1. Introduction
During the past years, researchers have based their studies of cities’ and buildings’ spaces on the Space Syntax Theory (SST), initiated by Bill Hillier (1984)[1]. SST defines movement and occupation as the fundamental functions of a space, and the measures they use are configurational: they calculate the relation between spaces within a system. Not much later, arose the idea of the natural movement(1993)[2] referring to the distribution of movement which is consequence of the spatial configuration.

Several papers explored the relations between the SST measures and social and economic activities within the space. This research deals with (1) examining two different case studies in the city of Nagoya, unifying the criteria for measures in both cases; (2) expansion and re-analyze of the studied areas; (3) comparison of results from both cases; and (4) conclusions.

2. Background researches on Space Syntax and underground malls in Nagoya city
Space Syntax is a set of techniques for analysing spatial configuration. In order to set a proper context, we explain briefly the basic concepts in which both, the SST and the software we used for the analyses, are based on.

3. Data collection and analyses method
After reviewing relevant literatures, we set the steps to develop the study, focusing on two different case studies located in the city of Nagoya: Sakae and Nagoya station (hereinafter Meieki) (fig. 1 and 2). Each has been previously studied by Mizuno[3] and Okamoto[4]. Both are divided into two parts: “closed” (exclusively the space that belongs to the underground malls) and “open” (including the directly neighboring spaces, i.e., the ground level sidewalks to which the malls access directly, and the basements and ground floors of adjacent commercial buildings) cases.

In order to obtain the number of users of the underground malls, avoiding commuters, we used the gate count survey, described by Grajewski[5], setting a number of “gate locations” in both case studies: 30 above ground and 55 underground in the Sakae study case; 30 and 50 gates respectively in the Meieki case.

This was followed by the collection and extension of data, the analyses of spatial configuration, and the several correlation and multiple linear regression analyses. Then, we first identify, for each case separately, the impact that “opening” the analysed space had on the measurements. Second, we compare the results in both “open” cases.
4. Sakae underground mall case study

Located in the centre of Nagoya CBD, the Sakae underground mall spreads around an area of approx. 83,199m². It started developing in 1957, together with the project of the first subway line in Nagoya (Higashiyama line), and continued expanding until 2002. Hosting more than 320 shops, it connects the exits of three different subway lines together with several commercial buildings surrounding the mall, especially in the south-west area.

4.1 Candidate variables list

After evaluating the results of Mizuno[3], we established what variables we would measure:

For the closed ones, connectivity (CNT), visual step depth from the station entry/exit (VSDS), metric shortest path from the station entry/exit (MSPS), global integration value (GIV), local integration value (LIV, \( r=3 \)), tenant count visual within step depth (TCD, d=1), and tenant count within metric distance (TCM, d=50m) were the selected measurements.

For the open cases, we put a special stress in factors measuring the relationship with commerce. Thus, adding to the ones already selected (CNT, VSDS, MSPS, LIV \( r=3 \), TCD, and TCM d=50m), we set two more variables: visual step depth from the entrance of adjacent commercial buildings (VSDA), and metric shortest path to adjacent commercial buildings (MSPA).

4.2 Closed case

As mentioned before, the layout for the “closed” case is limited to the area of the underground mall, ignoring connections to commercial buildings and ground floor.

After conducting the analysis, we proceeded to the correlation analyses, where we dismissed combinations of variables that, being too similar, presented risks of multicollinearity, i.e. CNT&LIV (0.810).

In the regression models, the two-variable model of: TCD&VSDS with the minimal AIC was accepted.

4.3 Open case

The called “open” case, is the result of extending the spatial layout into the directly adjacent areas. As in the “closed” case, we conducted the same analyses (visual graph analyses - correlation - multiple linear regression models). This time, the three-variable model of TCM&VSDS&MSPA was fitted with the minimal AIC.

4.4 Considerations on this case study

In the “open” case, the spatial distribution of LIV (related to natural movement), which is mostly concentrated in the central part of the underground mall in the closed case, looses strength (fig. 3). Also, in the “closed” case, the proximity to both, the subway ticket gates and the mall’s shops, influence the number of pedestrians, while in the “open” case, the presence of commerce within the mall and in adjacent buildings has a stronger impact (fig. 4 and 5). In Sakae mall, the results of both cases show that the presence of commerce has a stronger influence than traffic accessibility, and this fact gets emphasized after extending it into the “open” the spatial layout.
5. Meieki underground mall case study

The Meieki underground mall complex is around the Nagoya Station, another CBD pole of the city. It also started developing in 1957, and it expanded with the increase of nearby commercial buildings reaching approx. 83,345m² in the final extension (1976). The T-shaped underground complex connects two different subway lines, three railways and several commercial buildings in the surrounding area. With a daily average of 1.14 million passengers (2008), it is the largest terminal station in Chubu region.

