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Between Tradition and Modernity: The Sociospatial Dynamics of Japanese Residential Architecture from Pre-War to Present

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Abstract: This research examines the evolution of Japanese residential architecture throughout the 20th century, focusing on the transformation of house plans in response to changing societal needs. This study specifically examines how traditional spatial configurations adapted to urbanization, modernisation, and shifts in the family structure. By analysing house plans across three distinct periods—the pre-war and post-Kanto earthquake period, the post-war period, and the post-oil shock period to the present—this research illustrates the transition from detached houses to modern collective housing. Utilising a space syntax methodology, this research quantitatively analyses threshold spaces, circulation, and family gathering spaces to understand their social and architectural implications. Historical analyses are paired with a network analysis of selected house plans, highlighting the persistent significance of traditional elements such as the *doma* (vestibule) and the *en-gawa* (verandah) in contemporary designs. The findings demonstrate a significant reduction in the size and complexity of living spaces over time, reflecting broader trends towards efficiency and modernisation in public housing. This research contributes to architectural scholarship by providing a detailed account of how Japanese customary spaces have been reconfigured to accommodate evolving lifestyles, offering insights into the balance between tradition and modern living.

Keywords: residential design; traditional Japanese houses; Japanese public housing; danchi; space syntax analysis

Citation: Tamura, J. Between Tradition and Modernity: The Sociospatial Dynamics of Japanese Residential Architecture from Pre-War to Present. *Architecture* **2024**, *4*, 802–819. https://doi.org/10.3390/architecture4040042

Academic Editor: Nancy Shatzman Steinhardt

Received: 3 August 2024
Revised: 18 September 2024
Accepted: 24 September 2024
Published: 30 September 2024

1. Introduction

House plans have evolved in relation to the societal needs and lifestyles of people due to various influences such as urbanization, economic growth, modernisation, technological innovation, and changes in the family structure. Similarly, in Japan, the way people live has also greatly transformed due to the aforementioned reasons, especially after World War II, with Western influence pressuring Japan to enhance modernisation. Many literature reviews can be found on the history of Japanese house plans [1–7], which mostly cover theories related to the history of design, including studies of form and space, especially on the functionality of space that focuses on the relationship between people's way of living and the layout. The evolution of a typical family house in 20th-century Japan can be explained in three phases: firstly, there was the pre-war and the post-Kanto earthquake period, then the post-war period, followed by the post-oil shock period, which has continued until today. The first period was based on popularizing living in a detached house, while the latter two introduced a modern way of living in collective housing within the city.

During the pre-war period, one of the most significant transformations of house plans from the Edo period, which ended in 1868, through the Meiji period (1868 to 1912) to the Taisho period (1912 to 1926) can be understood in the demand for house layouts to be more family-centric rather than guest-centric [8]. This mechanism has been clarified in a study by Okawa [9], showing that houses for middle-class people commonly have two types of living rooms, called *zashiki* (parlour) for guests and *chanoma* (sitting room) for the family, with all other private rooms attached. The two zones are demarcated. However, in terms of

circulation, a family member always needs to pass through the guest area in order to reach the family zone. This is especially disturbing when one needs to use the toilet, which is most likely located at the far end of the house and is close to the guest area.

The emergence of the centre-corridor plan attempted to resolve this situation. The guest, family, and maid circulations were facilitated by a centre-corridor so as to not encroach on each other's spatial area. In other words, there are two important roles for the centre-corridor plan. One is to provide an alternative route for family members to reach the toilet and bathroom while guests are present. The other is to secure a service circulation for maids so that family members and maids do not interfere with each other within the private areas [8].

Alternative to the centre-corridor plan, a centre-living room type was created during the Showa period (1926–1989). The centre-living room type had a living room in the middle of the house. It was used to introduce the *Public/Private Distinction Theory* by Okawa [9], which makes a distinction between common rooms (living, dining, and parlour or guest rooms) and private rooms (the main bedroom, bedrooms for children and the elderly, a study room, and a maid's room) taken from Western-style house plans. Simultaneously, it provided a living room instead of a *chanoma*, the sitting room [10]. The changes from a sitting room to a living room did not only mean renaming room labels but was a customary shift from *tatami* mats to wooden flooring. The changes in materials suggested the integration of sofas, chairs, and tables to familiarize with the Western lifestyle and was part of the housing improvement movement to promote modernisation in Japanese houses [11].

Despite the transformation of the centre-corridor plan or the centre-living room type, both cases have something in common. One is that the house plan transformations aimed to provide a better-quality living environment for the family. Therefore, the location of a sitting room or a living room as a family gathering space was important and has remained the centre of the house and a symbol of family intimacy [12]. The emergence of centre-corridors also contributed to separating the zones, while simultaneously connecting different rooms by providing various options of circulation, thus acting as a threshold space. The other common aspect of threshold spaces that can be seen at all times is the presence of the *doma* (vestibule) and the *en-gawa* (verandah). In Japan, people consider the outside to be dirty, not only in the physical sense but also in the sense of spiritual impurity or danger [13]. Therefore, various daily hygiene rituals are required in order to keep the inside of the house clean. The most emblematic practices include removing one's shoes upon entering the house, whether from the outside via a *doma* or from the garden side through the *en-gawa*. Typically positioned between the house and the private garden, the *en-gawa* bears a resemblance to the doma, a feature prevalent in most traditional houses. Therefore, the *doma* and *en-gawa* are rather important threshold spaces used to accommodate ritual actions that are still relevant in the present context. Figure 1 shows the location of *doma*, *en-gawa* and centre-corridor of a centre-corridor plan.

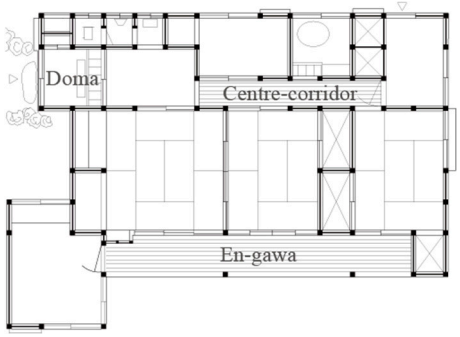


Figure 1. Location of *doma*, *en-gawa* and centre-corridor.

The post-Kanto earthquake period began when the great Kanto earthquake struck Tokyo in 1923, which destroyed the city with extensive firestorms and a fire whirl that

took many people's lives. After this, a corporation named *Dōjunkai* was set up to provide reinforced concrete collective housing in the Tokyo area. The corporation then passed on to establishing a housing corporation in Japan named *Jūtaku Eidan* in 1941. Since this was a hard period for Japan, right before the war, and there was a lack of labour, a building system was created to mass produce and construct buildings easily; in other words, standardisation of materials and prefabricated construction were developed. *Jūtaku Eidan* mostly supplied one-storied detached houses. Regarding the house layout, it applied the centre-corridor plan with the concept of separating eating and sleeping quarters. This was advocated by Uzō Nishiyama [14], who analysed the living environments of many common people's houses and argued that any small house should be planned with separate places for eating and sleeping. Further, he also promoted the idea of separating children's and parents' sleeping spaces. Eventually, the two concepts formed one prototypical plan named 51C of only 35 square meters during the post-war period [15]. In 1951, committee members aiming to explore new standard housing unit plans came up with the design of a 51C unit plan prototype. This consisted of two tatami rooms with a kitchen not only for cooking but also large enough to incorporate an eating space, which later on was identified as the *dining-kitchen* (DK) that can be seen in many public housings created by the Japan Housing Corporation (JHC)—*danchi*. The plan outlined three main principles for structuring living spaces: Firstly, both tatami rooms should function as bedrooms, complemented by a separate area combining dining and kitchen facilities to ensure a dedicated space for meals. Secondly, a wall should be placed between the two bedrooms to maintain their independence as separate rooms. Lastly, it was essential to include areas for essential services such as toilets, washstands, laundry, and water storage to support everyday life.

