Random city typology: A path-dependent urban design with irreversible consequences

Alberto Alonso Inope La Rosa, and Vrushab Shekhar

IE School of Economics, Politics & Global Affairs, IE University, Madrid, Spain
E-mail: ainope.ieu2022@student.ie.edu vshekhark.ieu2022@student.ie.edu

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Abstract

This paper builds upon the concept of random city typologies by Burke et al. (2022) by providing an expanded framework for randomness in developing cities. Then, the first and second-level disadvantages of random city typologies are explored. A connection is made between random cities and poor quality of life. The paper also brings attention to the problem of path dependence in random cities and explains why the self-reinforcing mechanisms of informality and urban sprawl impede the remediability of a random city. Two feasible solutions are suggested and evaluated based on the sustainability and competitiveness of the urban design. The first approach relates to the Egyptian solution of building new cities with centrally planned typologies. The second approach applies the 15-minute city standard to pre-existing random cities.

Keywords: Urban design factors, City typologies, Random city, Path dependency, 15-minute city standard (FMC)

I. Introduction

Urbanization represents the largest human migration phenomenon in all history, as more than 56% of the world population live in cities as of 2023[1]. The trends in rural-to-urban migration indicate that by 2025, about 70% of humanity will settle in cities[2]. As a result, the increase in urban population is regarded as a deterministic axiom with no signs of slowing down. For that reason, the field of urban economics has thoroughly studied the causes and consequences of urbanization. The causes are mostly related to better labor opportunities, agglomeration economies, higher salaries, and thus higher remittances for a migrant's family[3]. On the other side, the consequences of urbanization include several urban issues such as pollution, crime, housing shortages, traffic congestion, and urban sprawl[4]. As the urban population increases dramatically, the ability of cities to address these urban issues has become a major concern. Consequently, urban

[1] World Bank, "Urban Development Overview."
[2] World Bank.
[3] Hung and Peng, "Rural-Urban Migration with Remittances and Welfare Analysis."
[4] Burke et al., "Geospatial Analysis Framework for Evaluating Urban Design Typologies in Relation with the 15-Minute City Standards."

economists have focused their research on the sustainable development of cities[5]. In this way, the field seeks to contribute insights that aid cities in their efforts to accommodate higher inflows of urban residents.

However, the literature on urban economics has mostly concentrated on the urban issues of western cities in the United States and Europe[6]. Meanwhile, the academic community has left particular concerns about developing cities relatively untapped. There have been undeniable advances in linking urban economics to development economics[7] and formalizing urban characteristics of developing cities such as Mexico City's street markets[8] or Lagos' urban informality[9]. However, the theory of developing cities remains at its early stages and still dismisses many urban particularities. For instance, the urban form and spatial layout of developing cities is an unexplored subject, which could benefit from a unified framework that expands upon the randomness factor in urban development. Spatial expansion in developing countries differs from the planned suburbanization of American cities[10], where middle to high-earning individuals develop the land on the outskirts. Instead, spatial expansion in developing cities occurs at the peripheries, where land is often sold illegally by land traffickers or occupied by migrants. This peripheral land is developed in an improvised fashion, with self-built irregular establishments and the enmeshing of new and old infrastructure[11]. The resulting urban form is defined by its disorder and lack of homogeneity, which leads to the conspicuous randomness present in developing cities. The factor of randomness is traversal to the spatial organization of developing cities and serves as a heuristic device to characterize developing urban design. However, the urban form of developing cities is understated when it is simplified to only randomness. In reality, the urban form possesses a complex typology derived from the entanglement of developed and developing areas[12], which is characterized by the coexistence of entrenched informality with planned mass-produced housing and private initiatives.

This paper contributes to the literature by formalizing the urban form of developing cities under the typological framework of Burke et al. (2022). The adoption of this framework allows for further exploration of the randomness factor in developing cities and how it affects the spatial distribution of urban design factors. Utilizing the typological framework, this paper endeavors to highlight the intrinsic disadvantages of the urban design present in random city typologies. These disadvantages illustrate how poor urban design is an inhibiting factor for economic development in random city typologies. Additionally, the paper explains the problem of path dependence on urban forms and how it can become a long-term issue for developing countries experiencing rapid urbanization.

[5] Metaxas, Juarez, and Gavriilidis, "Planning and Marketing the City for Sustainability."
[6] Glaeser and Henderson, "Urban Economics for the Developing World."
[7] Harris and Todaro, "Migration, Unemployment and Development."
[8] Heathcott, "Architecture, Urban Form, and Assemblage Aesthetics in Mexico City's Street Markets."
[9] Streule et al., "Popular Urbanization."
[10] Mabin, Butcher, and Bloch, "Peripheries, Suburbanisms and Change in Sub-Saharan African Cities."
[11] Gilbert and De Jong, "Entanglements of Periphery and Informality in Mexico City."
[12] Gilbert and De Jong.

The paper continues as follows: Section 2 covers the main literature related to urban design, city typologies, and the definition of random cities. Section 3 presents a framework of first and second-level disadvantages that are inherent to random cities. Section 4 expands upon the path dependency problem of random cities and explains why self-reinforcing loops suffer from irreversibility. Section 5 presents the feasible solutions for random cities and evaluates how [1] the Egyptian solution, and [2] the 15-minute city standard may counteract the deepening of random typology structures. Finally, section 6 concludes.

