**SUPPLEMENTARY**

1. **Formulas**

This research uses OSMnx to measure the order of a neighborhood street network. OSMnx is a Python package developed by Boeing (2017, 2019) that offers various tools for calculating and presenting street network characteristics, including the entropy of neighborhood street orientations.

* 1. Shannon *Entropy*

where n is the total number of bins, indexes the bins, and P represents the proportion of orientations that fall in the ith bin.



where *n* is the total number of bins, indexes the bins, and P represents the proportion of orientations that fall in the *ith* bin.



* 1. Normalized *Entropy*



where equals 3.584 nats. equals 1.386 nats (Boeing 2019)



* 1. *Betweenness* Centrality

CB ­is betweenness.



where is the number of shortest routes between nodes j and k, and is the number of these shortest paths that overpass node i.



1. **Table**

*Table 1:* Mean values of betweenness and normalized entropies of one-square-mile samples of sixty world’s urban areas.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **City** |  | **φ** | **B** |  | **Block size (m)** |
| West Island | 2.74 | 0.62 | 7,193 | 12.81 | 58.3 |
| Bani Yas | 2.51 | 0.74 | 2,010 | 10.97 | 82.9 |
| Al Bahya East | 2.27 | 0.82 | 1,499 | 10.55 | 88.4 |
| MBZ | 2.3 | 0.83 | 1,323 | 10.37 | 101.1 |
| Khalifa | 2.19 | 0.86 | 838 | 9.71 | 108.6 |
| Falah | 2.17 | 0.84 | 750 | 9.55 | 136.5 |
| Al Bahya West | 1.66 | 0.98 | 118 | 6.88 | 192.8 |
| Bangkok | 2.86 | 0.55 | 6,245 | 12.61 | 57.6 |
| Beijing | 2.18 | 0.87 | 1,038 | 10.02 | 110 |
| Chandigarh | 2.46 | 0.76 | 2,785 | 11.44 | 79.5 |
| Hanoi | 2.7 | 0.64 | 3,492 | 11.77 | 67.2 |
| Hongkong | 2.75 | 0.61 | 7,853 | 12.94 | 51.1 |
| Melbourne | 2.63 | 0.68 | 7,567 | 12.89 | 50.6 |
| New Delhi | 2.57 | 0.71 | 2,281 | 11.16 | 86 |
| Pyongyang | 2.5 | 0.71 | 3,066 | 11.58 | 85.4 |
| Seoul | 2.79 | 0.59 | 3,352 | 11.71 | 64.4 |
| Shanghai | 2.68 | 0.65 | 4,047 | 11.98 | 92.2 |
| Singapore | 2.79 | 0.59 | 8,097 | 12.98 | 51 |
| Sydney | 2.76 | 0.61 | 9,246 | 13.17 | 46.3 |
| Taipei | 2.76 | 0.61 | 6,376 | 12.64 | 71.4 |
| Tokyo | 2.89 | 0.53 | 29860 | 14.87 | 33.1 |
| Barcelona | 2.71 | 0.64 | 10,770 | 13.39 | 41.5 |
| Berlin | 2.84 | 0.56 | 10,660 | 13.38 | 40.8 |
| Budapest | 2.58 | 0.7 | 3,338 | 11.7 | 61.9 |
| Kiev | 2.84 | 0.56 | 16,398 | 14 | 40.8 |
| London | 2.79 | 0.59 | 16,794 | 14.04 | 37.7 |
| Madrid | 2.81 | 0.58 | 10,406 | 13.35 | 47.3 |