Suzuki [5], a key architect behind the 51C design, elucidated that the prototype not only illustrated how individuals adapted to the space, but also established a new standard for future modern living in Japan, emerging from the tabula rasa of the post-war period. This indicates that the 51C plan, despite its limited scale, surpassed traditional house plans, as confirmed by the living environment analysis undertaken by Nishiyama [16]. The insights from this analysis were subsequently reintegrated into the prototype, thus enhancing the lifestyle it facilitated. This shift represents a significant evolution from traditional dwellings to a more streamlined model of collective housing. Concerns regarding the standardisation and homogeneity across Japan are significant; however, these are more accurately ascribed to the housing supply system of the era, rather than to deficiencies in residential design. While the uniformity has been rightfully criticised, it is also crucial to recognise its role in promoting modern living standards across the nation [5]. Therefore, the aim of this research is to delineate such a process through quantitative analyses, a pertinent methodology given that such studies typically employ a qualitative approach. These qualitative studies often involve classifying where family members gather during the day and where they sleep at night, as well as charting the furniture arrangements in rooms to gauge the living environment [17].

Building upon these foundational changes, the JHC, established in 1955, aimed to provide housing for young white-collar workers in the city, promoting a modern lifestyle. This initiative was in response to the social demands driven by the introduction of new technological innovations, such as the so-called *three treasures*—the refrigerator, the washing machine, and the vacuum cleaner—that significantly eased the domestic burdens of housewives. The introduction of these appliances necessitated alterations to the customary aspects of house plans, particularly in the allocation of space in the kitchen area and other rooms to accommodate these new devices. Concurrently, the emergence of the DK typology marked a shift in the design of *danchi* (public housing) units in Japan, commonly referred to as *n*DK and later as *n*LDK. Here, "*n*" denotes the number of rooms; with "DK", a *dining-kitchen*, indicating combined dining and kitchen area; and "LDK" adding a living room to the layout.

After the development of massive new towns in the suburbs in the 1970s during the post-oil shock period, the JHC shifted its objective from quantity to quality by creating a comprehensive living environment providing public facilities, and later by producing attractive and integral multifunctional cities in the 1980s and 1990s. The corporation then changed its name just after the millennium to *Urban Renaissance* (UR), where it attempted to utilise housing stocks along with rebuilding and renovating housing built in the 1950s and 1960s. To date, UR also engages architects to re-establish new communities, responding to the social consideration of a low birthrate and an aging population, as well as incorporating visions of new workstyles such as integrating SOHO-type unit plans, including the Shinonome Canal Court designed by Riken Yamamoto [18]. This trend can be seen in the variety of unit plans provided to support the diversity in the contemporary living style of today.

While considering the *Dōjunkai* and the *Jūtaku Eidan*, the history of *danchi* has evolved through two principal trajectories, reflecting distinct but interconnected approaches. The first trajectory follows a social approach, examining how customary and cultural elements manifest in everyday rituals and behavioural patterns within traditional house plans are integrated into the housing unit plans of danchi. This line of inquiry observes how newer housing layouts have naturally incorporated elements from previous designs. Understanding these transformations in layout through standardisation practices sheds light on broader aspects of contemporary Japanese society. The second trajectory stems from a building system approach, driven by the post-World War II demand for extensive housing supply, which catalysed industrialisation and mass production. This shift has significantly influenced house plans, where the dimensions of prefabricated components have come to dictate the basic structure of the buildings themselves, thus defining the overall framework of housing unit plans. Although there have been many innovative developments in building systems, the bearing wall structure has predominantly been employed until recently [17,18].

Given these perspectives, this research prioritises the social dimensions of public housing unit plans by analysing how traditional spaces in Japanese homes have preserved their significance over time and how they have adapted to modern living conditions, particularly through the evolution of danchi unit plans. Additionally, this study employs quantitative methods to provide a different understanding of the qualitative approach by especially focusing on threshold spaces—the *doma* (vestibule), *en-gawa* (verandah), and corridor; circulation; and the family gathering space—which are important features of traditional spaces in Japanese houses.

2. Research Method

2.1. Spatial Configuration of Japanese House Plans

This research aims to compare and analyse threshold spaces, circulation, and the family gathering space of various Japanese house plans from the 20th century selected from three periods in time. Since this research uses a social approach to understand spatial configurations, it employs the method taken from the *space syntax* by observing the social logic of space [19]. This method is based on a theory of space that translates building plans into networks. Using raw network data, it studies the relationship between space and the notion of its social position. It can thus be effective when comparing various types of buildings from historical timelines and contexts.

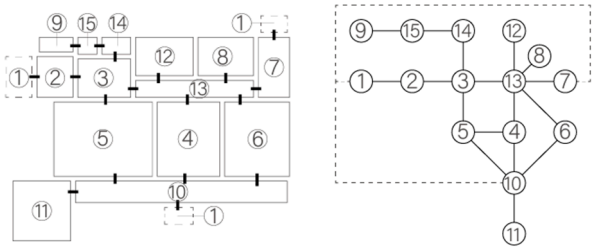
2.2. Selection of Japanese House Plans

Japanese house plans exhibiting the character and challenges of society at the time were selected from three periods. Representative house plans of six centre-corridor plans and six plans of centre-living room types were selected from the pre-war and post-Kanto earthquake periods. Danchi plans were selected from the post-war period. These comprised eight unit plans selected from various typical works illustrating the history, as well as eight others from the Akabanedai danchi completed in 1966. Lastly, twelve unit plans from

Nouvelle Akabanedai were selected from the post-oil shock period until the present. These included modern danchi, and the plans were extracted from *Shinkenchiku* magazine and introduced as works by architects providing a new vision for the future city lifestyle. From many other modern danchis, Nouvelle Akabanedai was chosen since this was a redevelopment plan by *UR* at the same site as the former 1966 Akabanedai danchi, and many original owners from the old ones had moved into the new housing. Therefore, it can be a good comparison in terms of understanding the history of the previous danchi and the contemporary plans. For the danchi cases, units that have fewer than 2 rooms plus a dining room and kitchen (studios) and those that are too similar in terms of the house plan, which can happen when two units are next to each other and are mirrored or only minor changes can be seen, were excluded to avoid repetition of the data in the analysis. In this research study, a total of twelve plans of traditional houses, sixteen unit plans, and twelve modern danchi unit plans were selected [5–8,10,11,20–24] and analysed using network analysis to compare the spatial configurations.