2. Literature Review

Urban design is the art of placing physical elements in public spaces for the enjoyment and utilization of the population[13]. These physical elements are defined as urban design factors, which involve any quality of street composition[14] that alters the behavior between individuals and the environment. Examples of urban design factors include the placement of monuments and main plazas, tree density, street connectivity, location of parking spots, distribution of waste bins, and the general land-use mix. Specifically, the land-use mix refers to the diversification of physical spaces with myriad functions (e.g., residential districts for housing, or malls for shopping).

On an aggregate level, cities are composed of a group of interdependent urban design factors with synergies and parasitic relations. In most cases, the outcomes from clustering different urban design factors are unique and cannot be replicated due to inherent socio-cultural divergences. However, Burke et al. (2022) present a framework for characterizing cities that share analogous configurations of urban design factors[15]. The framework introduces the concept of city typologies, which condenses the multiple urban forms and patterns into three dimensions: [1] the topological features, [2] morphology, and [3] the city order. The topology of a city is mainly determined by the network of the street layout, and how it adjusts to elevation changes, geographical landscapes, and climatic conditions. Meanwhile, the morphology of a city describes the overall architectural aesthetics, the outline of its buildings, and the function of a designed building depending on its residential, commercial, industrial, or educational usage[16]. Finally, the city order talks about the harmonization of urban design factors and how their interplay may lead to varying degrees of entropy. Burke et al. (2022) propose city typologies as a comparable metric to evaluate cities across time and space in a quantifiable manner. City typologies also offer a unified methodology to assess urban performance based on structural patterns of the street layout.

[13] Molaei, "The Role of Urban Design Qualities in Metro Stations Approaching Indigenous Patterns."
[14] Ortega et al., "Evaluating the Impact of Urban Design Scenarios on Walking Accessibility."
[15] Burke et al., "Geospatial Analysis Framework for Evaluating Urban Design Typologies in Relation with the 15-Minute City Standards."
[16] Weerasekara et al., "The Impact of Building Morphology Factors on the Cost and Aesthetical Appearance of Urban Detached Residential Buildings in Sri Lanka."

The historical depth of cities has led to the coexistence of multiple spatial layouts, which overlap and merge. Burke et al. (2022) capture well-defined patterns among spatial layouts and denote them as *"pure typologies"* for simplification purposes. Each pure typology is derived from network theory and describes a specific spatial organization of streets and buildings. Fig.1 provides a visual representation of pure typology structures, and classifies them according to the pattern followed. Typologies that follow a homologous pattern (e.g., a grid-based pattern) are classified as distributed. Typologies structured in different levels (e.g., central and smaller locations) are classified as hierarchical. Typologies with several scales and overarching concepts (e.g., fractal centers) are labeled as scalar & harmonic. Finally, typologies with no underlying pattern (e.g., random attributes) are considered irregular.

This paper focuses on the random city typology (see Figure 1), which is characterized by its irregular street layout and the absence of planned patterns[17]. Cities that fall under the random city typology are hereinafter referred to as *"random cities"*. Random cities differ from organic typologies because the streets are not integrated to fit the overall urban connectivity. Instead, random typologies forcefully chaotically insert new streets and buildings while disregarding urban harmony. This chaotic characteristic is also shared with atomized typologies, but random cities do not have low-density areas of undeveloped land.

Given the description of random cities by Burke et al. (2022), this paper expands upon the definition by incorporating the implied consequences of randomness and uncontrolled urban growth. Firstly, random cities are densely populated, as most of the urban land is developed and occupied. As a result, random cities often have overcrowding issues that put stress on public services. Secondly, random cities are mostly improvised, although infrastructure projects can sparsely give structure to specific areas. Random cities improvise by morphing existing structures to fit the demands of the growing population. For instance, the vertical growth of apartments and constructions in dangerous sites (e.g., riversides, mountain slopes) are done to increase the supply of housing near the city center. Thirdly, random cities have a high degree of informality, as informal constructions are usually built in irregular places and are devoid of urban harmony. This informality is often seen in slums (e.g., São Paulo, Mexico City), where residents self-build inadequate housing without having the proper engineering or architectural training[18]. Fourthly, random cities are prone to urban sprawl, as rural-to-urban migrants informally settle in the peripheries of the city. Although urban sprawl is characterized by low-density land[19], peripheral urbanization gradually becomes densely populated. Eventually, areas of urban sprawl are absorbed and integrated into the city. Although the concept of random cities is not exclusive to developing cities, the attributes of random cities are representative of the current situation of many developing cities.

[17] Weerasekara et al.
[18] Ren, Zhang, and Zhou, "Visualizing Urban Slum Population across the Globe."
[19] García-Palomares, "Urban Sprawl and Travel to Work."