5.1 Candidate variables list

The research of Okamoto[4] had also two cases: “closed” and “coupled”. The concept of the “closed” case is the same, while our “open” case takes into account more adjacent spaces, also interconnecting them, which simplified the understanding of the influence neighbouring spaces exert on the mall.

Once again, we performed the analyses using the same variables, to facilitate the subsequent comparison: CNT, VSDS, MSPS, GIV, LIV3, TCD and TCM50 for the closed case; and CNT, VSDS, MSPS, VSĐA, MSPA, LIV3, TCD, and TCM50 for the open case.

5.2 Closed case

Once conducted the same analyses steps as previously, we could recognize that, in Meieki, the two-variable model of MSPS&GIV was fitted with the minimal AIC. In this case, the presence of natural movement (related to GIV and LIV) has some influence on the pedestrian movement within the underground mall but, still, the variable with the most impact is the distance to the ticketing gates.

5.3 Open case

When analysing the open case, we opted to maintain the layout of the network as similar as it was four years ago as possible, for we intended to test how the addition of commercial buildings and interconnection between added spaces would have affected the results of the former study, that simply combined the streets and underground mall. This meant we wouldn’t take into account the tenants inside the old DaiNagoya Building, not above nor underground, as it was closed at that time.

In this case, the one-variable model: MSPS was fitted with the minimal AIC. The factor with most influence for this case is the distance to the station ticketing gates, which happens to be the same result Okamoto obtained in his study.

5.4 Considerations on this case study

When expanding into the “open” case, the LIV values decrease in the most crowded areas (fig. 6 and 7), while it increases in the southern part of the mall, with a lower record of pedestrian presence.

This time again, we can see that variables related to natural movement have a slight influence on the pedestrians in the “closed” case study, but once we “opened” the space to analyse, the metric accessibility becomes the most and only factor influencing the pedestrian flow (fig. 8).
6. Comparison

The correlations point some of the differences between both cases: in Sakae we dismissed 4 different values for surpassing the threshold of multicollinearity (0.496) in factors with similar values, while in Meieki there is only 1. This indicates a difference on the morphology and layout of shops: Sakae is more clustered and grid-like, whilst Meieki is more rectilinear and simple. Also, the most favourable combinations are different: in Sakae are all values related with commerce, albeit in Meieki they point into the metrical values.

The regression results (table 2 and 3), show further differences: in Sakae, the strongest influence is the three-variable model of TCM&VSDS&MSPA, with standard partial regression levels of 0.302, -0.274 and -0.221 for each. Also, the correlation coefficient improved for every variable up to a value of 0.471. The three have similar influence, being TCM the one with strongest impact. In the significance test, we recognize a significant difference of less than 1% for the three values separately and also when combined. Another key point is how the lowest AIC is in the three-variable model, increasing again in the next model.

In Meieki, the most influential factor, with the lowest AIC value, is MSPS, with a standard partial regression coefficient of -0.598 and a significant test result under 1%, surpassing the other models.

Provided that the most influencing factors in the “open” cases are: TCM&VSDS&MSPA in Sakae and MSPS in Meieki, we can assume: even though in both the natural movement measurements made a slight appearance in the “closed” cases, there is other more influencing factors. In Sakae, the presence of commerce has the most influence, while in Meieki, it is only the metrical accessibility to the ticketing gates that influences the pedestrian flows.

7. Conclusion

In this research, we evaluated previous case studies, challenging their results, expanding the areas and re-analyzing them. With the results, we examined them individually, understanding the influential factors in each case study and comparing them.

We conclude it is important not only knowing the general characteristics of the space when analysing them (i.e. underground malls), but also another factor: the pedestrian’s main use of the networks. After the analyse, it becomes clear the influence of the use as transport interchanging point of Meieki. On the other side, Sakae has a strong commercial use, boosted by the adjacent buildings and commercial streets.

8. References: