D(pd_2) = 1, \\ \text{or } D(pdr_1) \text{ and } D(pdr_2) = 1, \\ \text{or } D(mz_1) \text{ and } D(mz_2) = 1 \end{array} \right\} \Rightarrow W(\text{REM}/P) = 1 \quad (2)$$

If any of the phase dimensions (formula 2) of the compared objects (REM and P) are the same or very similar, we are dealing with a similarity of markets in terms of the given element. In order to be dealing with the similarity of the analyzed objects ($D(\text{REM}/P)=1$), it is enough for just one dimension of phase space to be similar to itself ($D=1$).

Figure 3 shows two real estate markets, i.e., $\text{REM}_1(pd_1, pdr_1, mz_1)$ and $\text{REM}_2(pd_2, pdr_2, mz_2)$, analyzed in the same period of time. The first market has much smaller dimensions in terms of the number participants & objects, as well as dimensions of the environment (place of the event); it is, therefore, most likely a small local market. The second one is characterized by a larger topological dimension, which means that the strength and influence of the elements of this market are greater, leading to the increase of the microstate, that is the occurring prices.

Transaction prices which occur on the market can easily inform market participants about the complexity of the whole system, as well as the expected future value. The more it is possible to accurately indicate and identify market dependencies, the more trust we can expect from market game participants. REM participants' socially acquired and confirmed expectations as to the real estate market, institutions and organizations, as well as of each other, will have an impact on accurately predicting human behaviors as well as making the correct decisions in the future.

5. Summary and conclusions

Decision processes are connected with the Latin word *decidere*, which means to decide, determine. Market participants make their decisions as a result of the decision-making process, thus directly creating local (indirectly - regional and domestic) real estate markets. This is how they establish

market relations and dependencies which ought to be investigated and described in greater detail. The gathered knowledge and experience on the REM should contribute to explaining the phenomenon of the formation of transaction prices.

Past research has indicated that many unexpected and even “chaotic” transactions have taken place on the real estate market. These observations appear to be especially important in the context of forecasting events and explaining how the price of real estate is formed. The analysis of existing models describing processes on the REM reveals a lack of models that describe the phenomenon of price formation. The individual models draw attention to selected aspects having a direct or indirect influence on the course, characteristics and possibility of predicting market phenomena.

The system approach to the real estate market cannot be restricted to being perceived as a system of participants, objects and the environment. In order to understand how the REM functions, the relations between the elements of this system ought to be defined, and the structure and principles of how it functions indicated. It seems only logical to search for new theories and solutions which will help us to understand the essence of the REMS and facilitate finding new tools for its analysis.

In this work, the concept of perceiving the REMS and/or P as a multidimensional phase space, which is a Cartesian product of all its dimensions, is presented. The capacity of space is its state at a given moment (t), determined by transaction price. The microstate of the REM (P) are the relations and mutual influences of all of the elements of the system, which is shown by the third dependency.

$$C_N=f(P_d,P_r,M_z) \quad (3)$$

The utilization of phase space in the real estate market seems to be theoretical, however, it ought to be noted that it may prove useful in defining and understanding REM structures. The heterogeneity and complexity of space has an impact on transaction prices, causing the phase space microstate (transaction price) to be higher. This dependency is connected not only with the capacity of space, but also with a higher number of random or not rational (from an economic point of view) transactions (there are a lot of transaction prices characterized by borderline values). What is more, the more participants appear in REM space, the more distorted market transactions (observations) are.

As the capacity of space (both physical and market) increases, so does the number of factors (features) describing it. Economic growth, spatial development, and an increasing population density all cause the dimensions of space to increase. The more complex the structure of the local market (examined in phase space), the higher the prices that occur within it, as the present article aimed to prove.

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