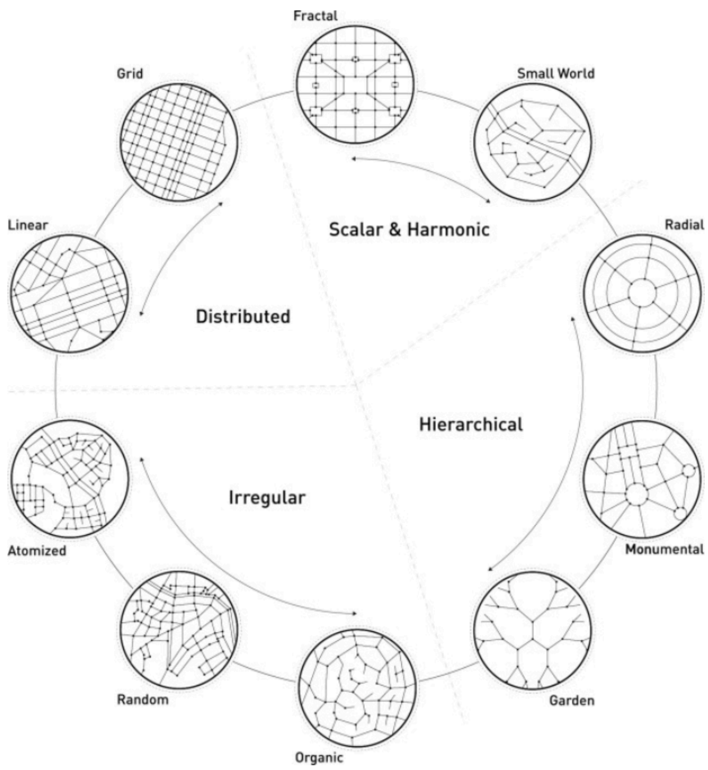

Fig.1. List of Pure City Typologies
Source: Burke et al. (2022)

This paper utilizes two main evaluation criteria present in the literature for assessing urban design solutions: [1] design sustainability[20], and [2] design competitiveness[21]. On the one hand, urban sustainability refers to the integration of city subsystems within a cohesive network that operates in symbiosis without harming the development possibilities of the neighboring areas. Therefore, urban sustainability is not only circumscribed to environmental factors such as levels of GHG emissions or air quality but rather to the constricting power of a city on its surroundings. On the other hand, design competitiveness encompasses the innovative potential of a city and its ability to integrate technology (Internet of Things) into its urban design factors. Ning et al (2017) further subdivide design competitiveness according to its benefit, design capacity, and design strategy[22]. The benefit mainly relates to the value added by R&D, the design capability comprises the prioritization of technology and R&D, and the design strategy mainly focuses on policy support to urban initiatives. These metrics provide a theoretical framework to measure the competitiveness of an urban policy, thus facilitating comparisons in efficiency among different urban planners. This paper endeavors to conduct qualitative comparisons between urban policymaking solutions based on their ability to address the issues brought by random cities.

[20] Zhang and Li, "Urban Resilience and Urban Sustainability."
[21] Ning et al., "Research on an Evaluation System for Urban Design Competitiveness."
[22] Ning et al.

3. Disadvantages of a Random City

The irregular nature of random typologies is not exclusively pernicious, as the lack of a rigid structure can contribute to a more flexible street layout. For instance, the spontaneity of Istanbul's city design is considered a valuable aspect of urban harmony, culture, and identity[23]. However, random typologies suffer from inherent disadvantages derived from the lack of supervisory mechanisms in urban design factors. The absence of supervision allows chaos to reign, which translates into individuals modifying the public spheres for their self-interests[24]. The uncontrollable characteristic of randomness leads to a series of negative consequences, which have been formalized in this section of the report.

The disadvantages of random cities are divided into two levels. The first level describes the general urban category that is hindered by randomness, whereas the second level refers to the specific activity or service negatively affected by randomness. Table 1 summarizes the list of first-level and second-level disadvantages, and includes a small description to explain the negative effect of random typologies on the indicator.

First-level Disadvantage	Second-level Disadvantage	Description
Environmental	**Waste Management**	Inconsistent waste collection mechanisms.
	Pollution	Higher air and noise pollution from car congestion.
	Green Spaces	Random allocation of green spaces.
Access to Basic Amenities	**Public Transportation**	Underdeveloped public transportation infrastructure.
	Electricity & Water	Topographical barriers to extending basic services.
	Healthcare Services	Deficient street connectivity & increased disease spread.
Security	**Reduced Walkability**	Lack of urban design factors for security.
	Theft	Perception of low security in public areas.
	Other Illegal Activities	Higher incidence in informal areas.
Spatial Distribution	**Urban Sprawl**	Lack of planning for city expansion.
	Centralization	Centrical structure of employment.
	Overpopulation	Poor control over population growth.

Table 1. Disadvantage of the Random City Typology
Source: Own elaboration

One of the main first-level disadvantages is related to environmental issues, as random typographies struggle to enforce compliance with environmental practices. At the second-level, random typologies hinder waste management, aggravate pollution, and reduce green spaces per square kilometer. Firstly, waste management has become a major problem for

[23] Turgut, "Istanbul."
[24] Streule et al., "Popular Urbanization."

developing cities due to the absence of a reliable mechanism for waste collection[25]. In random typologies, creating a one-size-fits-all solution for waste management is unfeasible due to the divergent morphology of the city. Without proper enforcement mechanisms, illegal dumpsites proliferate alongside informal waste collectors[26]. Secondly, random cities amplify air and noise pollution through augmented car traffic. The literature establishes a direct relationship between urban planning decisions and outcomes for car congestion[27]. Random typologies have inconsistent land usage, which leads to higher congestion times. Thirdly, randomness interferes with the urban planning of green spaces, which leads to unpredictable outcomes for green spaces per kilometer squared. For example, the lack of regulatory guidelines for green spaces in Ethiopia has inhibited the provision of high-quality green spaces[28].

The second main first-level disadvantage comprises all factors related to the ease of accessing basic amenities. For that reason, the second-level disadvantages include difficulties in accessing public transportation, water supply, electricity, and healthcare services. Accessibility to public transportation is closely related to the quality of public transport, which is a necessity for minimizing car dependence and reducing emissions[29]. However, many developing cities with random typologies lack public transport infrastructure. Moreover, random cities struggle to build infrastructure due to their chaotic urban underground space, which requires planning for its efficient development[30]. The same problem extends to internet and electricity wiring, which is often done above ground due to the intricacies of the underground infrastructure. The accessibility to water is also challenging in random typologies because of unconventional building spots. For instance, cities like Quito, Lima, and Istanbul have expanded to mountainous areas with meager water sources. Additionally, the poor street connectivity of random typologies acts as a barrier for suburban communities to access public health services[31]. Furthermore, the problem of urban sprawl in random cities increases the demand for health services, which exerts pressure on vulnerable health systems. Coupled with the increased transmission of infectious diseases, the high density of random cities poses a threat to urban healthcare services[32].