2.3. Network Analysis Using Translated Housing Plans

Housing plans from various periods were collected, and rooms were conceptualized as simple schematic diagrams represented in rectangular shapes with relations of permeability represented by lines illustrating connectivity to other spaces. The diagrams have been simplified from their original plans for clarity. Figure 2 is an example of a traditional house shown in Figure 1, which has been simplified into a plan diagram (Figure 2a). These diagrams are subsequently conceptualised into graphs (Figure 2b), which are assessed using the network analysis methods detailed in Section 2.3.1. Therefore, the diagrams in Figure 3, which are the plans used for this study are situated at the intermediate stage of the conceptualisation process, transitioning from a plan to a graph. The original plans, due to their complexity, obscure the understanding of the relationships between spatial nodes and their interconnections. In contrast, graphs facilitate a clearer comprehension of these interconnections, although they may abstract the nodes to a point where they are no longer recognisable as physical spaces. The plan diagram, therefore, remains effective as it retains the spatial characteristics of a room—such as size and shape—in relation to other rooms, while also illustrating the connections between them. The spaces connecting the exterior, predominantly comprising threshold spaces, such as the doma and the en-gawa, are situated adjacent to the outside and depicted as dotted squares in the diagrams. These schematic diagrams provide abstract illustrations of a house plan with the details eliminated but are still conceptual enough to show the spatial configuration. By translating them into graphs, each unit can be studied as a network, thereby enabling cross-comparisons despite the diversity in designs. The size of the tatami shown in Figure 2 provides a rough estimate of the scale. In this study, network measures were computed using UCINET version 6.0 [25].



(**a**) Plan Diagram (**b**) Graph

Figure 2. Example of plan diagram and graph. Legend: 1—outdoor space; 2—doma; 3—hall; 4—anteroom; 5—parlour; 6—sitting room; 7—kitchen; 8—bathroom; 9—toilet; 10—en-gawa; 11—study; 12—maid's room; 13—corridor; 14—washroom/changing room; 15—urinal.

Table 1. Network analysis results.

#	N	MD	DC	Closeness Centrality *1 and Core–Periphery Structure *2 with Room Names *3																
T1	15	2.5	28.6	53.8	53.8	45.2	45.2	43.8	42.4	42.4	41.2	41.2	40.0	35.9	35.9	31.8	30.4	23.7		
				13	3	10	5	4	1	6	2	7	14	12	8	11	15	9		
				C	*H*	*V*	*P*	*A*		*S*	*Do*	*K*	*w*	*M*	*b*	*St*	*u*	*t*		
T2	17	2.5	25.0	48.5	45.7	42.1	42.1	42.1	42.1	39.0	39.0	38.1	37.2	37.2	33.3	33.3	33.3	28.1	27.6	25.4
				16	17	3	10	6	4	1	7	5	2	14	13	12	8	11	15	9
				C	*C*	*H*	*V*	*S*	*A*		*K*	*G*	*Do*	*Do*	*u*	*t*	*b*	*St*	*t*	*t*
T3	15	2.8	34.6	63.6	53.8	50.0	48.3	48.3	46.7	45.2	43.8	42.4	42.4	40.0	40.0	37.8	33.3	30.4		
				11	7	3	5	1	10	6	12	14	13	2	4	8	15	9		
				C	*DK*	*H*	*A*		*V*	*S*	*M*	*u*	*w*	*Do*	*P*	*b*	*sr*	*t*		
T4	15	2.5	28.6	60.9	53.8	46.7	45.2	43.8	43.8	42.4	42.4	41.2	41.2	38.9	37.8	36.8	29.8	28.0		
				15	3	5	10	4	7	1	6	2	13	12	14	11	8	9		
				C	*H*	*A*	*V*	*P*	*K*		*S*	*Do*	*w*	*M*	*u*	*St*	*b*	*t*		
T5	12	2.5	27.3	61.11	57.9	55	50	45.83	45.83	44	42.31	40.74	39.29	34.38	29.73					
				12	3	4	7	2	1	10	5	11	6	8	9					
				C	*H*	*P*	*K*	*Do*		*V*	*A*	*u*	*S*	*b*	*t*					
T6	11	2.5	54.4	76.92	55.56	55.56	52.63	52.63	50	45.46	45.46	45.46	45.46	34.48						
				3	7	6	5	2	11	4	8	1	10	9						
				C	*K*	*S*	*P*	*Do*	*u*	*Rm*	*b*		*V*	*t*						
T7	15	2.7	35.7	60.9	53.8	45.2	43.8	43.8	43.8	41.2	41.2	40.0	37.8	37.8	36.8	34.1	28.0	28.0		
				4	13	10	14	7	3	5	6	12	9	11	1	2	8	15		
				L	*C*	*V*	*Rm*	*K*	*H*	*G*	*D*	*Rm*	*u*	*w*		*Do*	*b*	*t*		
T8	14	2.3	33.3	52.0	52.0	41.9	39.4	39.4	39.4	36.1	36.1	35.1	33.3	33.3	31.7	30.2	24.5			
				3	12	13	4	10	2	6	11	5	1	7	14	8	9			
				L	*C*	*w*	*S*	*V*	*Do*	*G*	*Rm*	*St*		*K*	*u*	*b*	*t*			
T9	18	2.2	18.4	50.0	43.6	40.5	37.8	37.8	36.2	35.4	33.3	32.7	30.9	30.4	30.4	28.8	27.9	26.2	23.6	23.6	21.0
				4	10	13	3	7	1	5	16	2	11	15	14	6	12	17	9	8	18
				LD	*V*	*C*	*H*	*K*		*P*	*w*	*Do*	*Rm*	*u*	*w*	*Rm*	*M*	*u*	*t*	*b*	*t*
T10	14	2.4	41.3	68.4	56.5	48.1	48.1	48.1	46.4	44.8	44.8	43.3	41.9	41.9	41.9	37.1	31.7				
				13	3	5	7	6	10	14	1	4	2	12	8	11	9				
				C	*H*	*L*	*K*	*Rm*	*V*	*u*		*P*	*Do*	*M*	*b*	*Rm*	*t*				
T11	18	2.1	19.1	45.9	43.6	42.5	38.6	37.0	35.4	34.0	32.1	32.1	32.1	30.9	30.4	27.4	26.6	26.6	24.6	24.6	21.8
				3	13	5	7	6	18	2	10	11	4	12	1	16	14	17	8	9	15
				H	*C*	*L*	*K*	*D*	*C*	*Do*	*u*	*w*	*P*	*M*		*Rm*	*St*	*sr*	*b*	*t*	*Rm*
T12	17	2.7	9.2	48.5	45.7	44.4	43.2	43.2	43.2	39.0	39.0	38.1	37.2	34.8	32.7	32.7	32.0	31.4	25.0	24.6	
				6	4	17	3	13	7	14	1	10	2	5	16	15	11	12	9	8	
				D	*L*	*C*	*H*	*C*	*K*	*Rm*		*V*	*Do*	*P*	*D*	*Rm*	*w*	*M*	*t*	*b*	

