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Impacts of COVID-19 Pandemic on the Global Flows of People and Goods: Implications on the Dynamics of Urban Systems

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Abstract: The emergence of the COVID-19 pandemic has significantly disrupted the flows or spatial mobility of people, goods, and services globally. The present study explored the impact of the pandemic on the global flows of people and goods, and the implications on the dynamics of urban systems. The study utilized desktop research methodology to collect relevant literature and secondary data, which were analyzed using content analysis and descriptive statistics. The study found that the restrictive measures imposed during the pandemic severely disrupted the global flows of people and goods. As a result, global movements of people declined by over 40% in 2020 from the 2019 levels. Similarly, the global flows of goods shrunk by at least 10% within the same period. These lockdown-related disruptions have significant implications on how socioeconomic activities are organized and conducted within and between cities, with civil aviation and hospitality sectors the hardest hit. The study concludes that there is a need for resilient urban systems in which cities, people, institutions, and firms can effectively adapt to the impact of the pandemic.

Keywords: COVID-19 pandemic; flows of goods; civil aviation; maritime transportation; population movement; global mobility; tourism; urban systems; air travels; resilient cities

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1. Introduction

The number of confirmed cases of COVID-19 has exceeded 456.7 million, including over 6.0 million deaths, as of 14 March 2022 [1]. The number of deaths since the outbreak is approximately twice the number of casualties attributed to natural disasters in the last five decades [2]. Apart from mortality and morbidity, the COVID-19 pandemic has significantly disrupted the dynamics of urban systems, defined as "the spatial organization of networks of urban centers at regional, national, and international scales" [3]. In most countries worldwide, severe lockdowns were imposed as a precautionary measure to break the contagion cycle and prevent the collapse of their fragile healthcare systems. Non-essential businesses, services, leisure, and sports were curtailed, which necessitated the reliance on adaptation measures such as remote work (telecommuting), distance learning, and online meetings [4,5]. Thus, the lives of billions of people have been largely impacted, as their ability to work, study, and socialize has been severely restricted.

The transport sector is among the hardest hit by the pandemic due to the lockdown measures taken to curb the spread of COVID-19. The lockdown greatly hampered the mobility of people, goods, and services, as the 21st century society is hypermobile. The mobility of freight by air, rail, road, and water—the main facilitator of social interaction and a key supplier for essential goods, such as food and medical supplies—has been impacted from local transport to the global supply chain [6–8]. In addition, transport companies faced unprecedented challenges to adhere to safety procedures such as physical distancing, inspecting COVID-19 test results, and managing queuing, which have lessened the capacity of different transportation modes [9]. The impact of the pandemic on the sector contributed

immensely to the downturn of the already struggling and embattled global economy with a cascade of multiplier effects and little hope for prompt recovery to pre-pandemic levels. In May 2020, the Economist Intelligence Unit [10] forecasted that by 2021, the pandemic could result in the global economy shrinking by 4.2%, with several countries entering a recession.

Several studies have investigated the impact of the pandemic from intra- and inter-city mobility perspectives. Barbieri et al. [11] empirically studied the impact of the pandemic on mobility in 10 countries and attendant-perceived risk for all transport modes. The study found "tremendous disruptions for commuting and non-commuting travels", with a significant decrease in all kinds of travel across all modes. Kim and Kwan [12] analyzed the impact of the pandemic on county-level mobility changes in the USA, finding increased poverty levels and more restrictive policies. Tardivo et al. [13] reported the underuse of the railway system, which threatened the urban transport sector, and recommended a new mobility paradigm. Other studies investigated the influence of the pandemic on transport mode choices, sectoral energy savings, and greenhouse gas (GHG) emissions [14–18].