Another first-level disadvantage is related to security issues in random cities. Poor safety measures lead to second-level disadvantages such as reduced walkability, increased theft, organized crime, and drugs. Academic literature on walkability scores indicates that urban design factors such as street lights, well-designed intersections, and speed limits are necessary

[25] Cobbinah, Erdiaw-Kwasie, and Amoateng, "Africa's Urbanisation."
[26] Ebekozien et al., "Sustainable Cities through Household Waste Management."
[27] Li et al., "Analysis of Urban Congestion Traceability."
[28] Eshetu, Yeshitela, and Sieber, "Urban Green Space Planning, Policy Implementation, and Challenges."
[29] Genç et al., "Commuters Opinion on Public Transport Services in Mega Cities."
[30] Zhao et al., "Advances in Master Planning of Urban Underground Space (UUS) in China."
[31] Genovese et al., "Urban Sprawl and Health."
[32] Chen et al., "Effect of Modelling Slum Populations on Influenza Spread in Delhi."

to create a feeling of security among pedestrians[33] [34]. The issue with random typologies is the prevalence of informal settlements, which are not properly equipped with security elements. As a result, these areas are more vulnerable to theft and general insecurity[35]. The literature supports the fact that organized crime is more recurrent in densely populated slums, which often have random street layouts[36]. In general, there is a consensus that illegal activities have a higher incidence in informal urban areas. These activities include the commerce of drugs, prostitution, gambling, etc. Therefore, the informal characteristics of random cities significantly contribute to worsening their perception of security.

Finally, the last first-level disadvantage is the inefficient spatial distribution of land. Random city typologies suffer from uncontrolled metropolitan expansion, which leads to the problem of urban sprawl. As residents sprawl to undeveloped land, the commuting time of residents increases[37]. Urban sprawl is also accompanied by suburbanization[38], which leads to the creation of unplanned suburbs with random typologies. Another spatial issue of random cities is centralization, as the most developed information and communication technology (ICT) is condensed at the city center[39]. By extension, a large portion of employment occurs at the city center, which deepens the transportation issues of the suburban population. However, the largest spatial issue of developing cities is overpopulation, which causes the collapse of basic services such as water supply or electricity[40]. At the same time, overpopulation is a key driver for an irregular urban design, as the city layout is modified to accommodate the increasing population[41]. As the population increases uncontrollably, the city typology is also transformed uncontrollably. Consequently, cities that receive an excessive influx of migrants end up with random typologies.

4. Problem: Path Dependence of random city typologies

The previous section has set the premise that random city typologies have a series of inherent disadvantages that hinder urban development. The cumulative presence of these disadvantages creates a state of inefficiency[42] that requires correction. For example, a correction strategy is to switch to a fractal city typology, which is found to be positively correlated to urban performance[43]. The need for correcting random cities is well-documented knowledge that is readily

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[33] Debnath et al., "An Investigation of Urban Pedestrian Behaviour in Bangladesh Using the Perceptual Cycle Model."
[34] Ortega et al., "Evaluating the Impact of Urban Design Scenarios on Walking Accessibility."
[35] Kamalipour and Peimani, "Informal Urbanism in the State of Uncertainty."
[36] Monday, Ilesanmi, and Ali, "Security and Safety Planning in Slum Areas of Jimeta, Adamawa State, Nigeria."
[37] Oueslati, Alvanides, and Garrod, "Determinants of Urban Sprawl in European Cities."
[38] Kovács et al., "Urban Sprawl and Land Conversion in Post-Socialist Cities."
[39] Dadashpoor and Yousefi, "Centralization or Decentralization?"
[40] Melchert, "The Dutch Sustainable Building Policy."
[41] Ribeiro et al., "The Adoption of Strategies for Sustainable Cities."
[42] North, "Structure and Change in Economic History."
[43] Burke et al., "Geospatial Analysis Framework for Evaluating Urban Design Typologies in Relation with the 15-Minute City Standards."

available to urban economists and designers[44]. Therefore, cities have an incentive to escape randomness to improve their performance, which should lead to an equilibrium where there are no random cities. Contrary to expectations, random cities flourish in number within the developing world. This paradox raises the question of whether there is a force that makes cities gravitate to randomness. The mentioned gravity effect also impedes random cities from escaping the status quo and adopting efficient urban forms. Therefore, the main problem of random cities is not any individual disadvantage, but rather the lock-in that tethers them into their typology. This paper explains gravitation to random cities using path dependency theory.

Path dependence is defined as a self-reinforcing, self-sustaining, and autocatalytic process of historical inertia that determines future outcomes[45]. It is a probabilistic phenomenon, which restricts the available future trajectories based on past events and initial conditions[46]. Path dependence does not close the door to specific trajectories but rather shapes structural patterns in decision-making through past decisions[47]. Initially, the literature introduced path dependence to explain the historical evolution of technological change, which was bound to a lock-in state[48]. Later on, path dependence was related to institutional economics, as institutional persistence stems from self-reinforcing mechanisms and initial chance events such as colonization[49] [50]. The concept of path dependency has also been applied to urban economics to explain the persistence of urban sprawl[51] and the innovation systems of city regions [52]. Jedwab et al. (2015) introduce the concept of urban path dependence, which illustrates how historical shocks have an indelible impact on the spatial layout, which leads to multiple spatial equilibria[53].