Table 1. *Cont.*

#	N	MD	DC	Closeness Centrality *1 and Core–Periphery Structure *2 with Room Names *3															
D1	10	2.0	27.8	56.3	52.9	45.0	45.0	42.9	37.5	32.1	32.1	31.0	31.0						
				4	2	6	7	10	8	5	9	1	3						
				DK	*H*	*b*	*Rm*	*Do*	*B*	*t*	*b*		*sr*						
D2	9	2.0	32.1	61.5	57.1	44.4	44.4	42.1	42.1	40.0	32.0	30.8							
				2	4	9	6	7	5	3	1	8							
				H	*DK*	*Do*	*Rm*	*Rm*	*b*	*t*		*B*							
D3	10	2.0	41.7	69.2	52.9	50.0	47.4	47.4	42.9	36.0	36.0	34.6	33.3						
				3	4	9	2	8	7	6	5	10	1						
				LDK	*w*	*B*	*Do*	*Rm*	*Rm*	*b*	*t*	*sr*							
D4	8	2.3	71.4	87.5	58.3	58.3	53.8	53.8	50.0	50.0	38.9								
				2	8	6	5	7	3	4	1								
				DK	*Do*	*Rm*	*Rm*	*B*	*t*	*b*									
D5	11	2.2	58.9	76.9	55.6	50.0	50.0	50.0	45.5	45.5	45.5	40.0	40.0	34.5					
				2	6	8	11	7	4	5	3	9	10	1					
				H	*DK*	*Rm*	*Do*	*Rm*	*b*	*sr*	*t*	*Rm*	*B*						
D6	12	2.0	32.7	64.7	52.4	47.8	44.0	40.7	40.7	36.7	36.7	35.5	33.3	33.3	31.4				
				3	7	4	2	11	10	12	8	9	5	6	1				
				C	*LDK*	*w*	*Do*	*Rm*	*Rm*	*B*	*Rm*	*G*	*t*	*b*					
D7	11	2.2	34.4	62.5	52.6	47.6	43.5	41.7	41.7	35.7	35.7	35.7	35.7	27.0					
				4	8	3	6	5	7	2	11	9	10	1					
				LDK	*w*	*H*	*Rm*	*Rm*	*Rm*	*Do*	*B*	*t*	*b*						
D8	16	2.5	19.5	53.6	48.4	45.5	40.5	39.5	37.5	37.5	36.6	30.0	30.0	30.0	29.4	29.4	28.8	28.8	27.8
				3	5	4	9	11	2	6	14	15	16	10	7	8	13	12	1
				C	*LD*	*K*	*L*	*w*	*Do*	*C*	*B*	*B*	*B*	*Rm*	*Rm*	*Rm*	*b*	*t*	
D9	10	2.0	41.7	69.2	52.9	52.9	42.9	42.9	42.9	37.5	37.5	36.0	36.0						
				3	6	2	4	5	7	8	10	9	1						
				C	*DK*	*Do*	*t*	*b*	*Rm*	*Rm*	*B*	*sr*							
D10	10	2.0	55.6	75.0	56.3	50.0	45.0	45.0	45.0	45.0	39.1	39.1	34.6						
				3	6	2	4	5	7	9	8	10	1						
				C	*DK*	*Do*	*t*	*b*	*Rm*	*sr*	*Rm*	*B*							
D11	11	2.4	32.2	62.5	52.6	50.0	47.6	43.5	41.7	37.0	35.7	35.7	35.7	27.8					
				7	4	3	10	9	11	2	6	8	5	1					
				DK	*w*	*H*	*Rm*	*Rm*	*B*	*Do*	*b*	*Rm*	*t*						
D12	12	2.0	32.7	64.7	55.0	47.8	45.8	40.7	40.7	40.7	37.9	36.7	36.7	33.3	33.3				
				3	2	4	9	7	8	10	11	12	1	5	6				
				DK	*Do*	*w*	*Rm*	*Rm*	*Rm*	*Rm*	*B*	*sr*		*t*	*b*				

Table 1. *Cont.*

#	N	MD	DC	Closeness Centrality *1 and Core–Periphery Structure *2 with Room Names *3														
D13	12	2.2	3.9	61.1	52.4	45.8	45.8	42.3	39.3	39.3	39.3	37.9	32.4	32.4	32.4			
				3	6	10	2	7	5	4	11	8	9	1	12			
				C	*DK*	*Rm*	*Do*	*L*	*b*	*t*	*B*	*Rm*	*Rm*		*sr*			
D14	12	2.0	21.8	61.1	50.0	45.8	45.8	39.3	35.5	35.5	34.4	32.4	32.4	32.4	32.4			
				3	9	4	2	7	11	10	8	6	1	5	12			
				DK	*L*	*w*	*Do*	*Rm*	*B*	*Rm*	*Rm*	*b*		*t*	*sr*			
D15	13	2.0	39.4	66.7	48.0	48.0	48.0	41.4	41.4	41.4	34.3	34.3	33.3	33.3	33.3	33.3		
				3	7	2	4	8	9	10	11	12	1	5	6	13		
				C	*DK*	*Do*	*w*	*Rm*	*Rm*	*Rm*	*G*	*B*		*t*	*b*	*sr*		
D16	12	1.8	45.5	68.8	50.0	50.0	45.8	42.3	42.3	42.3	34.4	34.4	34.4	34.4	32.4			
				3	4	2	7	8	9	10	5	6	1	12	11			
				C	*w*	*Do*	*DK*	*Rm*	*Rm*	*Rm*	*t*	*b*		*sr*	*B*			
M1	12	2.3	4.0	68.8	57.9	47.8	47.8	45.8	45.8	45.8	42.3	40.7	40.7	37.9	32.4			
				3	8	2	9	10	5	12	7	1	11	4	6			
				C	*LD*	*Do*	*Rm*	*Rm*	*w*	*T*	*t*		*B*	*K*	*b*			
M2	12	2.3	18.2	55.0	52.4	47.8	45.8	42.3	39.3	37.9	37.9	36.7	35.5	28.9	28.2			
				4	3	8	12	9	6	11	2	5	10	7	1			
				C	*LDK*	*sr*	*C*	*Rm*	*w*	*B*	*Do*	*t*	*Rm*	*b*				
M3	9	2.0	32.1	61.5	50.0	50.0	44.4	42.1	42.1	40.0	36.4	32.0						
				6	3	4	8	5	2	7	1	9						
				C	*LDK*	*F*	*w*	*T*	*Po*	*t*		*b*						
M4	13	2.5	25.0	57.1	50.0	50.0	48.0	42.9	41.4	38.7	37.5	36.4	35.3	34.3	28.6	28.6		
				5	4	6	2	3	8	10	7	13	1	9	11	12		
				LD	*C*	*F*	*T*	*K*	*sr*	*w*	*Rm*	*Do*		*Rm*	*t*	*b*		
M5	16	2.1	21.9	41.7	39.5	35.7	34.1	31.3	31.3	30.0	30.0	26.3	26.3	25.9	25.9	25.0	24.2	21.4	20.8
				5	4	3	10	2	8	7	6	13	12	11	14	1	9	16	15
				C	*H*	*Do*	*LD*	*T*	*w*	*Rm*	*t*	*T*	*Rm*	*K*	*An*		*b*	*T*	*t*
M6	13	2.0	29.6	57.1	52.2	42.9	41.4	38.7	37.5	37.5	37.5	35.3	35.3	32.4	27.9	25.0			
				4	7	3	12	11	5	9	6	13	8	2	10	1			
				LD	*C*	*Do*	*T*	*Rm*	*K*	*w*	*Rm*	*B*	*t*	*Po*	*b*				
M7	10	2.0	27.8	56.3	50.0	45.0	39.1	39.1	37.5	34.6	34.6	28.1	26.5						
				5	3	6	7	10	2	4	8	1	9						
				LD	*H*	*K*	*Rm*	*B*	*Do*	*t*	*w*		*b*						
M8	17	2.4	25.8	48.5	48.5	41.0	40.0	39.0	38.1	35.6	34.8	34.8	33.3	33.3	32.7	29.1	29.1	26.7	26.2	26.2
				10	4	14	9	13	3	11	7	15	6	5	2	1	17	12	8	16
				LD	*C*	*T*	*K*	*B*	*Do*	*Rm*	*w*	*An*	*t*	*Rm*	*Po*		*Do*	*B*	*b*	*t*

Table 1. *Cont.*

#	N	MD	DC	Closeness Centrality *1 and Core–Periphery Structure *2 with Room Names *3														
M9	10	1.8	16.7	52.9	47.4	42.9	39.1	36.0	33.3	33.3	29.0	27.3	25.7					
				4	3	5	7	2	8	6	10	1	9					
				LD	*H*	*K*	*Rm*	*Do*	*w*	*t*	*B*		*b*					
M10	12	2.2	3.9	61.1	50.0	50.0	47.8	45.8	44.0	42.3	40.7	39.3	34.4	33.3	30.6			
				4	5	3	2	7	11	8	12	10	6	1	9			
				C	*LD*	*Do*	*Po*	*Rm*	*T*	*w*	*B*	*t*	*K*		*b*			
M11	15	2.4	29.7	60.9	50.0	45.2	43.8	41.2	38.9	38.9	35.9	35.9	35.9	35.0	35.0	35.0	29.8	26.9
				5	8	3	6	13	7	12	2	11	10	15	4	9	14	1
				H	*LD*	*Do*	*Rm*	*w*	*Rm*	*t*	*Po*	*T*	*Pa*	*K*	*B*	*Rm*	*b*	
M12	14	2.1	25.6	59.1	50.0	46.4	46.4	44.8	41.9	40.6	39.4	38.2	34.2	34.2	32.5	31.7	29.5	
				6	8	9	5	4	2	11	3	7	10	14	13	1	12	
				C	*LD*	*Rm*	*Do*	*Po*	*T*	*w*	*T*	*t*	*sr*	*K*	*B*		*b*	

Note: *1 Closeness centrality is ordered from the highest-ranked node (left side) to the lowest (right side). *2 Core–periphery structure is depicted with nodes representing the core indicated by underlining. *3 *Do*: doma; *H*: hall; *A*: anteroom; *C*: corridor; *P*: parlour; *G*: guest room; *S*: sitting room; *St*: study room; *M*: maid's room; *K*: kitchen; *D*: dining room; *DK*: dining + kitchen; *L*: living room; *LD*: living + dining room; *LDK*: living + dining + kitchen; *Rm*: room; *V*: verandah; *T*: terrace; *B*: balcony; *t*: toilet; *b*: bathroom; *u*: urinal; *w*: washroom/changing room; *Po*: porch; *F*: free space; *An*: annex; *Pa*: patio; *sr*: storage room/service room. Numbers correspond to Figure 3 diagram.

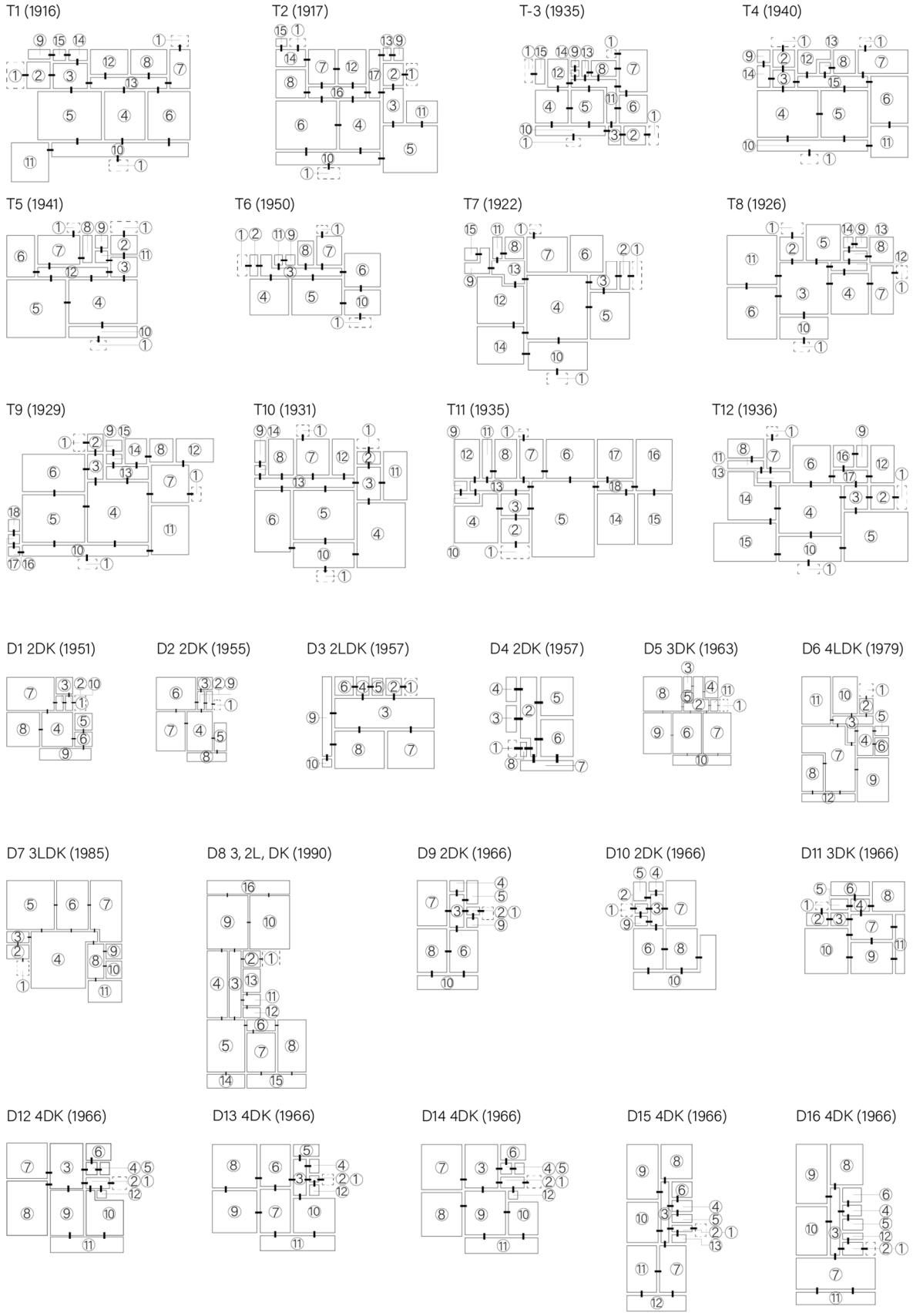


Figure 3. *Cont*.