However, few studies investigated the implications of restricted flows of people and goods on physical and socioeconomic activities in cities. For example, a study by Megahed and Ghoneim [19] focused on how urban design approaches such as density, walkability, housing layout, and public spaces can increase the safety of the built environment against the pandemic. Afrin et al. [20] studied the role of disaster risk management in developing pandemic-resilient cities. Martínez and Short [21] investigated the role of public space configuration, transportation, and urban connectivity in developing safer cities during the pandemic. Corazza et al. [22] studied how the pandemic caused a new drive towards walkability and a major shift from public to private transportation modes in some European cities. Patel and Shah [23] explored the pandemic's impact on slums in Global South cities toward making cities healthier, equitable, and resilient. Sharifi and Khavarian-Garmsir [24] conducted a systematic review of the pandemic's impact on cities worldwide and found substantial increases in water and air quality, and rising poverty and the marginalization of people with low socioeconomic status. In another study, Lai et al. [25] commented on the relevance of key attributes of the built environment, including urban density, carrying capacity, and the quality of basic services and infrastructure on the pandemic. In addition, Mouratidis [26] assessed the impact of the pandemic on reshaping the quality of life of city dwellers. However, the literature paid little attention to how the restricted mobility of people and goods affects the dynamics of urban systems.

The objective of the present study is to investigate how the pandemic has impacted the intra- and inter-city flows of people and goods and the implications of disrupted flows on the dynamics of urban systems. The implications of the study concern how cities can cope with the severed linkages between them to sustain the integrity and functioning of urban systems. The next section reviews the literature on the roles of flows in shaping the dynamism of the urban system, which is followed by the materials and methods in Section 3. The research methodology is based on a desktop study of the literature and secondary data. The section that follows presents and discusses the impact of the pandemic on two types of flow: the movement of people and of commodities. Section 5 highlights the implications of disrupted flows on the dynamics of urban systems, and Section 6 concludes the paper with how cities can better cope with the current and similar future pandemics.

2. Flows as Determinants of the Dynamics of Urban Systems

Urban systems exist at the *micro*, *meso*, and *macro* scales. The micro scale consists of people, institutions, and firms as key elements of a city. The meso scale represents a city as a geographic entity, and the macro scale involves a system or network of cities interacting at national and global levels [27]. The study of how an urban system at the macro scale is influenced by flows of people and goods gained prominence in the 19th century when Ravenstein [28] hypothesized that population movement is influenced by the size, distance, and direction between settlements, and their economic development levels, as well the socioeconomic characteristics of their inhabitants. Later, in the late

1960s, the sociologist Everett Lee [29] suggested a model that describes a set of push and pull factors that govern the volume of population flows between two cities: origin and destination (Figure 1). The model postulates that population mobility is influenced by some attractions (pull factors) and detractions (push factors) present in origins and destinations and intervening opportunities. Socioeconomic factors such as employment, education, tourism, and entertainment, and natural endowments like water, minerals, and climate push or pull people from one city to another. The distance between cities is one of the most important intervening factors, because it is always present regardless of the number and gravity of attractions and detractions. Thus, the volume of flows depends on the interplay of all of these factors.

Figure 1. An illustration of Everett Lee's model of population mobility [29].

Similarly, from a statistical modeling point of view, flows of people and commodities between two places can be examined using the gravity model. The model considers the population size and distance between two cities (some scholars include job opportunities) as factors that determine the extent of flows between them [30]. Using a version of this model, Lowry [31] analyzed population flows between 90 metropolitan areas in the USA from 1955 to 1960 and found that the model explained 68% of the variations in population flows. A similar model was used by Ian Masser [32] to investigate inter-urban population movements in England and Wales from 1965 to 1966 and found that the model explained 94% of the variations. In addition, Gober-Meyers [33] integrated differences in flow propensity amid different population sub-groups and drew a clear distinction between net and gross flows.

Regarding the flow of goods, the contribution of Ullman's [34] essay on *American Commodity Flow* is vital to understanding the impact of flows on urban system dynamics. The essay identified complementarity, intervening opportunity, and transferability as three key elements that shape the geography of commodity flows (Figure 2). At the end of the paths that goods and services follow and cross is the ultimate goal of achieving strong supply chain management that integrates process-oriented planning and controls the flows from the end consumer to the raw material supplier.