Urban path dependence is relevant for random cities because informality and urban sprawl follow positive feedback loops (i.e., self-reinforcing mechanisms)[54]. On one side, informal environments are subject to socially reinforced noncompliance due to the absence of enforcement mechanisms from the competent authorities. When individuals observe that the expected punishment for engaging in informal activities is low, it incentivizes them to turn to informality. An initial condition of generalized informality sets a particular dynamic path that further amplifies the spatial improvisation and irregularities in random cities. For instance, informal housing follows network effects, as more informal self-built houses are built when informality is prevalent in the neighborhood. Similarly, more informal

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[44] Liebowitz and Margolis, "Path Dependence, Lock-In, and History."
[45] Martin and Simmie, "Path Dependence and Local Innovation Systems in City-Regions."
[46] Martin and Sunley, "Path Dependence and Regional Economic Evolution."
[47] Sorensen, "Uneven Processes of Institutional Change."
[48] Arthur, "Competing Technologies, Increasing Returns, and Lock-In by Historical Events."
[49] North, "Structure and Change in Economic History."
[50] Acemoglu, Johnson, and Robinson, "The Colonial Origins of Comparative Development."
[51] Atkinson and Oleson, "Urban Sprawl as a Path Dependent Process."
[52] Martin and Simmie, "Path Dependence and Local Innovation Systems in City-Regions."
[53] Jedwab, Kerby, and Moradi, "History, Path Dependence and Development."
[54] Atkinson and Oleson, "Urban Sprawl as a Path Dependent Process."

businesses open in spaces where formal businesses are not commonplace. Both informal housing and businesses pick up momentum once initial conditions are propitious. Once path dependence is set in motion, the social norms transform and change the perception of informality. In the long run, social norms become embedded, which leads cities to a lock-in situation in which individuals have warmed up to informality. The cumulative nature of feedback loops[55] then reaches a point of no return, where the structural change becomes entrenched in the culture of the city. Although path dependence is characterized by its dynamic nature, a structural lock-in blocks potential paths that require different structures.

On the other side, urban sprawl is another feature of random cities that is influenced by path dependence. The breakthrough of the automobile was a major structural break for many cities, which have configured their spatial layout to facilitate automobile transportation[56]. This initial condition coupled with increasing rent prices has given an adequate incentive structure for individuals to locate in the peripheries of the cities. Consequently, a first generation of individuals relocated to the periphery of the city, thus initiating urban sprawl. This first generation generates knowledge spillovers, which makes the rest of the population realize the advantages of moving to low-density land (e.g., lower cost of living). In this way, the self-reinforcing mechanism starts to loop, which leads to a second wave of urban sprawl. In theory, the real state markets should act as an opposing force to the positive feedback loop of urban sprawl. As more residents move to the peripheries, the price mechanism would raise the property price of peripheral land due to higher demand. Therefore, the real state market is a self-correcting mechanism that clashes directly with the compounding urban sprawl. However, the self-reinforcement forces overcome the self-correcting forces[57], as the real state market is bound to time lags and reacts to urban sprawl movements ex-post.

Both informality and urban sprawl are critical path-dependent dimensions of random cities, but the baseline for path dependency stems from sunk investments in infrastructure[58]. The construction of schools, hospitals, public services, paved roads, residential houses, and other urban design factors incur sunk investments that are site-specific[59]. These investments are static in the short term and require more investment for relocation efforts. In other words, random cities are difficult to reverse or transform into other typologies because it would imply restructuring the city and rebuilding existing infrastructure. Even if the government could cover the costs of rebuilding, it would have to obtain property rights from private owners. These owners may oppose yielding their property for a common purpose, which would entail more transaction costs (e.g., coordination costs, and indemnizations). Martin & Simmie (2008) characterize sunk

[55] Martin, "Putting the Economy in Its Place."
[56] Atkinson and Oleson, "Urban Sprawl as a Path Dependent Process."
[57] Atkinson and Oleson.
[58] Li, "On the Path Dependence and Transcendence in the Environment Protection in China."
[59] Jedwab, Kerby, and Moradi, "History, Path Dependence and Development."

investments as quasi-irreversible due to the high switching costs involved. The existence of switching costs is a catalyst for inertia toward initial conditions[60], which perpetuates the spatial layout present in random cities. Knowing the irreversibility of location endowments[61], it is mostly unfeasible to break away from a random city typology. Therefore, the remediability of random cities enters into question. Although superior alternatives exist to random cities, the issue of path dependency challenges the feasibility of those alternatives[62]. The following section explores potential solutions for remediating random cities despite the gravity of path dependence.

5. Solution: What is the future of random city typologies?

The irreversible and path-dependent nature of random cities impedes local governments from redesigning the city into a more advantageous typology. Therefore, solutions involving the reconstruction of a random city are mostly unfeasible[63], as it would involve displacing countless residents and businesses. Gradualist policy solutions are also inefficient because random cities become more entangled as urban-to-rural migration and informality advance (i.e., positive feedback loops). Random cities can be thought of as spider webs, which get incrementally intricate as more layers of silk are placed on top. Therefore, the application of a gradualist policy would be counterproductive, as the random city would relapse and converge to its chaotic structure as time goes by.

Given the progressive entanglement of random cities, this paper recommends implementing shock policy solutions to cut off the spider web in half. Despite the infeasibility of redesigning cities, there are alternative shock therapy solutions that do not involve changing the street layout of random cities. The solutions explored in this paper are [1] the Egyptian solution, and [2] the 15-minute city standard solution. The former follows a top-down approach to central planning, whereas the latter involves a bottom-up approach to adapting neighborhoods.

6.1 The Egyptian solution

The city of Cairo exemplifies the characteristics of a random city: a high degree of informality[64], densely populated areas[65], vehicular congestion[66], overcrowding[67], and overloaded transportation systems[68]. From all of the listed issues, the government of Egypt is primarily concerned with the subject of overpopulation. Cairo has an estimated population of

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[60] Liebowitz and Margolis, "Path Dependence, Lock-In, and History."
[61] Jedwab, Kerby, and Moradi, "History, Path Dependence and Development."
[62] Williamson, "Transaction Cost Economics and Organization Theory."
[63] Atkinson and Oleson, "Urban Sprawl as a Path Dependent Process."
[64] Kaye-Essien and Bhuiyan, "Capital City Boosterism as Policy Legitimation."
[65] Ali, "Smart City Policy in Developing Countries."
[66] Kaye-Essien and Bhuiyan, "Capital City Boosterism as Policy Legitimation."
[67] Goda, Foda, and Elsayyad, "Using Green Roofs for Social Housing to Improve Energy Consumption in New Cities. (An Applied Study of Social Housing in Egypt's New Cairo City)."
[68] Goda, Foda, and Elsayyad.

over 22 million people in 2024[69], and projections indicate that by 2030 the population will reach 25.5 million. The annual population growth of Egypt is situated at 1.6%[70] with a birth rate of 2.9 children per woman[71]. These statistics suggest that the increasing population will eventually collapse Cairo, as the city was not built to accommodate nor sustain such a large population. For that reason, the Egyptian government has designed a mitigation strategy to absorb a portion of Cairo's population away from the densely populated capital city.

The Egyptian solution consists of building a new city away from the geospatial location of the random city. This solution successfully circumvents the issue of path dependency, as the newly built city is not subject to any initial conditions. Instead, the government has total control over the morphology, street layout, and urban form of the city. The Egyptian solution gives complete freedom to urban designers, who can meticulously plan each area of the new city and decide upon the exact typological structure. Essentially, this alternative allows for top-down master planning of a city's urban design. In the case of Egypt, the government has decided to move its old capital city to the *"New Administrative Capital"* (NAC).

The NAC is a new city located in the Eastern Desert, which is found 45km away from Cairo and 60km away from Tahrir Square[72]. The project was first announced in March of 2015 during the Economic Development Conference[73]. In its presentation, the NAC was revealed as the solution to the current congestion in Cairo. This new city is expected to host up to 6.5 million people[74] and accommodate all governmental buildings. Initially, the expected cost of the NAC ascended to 45 billion dollars, although it has recently been revised upwards to 58 billion dollars. Egypt has the second highest debt with the IMF—second only to Argentina —, which raises concerns about the fiscal health of Egypt whilst moving forward with the NAC. In total, the international debt reached $164 million back in September 2023, which caused soaring inflation up to 40%. Therefore, there are critics who point to the lavish and opulent constructions in the NAC as the root cause of fiscal irresponsibility. Building a new city from zero requires heavy upfront investments, which is the main downside of the Egyptian solution. As a result, economic agents often fall to the sunk cost fallacy (i.e., investing in path-dependent random cities) because it requires the least investment, whereas rebuilding (i.e., the Egyptian solution) needs vast financial resources.

Another important aspect to consider from the NAC is its urban form. Given the flexibility of master planning, the NAC does not follow any pure typology. Instead, the city is fragmented into Marshallian industrial clusters[75] focused on

[69] "World Urbanization Prospects 2018."
[70] Werr, "Egypt Plans Expansion of New Capital as First Residents Trickle In."
[71] World Bank, "Urban Development Overview."
[72] Rapacki, "Centre of Power."
[73] Loewert and Steiner, "The New Administrative Capital in Egypt."
[74] Loewert and Steiner.
[75] Zhao et al., "Environment, Network Interactions and Innovation Performance of Industrial Clusters."

specific trades. For instance, the NAC has a central business district with skyscrapers such as the Iconic Tower, where most of the corporate buildings are located[76]. Moreover, the NAC has an Olympic City complex, a military area with the Octagon, a medical city, a banking district, an Arts & Culture City, and many more specialized districts. The city is also endowed with six different residential areas that contain 25,000 units per area[77]. There are many more particularities related to the NAC, but the main point concerns the segmentation of purpose-driven areas. A critical typological characteristic of the NAC is the 23 squared-kilometer park complex that connects all districts together[78]. This park is meant to mimic the Nile River and serves as a joining node that fosters green spaces and facilitates urban connectivity. The typology of the New Administrative Capital is illustrated in Fig.2.