| Moscow | 2.84 | 0.56 | 21,307 | 14.38 | 43.2 |
| Paris | 2.75 | 0.61 | 7,174 | 12.81 | 50.3 |
| Prague | 2.89 | 0.53 | 14,650 | 13.84 | 40.9 |
| Rome | 2.79 | 0.59 | 6,301 | 12.62 | 53.4 |
| Vienna | 2.9 | 0.53 | 14,153 | 13.79 | 38.7 |
| Bogota | 2.68 | 0.65 | 3,998 | 11.97 | 69.1 |
| Brasilia | 2.49 | 0.75 | 4,783 | 12.22 | 65.1 |
| Buenos Aires | 2.44 | 0.76 | 2,967 | 11.53 | 66.5 |
| Caracas | 2.54 | 0.72 | 1,022 | 10 | 116.3 |
| Havana | 2.62 | 0.68 | 2,730 | 11.41 | 68.9 |
| Mexico City | 2.52 | 0.72 | 1,766 | 10.79 | 88.5 |
| Rio de Janeiro | 2.74 | 0.62 | 2,439 | 11.25 | 77 |
| Sao Paulo | 2.61 | 0.69 | 1,652 | 10.69 | 82.1 |
| Baghdad | 2.45 | 0.76 | 1,143 | 10.16 | 118 |
| Beirut | 2.74 | 0.62 | 7,805 | 12.93 | 52.8 |
| Cairo | 2.78 | 0.6 | 19,309 | 14.24 | 40.7 |
| Casablanca | 2.74 | 0.62 | 5,549 | 12.44 | 56.6 |
| Damascus | 2.75 | 0.61 | 2,865 | 11.48 | 74 |
| Dubai | 2.68 | 0.65 | 3,472 | 11.76 | 70.5 |
| Istanbul | 2.79 | 0.59 | 7,592 | 12.89 | 52.6 |
| Jerusalem | 2.73 | 0.63 | 8,213 | 13 | 54.9 |
| Johannesburg | 2.59 | 0.7 | 1,320 | 10.37 | 95.3 |
| Lagos | 2.56 | 0.71 | 1,974 | 10.95 | 94.7 |
| Mogadishu | 2.65 | 0.66 | 4,876 | 12.25 | 58.9 |
| Tehran | 2.76 | 0.61 | 11,748 | 13.52 | 52.8 |
| Boston | 2.84 | 0.56 | 9,457 | 13.21 | 49.4 |
| Chicago | 2.73 | 0.62 | 10,157 | 13.31 | 47.1 |
| Honolulu | 2.66 | 0.66 | 3,329 | 11.7 | 76.5 |
| Houston | 2.65 | 0.67 | 9,245 | 13.17 | 43.8 |
| Las Vegas | 2.66 | 0.66 | 7,508 | 12.87 | 56.6 |
| Los Angeles | 2.64 | 0.67 | 4,253 | 12.05 | 69.2 |
| Manhattan | 2.58 | 0.69 | 5,895 | 12.53 | 53 |
| Miami | 2.48 | 0.75 | 2,849 | 11.48 | 67.6 |
| Phoenix | 2.44 | 0.76 | 3,315 | 11.69 | 87.8 |
| Portland | 2.75 | 0.61 | 14,345 | 13.81 | 43.5 |
| San Francisco | 2.6 | 0.69 | 11,206 | 13.45 | 45.5 |
| Seattle | 2.72 | 0.63 | 17,132 | 14.06 | 39 |
| Toronto | 2.59 | 0.7 | 15,253 | 13.9 | 54 |
| Vancouver | 2.7 | 0.64 | 6,604 | 12.69 | 51.7 |
| Washington | 2.64 | 0.66 | 12,034 | 13.55 | 47.1 |

1. **Figures**



*Figure 3.1:* Betweenness maps of selected samples in Abu Dhabi.



*Figure 3.2:* Betweenness maps of eight selected samples of world’s cities.

**REFERENCES**

Boeing, G. (2017). OSMnx: A Python package to work with graph-theoretic OpenStreetMap street networks. *The Journal of Open Source Software*, *2*(12), 215.

Shannon, C.E., 1948. A mathematical theory of communication. *The Bell System Technical  
Journal* 27, 379–423, p. 623–656.