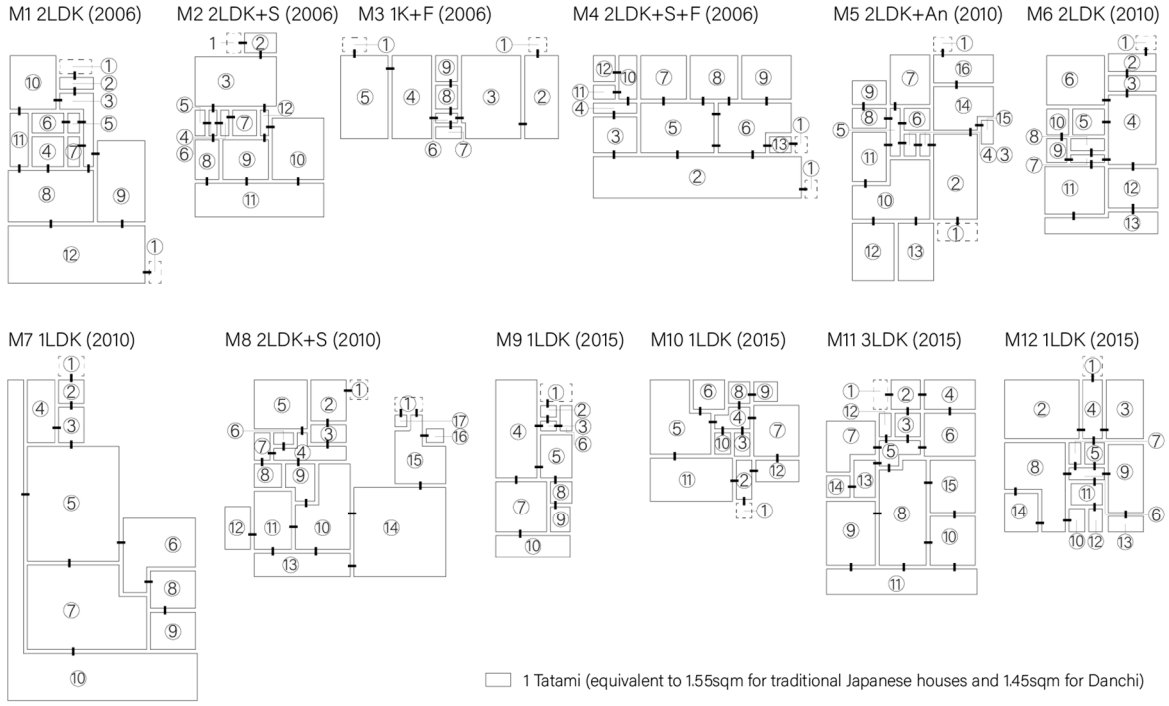


Figure 3. Diagram showing spatial configuration of house plans from various periods. Numbers correspond to Table 1 with room names.

2.3.1. Number of Nodes, Mean Depth, Degree Centralization, Closeness Centrality, and Core–Periphery Structure of a Network

After translating all the house plans into graphs, network analysis was utilised to determine the number of nodes, the mean depth, degree centralization, closeness centrality, and core–periphery structure, which can be useful in identifying social activities defined by space [26,27]. First of all, the number of nodes is calculated to simply determine the size of a house by counting the number of rooms that exist in the house plan. This also includes a node for the outdoor space.

The mean depth identifies the average number of steps from one node to another. In other words, it informs the distance between two places within the house by identifying the number of rooms one needs to travel from one place to another. A greater mean depth means more rooms to pass through from an origin to a destination.

The degree centralization shows how unequal the distribution of centrality is in a network [28]. It measures the number of connections of a room and how much variance there is in the distribution of the centrality of a network on a macro level. For example, the two extremes can be represented as star-shaped and wheel-shaped networks, which are measured as 100% and 0%, respectively. A node located in the centre of a star is universally assumed to be structurally more central than any other node in any other position. On the other hand, a wheel shape is more dispersed and enables more options to reach from one room to another [29].

Closeness centrality measures the characteristic of a room's position in a network on a micro level and can be considered an index of the expected time-until-arrival for things flowing through the network via optimal paths [29]. It emphasizes the distance of a node to all others in the network, and although it measures the position globally, it is a characteristic of a node's position in a network. Therefore, it examines and ranks each node according to the room closest to all rooms in the house.

The core–periphery structure is the arrangement of a network with a dense "core" of tightly connected nodes and a sparse "periphery" of nodes loosely connected to the core and each other [30]. While the degree centralization measures a network on a macro level and closeness centrality measures a network on a micro level, the core–periphery

structure can be useful to investigate meso-level features that lie between the macro and the micro levels [31]. It helps represent the house plan as a network system with a community structure and description of a network's organization around its core. In this research, the number of nodes was used to suggest the house size, mean depth, and degree centralization to understand the traversal circulation, closeness centrality, and core–periphery structure to characterize threshold spaces and analyse the family space.

3. Results

3.1. Number of Nodes

The number of nodes refers to the number of various spaces in the house. It suggests the scale of a house despite the fact it may not correlate to the actual size in terms of the floor area. Table 1 shows the network analysis results. Here, the number of nodes before the war in the traditional houses was rather high, but it dropped during the post-war period. This implies that houses in the city area became smaller or rather compacted due to population growth alongside the one-storied detached public houses (#T5, T6) provided by the *Jūtaku Eidan* in the urban areas. There are few differences when comparing centre-corridor plans (#T1–T6) and centre-living room types (#T7–T12), with an average of 14.2 and 16.0, respectively. However, differences can be seen in the private houses of both cases (#T1–T4, #T7–T12), with an average of 15.8, and in the public houses (#T5, T6), with an average of 11.5.

This is more obvious in the danchi since it is a multi-story housing block. The housing units are even more compacted, and the average number of nodes for all danchi units (#D1–D16) is 11.2, which indicates the small size of danchi units. Looking closely, the number increases relative to the number of bedrooms. This can be seen clearly in Akabanedai danchi units (#D9–D16), where 2DKs are 10, 3DK is 11, and 4DKs are either 12 or 13.

On the other hand, the number of nodes of modern danchi (#M1–M12) increased slightly compared to old danchi (#D1–D16), with an average of 12.8, yet the number of rooms did not increase as much. Today, it is quite rare to find 4DK units. Therefore, most cases selected for this research are units with one to two rooms with an LD and K. Despite such consequences, the numbers of modern cases are higher than the danchi since some units contain such spaces that did not exist previously. A free room, porch, terrace, patio, annex room, and large storage room or service room are new room types, which are labeled with "+" after *n*LDK (Figure 3), where *n* indicates the number of bedrooms.

3.2. Mean Depth

The mean depth identifies the average number of steps of the shortest route one needs to take from one room to another. The mean depth is an average of 2.6 for the centre-corridor plan (#T1–T6) and 2.4 for the centre-living room type (#T7–T12). This is higher than that of danchi and modern danchi (2.1 and 2.2, respectively). Looking at case #T3, for example, where the mean depth is the highest at 2.8, four steps are needed to traverse from the house's entrance to the living room, whereas only three steps are needed for most other cases (Figure 3). It is rare to see fewer than three steps regardless of the time period since Japanese houses typically have a doma and a hall and/or a corridor to reach the main room. Furthermore, in general, many steps are needed to reach toilets and bathrooms.

There is a smaller mean depth than traditional houses and danchi types. This is also assumed to be affected by the size of the house compared to traditional houses that are larger and that a danchi has less space joining one room to another continuously. Furthermore, the corridor in the larger danchi units, for example, node 3 in the case of #D16, which is a 4LDK and has the smallest mean depth of 1.8, functions mainly as a core connector of most of the rooms, and these rooms do not expand much to join other places.

However, the mean depth of modern danchi is increased slightly compared to the danchi type. Looking at the #M4 unit plan with a mean depth of 2.5, five steps are needed to reach the kitchen. However, the unique aspect of this danchi is that there is another route that one can take through the terrace. With this route, there are only two steps to the

kitchen once entering from the outside, providing more options in terms of paths one can take to travel from one room to another.

3.3. Degree Centralization

Degree centralization (DC) measures the number of connections on a macro level. The higher the percentage of DC, the more the network connection is concentrated in a specific node, which means one needs to go through a specific space to travel from one room to another, regardless of where they are. Therefore, the travel routes are determined and limited. On the contrary, a lower percentage allows network connections to be dispersed, providing more options to move around the house, thus representing the traversal circulation characteristic in a traditional Japanese house. This can be seen when comparing the average of traditional houses, 27.7% (#T1–T12), versus 38.6% for danchi (#D1–D16). This implies that traditional houses have a more wheel-shaped network than danchi, which is a star-shaped network.

Looking closely at the centre-living room type—which conceptually positions the living room, a family gathering place, as the central place of the house, where rooms are accessed via it—the network shows various circulation options within the house. The centre-living room type combines the spatial character of the centre-corridor plan. However, the centre-corridor plan has a slightly higher average percentage of DC than the centre-living room type. This can be understood by the fact that many rooms are branched out from the corridor, creating a more star-shaped network while providing traversal circulation.

Overall, the results of this study indicate an increase in DC as housing units become more compact, evidenced by a negative correlation between the number of nodes and DC. This suggests that a decrease in the number of nodes is associated with an increase in DC, implying a denser, more interconnected network within smaller housing configurations. The rise in DC within danchi configurations suggests reduced traversal circulation within the house. However, contemporary danchi exhibit characteristics similar to traditional houses, particularly those with a central living room layout, offering more pathways for moving from one room to another. Moreover, the presence of transitional spaces, such as wash rooms or changing rooms, consistently adjoining toilets and bathrooms affects the overall network by making it more dispersed rather than concentrated. This characteristic is evident across all three types examined and is further elaborated through the mean depth analysis in Section 3.2.

3.4. Closeness Centrality

Closeness centrality measures and ranks each node according to the room that is the closest to all rooms, classifying the most central place within the house. Closeness centrality in Table 1 is arranged from the highest-ranked node on the left side of the column to the lowest on the right, with node number and room names noted below. It is clearly defined that corridors are the most central place in the centre-corridor plan, while living rooms or dining rooms are the most central in the centre-living room type in traditional houses. For both danchi and modern danchi, either the corridor, DK, or LD is the most central place. Since the DK has been altered to an LD in modern danchi, this has separated the dining room and the kitchen while being integrated with the living room instead. The kitchen, therefore, has been positioned in a less central place in many cases, similar to traditional houses. However, the difference is in the kitchen's position, where it is adjacent to the LD in modern danchi, whereas most traditional houses have an outdoor space as one of their adjacent nodes.

3.5. Core–Periphery Structure

The core–periphery structure typically partitions a network into two sets, a core and a periphery, where there are dense connections within the core and sparse connections within the periphery, thus identifying community within a network. In Table 1, the core–periphery structure is depicted with nodes representing the core highlighted by underlining.

For traditional houses, either a sitting room, a parlour, a living room, or sometimes a combination of several of these, along with the corridor and/or a hall, acts as the core in terms of the core–periphery structure. A total of 7 (#T1, T2,T 4,T 5,T 7, T10, and T12) out of 12 houses has a kitchen as the periphery.

On the contrary, corridors or halls (if there is no corridor), DK, and sometimes a doma are typically the core in the danchi case. With the introduction of the DK and LDK, the kitchen became part of the core instead of the periphery. When looking at Akabanedai danchi, specifically #D9–D16, balconies are also included in many units. For modern danchi (#M1–M12), corridors and/or halls and the LD are the core, similar to the danchi case; however, the difference is that kitchens are always at the periphery. On top of this, there are unit types with more than one core, which can be seen in #M5, M6, M10, and M12. The house plans show that node 3 of #M5 and #M6; nodes 3, 7, and 11 of #M10; and nodes 2 and 3 of #M12 are classified under the periphery, separating the core into multiple core structures.

4. Conclusions and Discussion

This study aimed to understand how traditional spaces in Japanese houses maintained their meaning while transforming into modern living environments, with a particular focus on public housing, *danchi*. To achieve this, this research conducted a comparative analysis among traditional houses, danchi, and modern danchi using network analysis, where the number of nodes was used to determine the house size, mean depth, and degree of centralization to understand the traversal circulation, closeness centrality, and core–periphery structure to characterize threshold spaces and analyze the family space. This section provides the conclusions and discussion in the order of the role of threshold spaces, traversal circulation, and the family gathering space.

4.1. The Role of Threshold Spaces

4.1.1. Doma

The doma acts as a separation between the outdoors and the indoors. Therefore, it avoids bringing dirt inside the house. In other words, it is a buffer space used to allow for the removal of dirt before entering into the clean space, the interior space of one's home. In this research, almost all houses included in the three house types still maintained a doma in the house plans located adjacent to the entrance node. While the space allocated to the doma may have reduced in both danchi and modern danchi, its fundamental role as a threshold space for removing shoes and dirt remains intact.

4.1.2. En-Gawa

The *en-gawa* is usually located between the house and the private garden, similar to the doma, which can be seen in most traditional houses. For danchi, it has been replaced by a balcony. Since multi-story houses normally do not have a private garden in each unit, it may not allow for traversal circulation between the outdoors and the indoors and between various rooms that traditional en-gawa may have allowed for. However, it still supports some activities found in the garden, such as hanging laundry and growing plants. The same can be said for modern danchi. However, differences can be found in the development of doma and en-gawa that have been replaced by a new category of spaces named "terrace", "porch", and "patio" that bridge outdoor and indoor areas.

4.1.3. Centre-Corridor

The role of the centre-corridor traditionally was to connect various rooms while also separating the circulation of the family, guests, and maids. It demarcates the space clearly between family and guest zones and the maids' housekeeping circulation. The centre-corridor plan of traditional houses has the corridor as the most central place within the house, whereas the centre-living room type replaces it with a living room. This can be seen in the closeness centrality analysis of this research, where the living rooms and/or dining

rooms are the most central place for the centre-living room type, which meets the design intention of such a house plan.