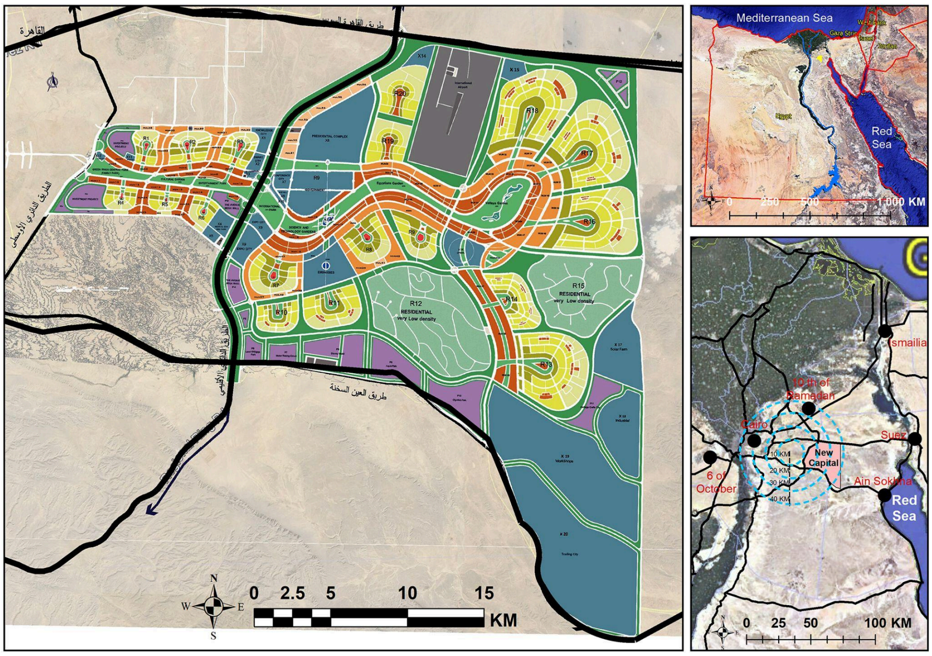

Fig.2. NAC City Typology
Source: Ali (2021)

The optimality of the Egyptian solution is evaluated utilizing sustainability and competitiveness criteria. Firstly, the sustainability of the Egyptian solution relies on the urban philosophy of its designers. Master planning allows for freedom in urban design, which delegates power to designers to prevent urban sprawl from spreading within the new city. Under the premise of rational urban designers, the Egyptian solution has the potential to create idyllic typological cities that do not sprawl and optimize urban performance. For example, many urban analysts believe that the NAC runs the risk of becoming a satellite city of Cairo due to its close proximity. The optimal distance between an old and new capital city is

[76] Ali, "Smart City Policy in Developing Countries."
[77] Kaye-Essien and Bhuiyan, "Capital City Boosterism as Policy Legitimation."
[78] Kaye-Essien and Bhuiyan.

at least 500 kilometers, which is more than ten times the Cairo-NAC distance[79]. Also, experts recommend locating new capital cities in underdeveloped areas, which requires exogenous shocks to bridge regional inequalities. Although the NAC is a flawed example, the notion behind the Egyptian solution can be sustainable with proper urban planning.

Secondly, the competitiveness of the Egyptian solution depends on a trade-off between infrastructure and financial resources. Assuming there are no financial constraints, the Egyptian solution maximizes competitiveness because the city can build as many catalysts for economic development (e.g., libraries, and sports facilities). In the case of the NAC, the segmented urban form has the potential to breed innovation environments specialized in certain activities[80]. By attracting international branches of universities and establishing knowledge hubs (e.g., knowledge cities), the NAC has the tools to become a regional hub for global investments in science and technology[81]. However, the opportunities for foreign direct investment are limited by the fiscal health and credibility of the nation. For that reason, the trade-off between infrastructure and finances must be adequately balanced to prevent chronic fiscal deficits or defaults.

6.2 The 15-minute city standard solution

This solution originates from a concept introduced by Carlos Moreno (2021) called the 15-minute city standard (FMC)[82]. The FMC is an urban planning model in which residents can access all of their essential needs within a walking/cycling distance of 15 minutes[83]. Among those basic needs, residents must be able to access their homes, their workplaces, their educational institutions, fundamental amenities, grocery shopping, healthcare, banking, and even leisure activities. Under the FMC, cities are no longer centralized in specific areas, but rather units of 15-minute radiuses that are interconnected. The notion of the FMC model stems from chrono-urbanism, which states that the quality of life of a resident is inversely proportional to the time spent on transportation. Therefore, the main advantage of the FMC is that it drastically reduces the need for long journeys, which minimizes the time lost by residents in commuting. Other advantages of the FMC are that it reduces car dependence and promotes active modes of transportation[84]. After the COVID-19 pandemic, the FMC gained popularity due to the mobility restrictions (curfews, quarantines) imposed during lockdown periods. These mobility restrictions made residents appreciate proximity-based urban designs, as it eased their ability to get essential amenities at close distances. As the FMC gained a reputation as an efficient urban policymaking paradigm, the model was adopted by main cities worldwide. For instance, Shanghai implemented 15-minute neighborhoods in 2016 intending to foster walking and thus reduce the risk of obesity[85]. Later on, the mayor

[79] Serag, "The New Administrative Capital of Egypt a Critical Review from the Regional."
[80] Ali, "Smart City Policy in Developing Countries."
[81] Khalil and Mousa, ACUD officials.
[82] Moreno et al., "Introducing the '15-Minute City.'"
[83] Pozoukidou and Angelidou, "Urban Planning in the 15-Minute City."
[84] Gorrini et al., "Walkability for Children in Bologna."
[85] Weng et al., "The 15-Minute Walkable Neighborhoods."

of Paris declared the adherence of the city to the FMC standard[86]. Moreover, multinational networks such as the C40 Cities have incorporated 15-minute planning into their agenda[87].

The overhaul of a random city has been previously framed as unfeasible, which remains true. However, embracing the FMC model does not entail any structural changes in the random city. The street layout and city order would remain untouched, while the morphology of the city is transformed. Rearranging the morphology of a random city would imply optimizing and diversifying the land-use mix. In this way, the city would ensure that residential, commercial, educational, and office areas are well distributed and dispersed within a 15-minute radius. To achieve the FMC standard, unused government buildings can be repurposed to fit the needs of the surrounding areas. For example, if the neighborhood lacks a closeby hospital, then the public areas can focus on building medical centers. This methodology should be repeated until all essential amenities are available in the 15-minute zone. In case public land is unavailable, the local authorities can give incentives to private agents for building specific establishments that are absent in the close vicinity. Using the previous example, local municipalities could grant tax breaks and exemptions to companies building medical centers. In summary, the FMC model serves as a feasible redesign solution for random cities to improve the quality of life of their residents without untangling its embedded randomness.

The paper uses two evaluation criteria to assess the urban design quality of the FMC solution: [1] sustainability, and [2] competitiveness. In terms of sustainability, the FMC model excels in promoting sustainable modes of transportation such as walking and cycling. At the same time, it removes the need for car usage, which is fundamental as cities become unable to accommodate more cars due to heavy traffic congestion[88]. By disincentivizing car mobility, urban sprawl is mitigated, as residents would prefer to live within their 15-minute neighborhood over commuting from the periphery. However, it must be noted that the randomness factor of the city would persist, which could perpetuate the existing informality and unsafety. In competitiveness terms, the evolution of R&D and innovative activities under FMC models lacks comprehensive literature and requires further studies. Therefore, assessment based on benefits and design capacity remain unclear. Nonetheless, the design strategy of a city vastly improves with the FMC model, as there is a clear urban planning philosophy that can be enhanced through public policy. The decentralization attained through the FMC model also raises economic concerns, as it opposes the concept of economies of agglomeration. Economic literature argues that clustering certain economic activities in one place is a boon for specialization and innovation. Thus, the contrapositive implies that decentralization would hinder specialized activities. Adhering to the contrapositive without proper empirical studies would only lead to logical fallacies. Consequently, the paper recommends conducting further quantitative research on the FMC model to draw data-driven conclusions.

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[86] Logan et al., "The X-Minute City."
[87] Sala et al., "C40 Mayors' Agenda for a Green and Just Recovery."
[88] Afrin and Yodo, "A Survey of Road Traffic Congestion Measures towards a Sustainable and Resilient Transportation System."

6. Conclusion

In conclusion, the concept of random city typologies by Burke et al. (2022) is expanded to fit the particularities of developing urban design. Namely, the proposed definition covers the high population density, overcrowding, improvised structure, generalized informality, and urban sprawl issues of developing cities. These characteristics are added to the basic features of random cities, consisting primarily of the irregular and unharmonious distribution of urban design factors. In this way, the paper formalizes a typology representative of developing cities and provides a framework to analyze the deficiencies of developing urban design.

Random cities are not exclusively detrimental, as the randomness factor contributes to the cultural identity and flexibility of the urban design. However, there are intrinsic disadvantages that outweigh the positive aspects brought by random cities. These disadvantages are categorized into first and second levels, with the second-level delving into specific aspects of the general first-level. The general first-level categories include [1] environmental issues, [2] scarce access to basic amenities, [3] lack of security, [4] and spatial asymmetries that require correction. Each of these disadvantages is associated with a decrease in the quality of life, which hinders the urban performance of random cities. The exploration of such negative aspects led to the conclusion that random cities share inherent flaws, which positions them as suboptimal typologies relative to fractal cities. Given the premise that random cities underperform, it does not follow that many developing cities adopt random typologies. The logic error becomes coherent once path dependency theory is accounted for.

Random cities are influenced by path dependence because the initial spatial endowments are relatively static and persist over time. The switching costs of restructuring existing infrastructure are high, and generate an invisible inertia towards the previous state of affairs. For that reason, random cities enter a lock-in phase that blocks previous equilibria and pushes the city to a path where randomness is perpetuated. Path dependency stems from self-reinforcing mechanisms that create positive feedback loops that preserve and accentuate the status quo. Positive feedback loops are present both in informality and urban sprawl. Firstly, informality generates environments of general noncompliance, which pushes more individuals to adopt informal behavior (e.g., self-built housing or settling informal businesses). The increasing acceptance of informal affairs turns into social norms that accumulate over time until an equilibrium of generalized informality is reached. Secondly, urban sprawl is subject to positive feedback loops, as rent prices and mobility options provide ideal conditions for sprawling. As residents and migrants recognized the advantages of sprawling to the peripheries, a self-reinforcing mechanism activated recurrent waves of urban sprawl. Furthermore, the sunk investments in spatial endowments prompted cities to maintain their initial urban forms. The efforts of rebuilding established infrastructure are costly, which makes spatial elements sensitive to path dependence.

Understanding the nature of urban path dependence allows for an objective analysis of the feasibility of policy solutions. Redesigning random cities and implementing gradualist policies is unfeasible due to the inertia exerted by path dependence. On one hand, redesigning the random city requires heavy investments and does not halt the self-reinforcing mechanisms. On the other hand, gradualist solutions are outpaced by the positive feedback loops, which cause the solution to only delay the inevitable. Therefore, the feasible area for path-dependence solutions rests upon shock policies such as [1] the Egyptian solution, and [2] the 15-minute city. The first solution involves the construction of a brand-new ′planned city. The master planning allows the new urban form to fit the desired typology and even incorporate the modern spatial layout of smart cities (e.g., IoT elements). The second solution consists of an endogenous adoption of the 15-minute standard, which dictates that essential services ought to be within a 15-minute radius of walking. Although the randomness factor is not removed, most of the first-level disadvantages of random cities are solved. The proposed solutions are still novel to urban economics and require further testing to gauge their effectiveness in terms of sustainability and competitiveness.

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