On the other hand, corridors still act as the central place for most danchi, although the role may not have retained its original meaning of connection and separation. It acts to connect various rooms rather than separate them. In some cases, corridor spaces were minimized and diminished, replaced by a DK as the centre, similar to the centre-living room type. This was probably effective in optimizing the limited floor areas of small danchi units. As for modern danchi, we can see more corridors due to the size increase in each unit, which can be seen in the average number of nodes, but another aspect is the introduction of other threshold spaces such as the "terrace" and "porch" used to function as part of the connecting space.

4.2. Traversal Circulation

Traversal circulation was important to provide alternative paths for the family to move from one room to another. This was especially notable in cases such as when family members needed to use the toilet while guests were present; providing them with another route was important to avoid any disturbance from both sides. On top of this, it separated the maids' and family's circulation. This was the standard for most houses until employment of maids slowly disappeared, and Western living styles were simultaneously introduced, which could be seen in the emergence of the centre-living room house type.

Using mean depth and DC analysis, we can see that traditional houses form a wheel-shaped network, allowing for traversal circulation, whereas the danchi type has less circulation and is more of a star-shaped network. Traversal circulations between outdoor and indoor were lost when balconies replaced the en-gawa. Surprisingly, modern danchi are quite similar in terms of the mean degree and DC to traditional houses compared to danchi; it is more of a wheel-shaped network, allowing for traversal circulation and supporting an outdoor–indoor relationship. When en-gawas were transformed into balconies within the evolution of traditional houses to danchi, they lost their role of circulation where people could access the house from both the main entrance and the garden. However, despite the absence of traditional gardens in modern danchi, traversal circulation has been reintroduced with thoughtful layout plans that incorporate new types of threshold spaces, as mentioned in Section 4.1.

4.3. Family Gathering Space

The traditional family gathering space known as *chanoma*, which is a sitting room. Since this was used for family members only, the guests used the parlour when they visited one's home. Therefore, there were both sitting rooms and parlours in a typical Japanese house plan. Over time, as Western lifestyles became more influential, the sitting room was often replaced by a living room, a change encouraged by the introduction of Western lifestyle with placing furniture such as sofas and dining tables. Subsequently, the centre-living room type was proposed, but it still allowed for parlours to be present in some cases.

In traditional houses, the centre-corridor plan had corridors positioned to rank highest in terms of closeness centrality, while living rooms were ranked higher for most of the centre-living room type. In terms of core–periphery analysis, either a sitting room, parlour, living room, or sometimes a combination of several of them, along with a corridor and/or hall, acted as the core. Kitchens were typically located at the periphery of most houses. Thus, we can say that the classifications of the "centre-corridor plan" and "centre-living room type" effectively reflect their intended architectural functions and spatial dynamics.

On the other hand, since danchi units are smaller, seen in the average number of nodes, and became more compact, sitting rooms and parlours were mostly replaced by a DK to rationalize the limited space. Consequently, the family gathering space has merged with the kitchen. In contrast to the centre-living room type, the DK has become the centre of the house and the primary area for family gatherings in most danchi. Moreover, the DK

and/or living room, along with a corridor and/or a hall, often form the core in terms of the core–periphery structure, thus incorporating the kitchen into the core nodes. Therefore, danchi can aptly be classified as a "centre-DK type".

In modern danchi, the DK has evolved into either a LD or LDK, maintaining a similar spatial relationship as the rest of the rooms of typical danchi. However, with the separation of the kitchen now being an independent node, it has again been positioned as part of the periphery, much like in traditional house plans. The difference can be seen when looking closely at the position of a kitchen (K) in modern danchi plans, which will always be located adjacent to the LD, which means the proximity to the dining room (D) is still maintained. This layout allows for the kitchen to functionally separate but still readily integrated into the family gathering space, facilitating both distinct utility and communal interaction.

As alternatives to the parlours of traditional houses, there are other room types, such as "free space", "service rooms", or "annex" emerging in modern danchi plans. These rooms are designed to accommodate the diverse lifestyles prevalent today, providing residents with flexible spaces that can be used for purposes such as home offices (SOHO) or tailored to meet different household needs. The introduction of these versatile room types into modern threshold spaces has led to the formation of multiple cores within the housing units, as evidenced by core–periphery analysis. Given this, the character of modern danchi can be described as a "centre-LD type" or, in some configurations, as a "multi-core type" reflecting the complex and varied use of space in contemporary living environments.

4.4. Summary of Continuity and Change

In response to the evolving social environment, traditional house plans in Japan have undergone significant transformations, giving rise to the modern danchi. This evolution has seen certain architectural elements retain their essence, while others have adapted to better align with contemporary lifestyles.

Despite a reduction in size, the doma has remained a consistent feature in Japanese house plans, from traditional settings to modern danchi, its sustained presence underscoring a significant cultural relevance. Similarly, the function of centre-corridors in connecting various rooms has largely been preserved in danchi. Although the social dynamics of space utilisation—such as the separation of areas for family, guests, and maids—have diminished, the architectural importance of these corridors continues.

In contrast, the traditional en-gawa, which once facilitated seamless movement between indoor and outdoor spaces, has been largely supplanted by balconies in contemporary designs. However, the spirit of the en-gawa as a connector persists through new architectural elements such as terraces, porches, and patios. The transition from en-gawa to balconies initially led to a reduction in traversal circulation, yet this feature has experienced a resurgence in modern danchi designs, reintegrated through new threshold spaces that enhance the indoor–outdoor connection.

Historically, family interactions were centred around dedicated sitting rooms and parlours. These traditional gathering spaces have been replaced by the dining kitchen (DK), which has become the focal point of household interactions in most danchi. Over time, the DK has evolved into more expansive configurations like the living dining kitchen (LDK), reflecting a broader shift towards flexible and versatile living arrangements. Additionally, modern danchi plans have introduced elements such as "free space", "service rooms", and "annexes", designed to cater to the complex and varied needs of modern living, marking a significant evolution from traditional house plans.

This analysis delineates the dynamic nature of architectural adaptation in response to changing societal needs, providing a clearer understanding of how traditional components have been reinterpreted or replaced to form the backbone of modern danchi architecture.

4.5. Limitations of This Study

Despite the house plan analysis clarifying the role and purposes of various types of spaces and providing new insights into understanding the transformation of house plans

from traditional to danchi and then to modern danchi, this study focused only on the spatial relationships between rooms. It did not include the degree of permeability between rooms; in other words, the types of partition that can influence how people use the space dynamically were not considered. For example, shoji sliding doors seen in Japanese *tatami* rooms can merge two to three or more rooms and be used almost as one big room, which can influence the way people use the space. Therefore, the flexibility of partitioning the rooms seen in Japanese houses is another qualitative dimension that has the potential to enrich the study. This research can also be further elaborated upon by revisiting the traditional qualitative approach of observing the actual activities and the way rooms are used, as well as how the furniture layouts influence the way people use the space.

Funding: This research received no external funding.

Institutional Review Board Statement: No applicable.

Informed Consent Statement: No applicable.

Data Availability Statement: The original contributions presented in the study are included in the article.

Conflicts of Interest: The author declares no conflicts of interest.

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