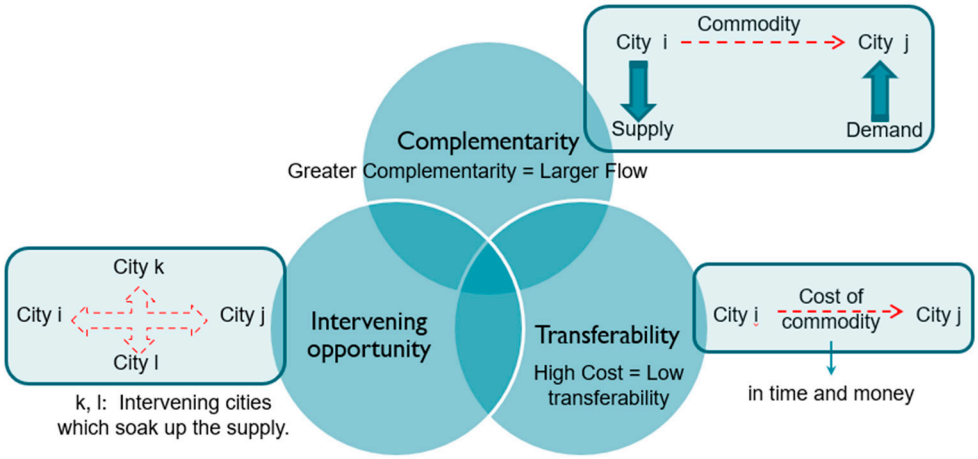

Figure 2. An illustration of Ullman model of commodity transfers (adapted from [34]).

The complementarity and intervening opportunities in cities include the supply of and demand for infrastructure, healthcare, job opportunities, water and sanitation, housing, education, and food security, in addition to access to social and cultural facilities [35–40]. However, lack of access to these vital services exacerbates the income and social inequalities in cities. These urban challenges are the impetus for migration; they influence flows of goods, energy, information, and capital, and determine the comparative advantages of cities.

At the macro and micro scales, there is an emerging body of literature focusing on the influence of the pandemic on cities and their constituents. For example, Iturriaga [41] explored how the pandemic exposed the inequality between poor and elite neighborhoods in terms of their access to and the experience of urban landscapes. Salama [42] investigated the socio-spatial implications of the pandemic on cities and suggested that urban design and planning can play a vital role in safeguarding human health in post-pandemic architecture and urbanism. Bereitschaft and Scheller [43] explored how the pandemic could influence urban design adaptations to improve resilience. Pinheiro and Luís [44] reviewed built environment measures that can prevent the spread of the pandemic and improve urban sustainability. Eltarabily and Elghezanwy [45] reviewed the impact of COVID-19 on cities and urban design, and suggested that appropriate development density and designs of public spaces, including streets, parks and gardens, and walkability, are key to developing safe and resilient cities.

In sum, a consensus seems to emerge of the above review that the determinants of the dynamics of urban systems are the nature and intensity of flows. Furthermore, the linkages enabled by the flows are vital to the urban system's integrity and functioning. Based on population mobility theory (Figure 1) and commodity transfers theory (Figure 2), the following summarizes the roles of flows in sustaining urban system integrity and functions and shaping the socioeconomic development of cities.

1. Preserving and sustaining the linkages and flows between and within cities is vital to managing and optimizing the processes and patterns of urban change. By maximizing the advantages of diverse opportunities of the flows of people and goods, cities will continue to be driven by a combination of pull and push factors that need to be considered in the planning and management of urban systems to cope with disruptions to human socioeconomic activities and environmental quality.
2. Cutting or restricting the flows can prevent cities from playing their role as economic production and consumption centers, arenas of social networks and cultural activities, educational epicenters, and seats of government and administration. The alarming drop in the economic activities due to COVID-19 restrictions, detailed in the present study, confirms the risk of undermining this fundamental role.
3. Disrupting the linkages (mobility) can alter the structure of urban systems by preventing cities from ensuring their socioeconomic and political functions. Deciding to

quarantine citizens and restrict individual rights in favor of public safety can hinder the fulfillment of these functions. Cities are expected to coordinate and promote the harmonious development of various human activities, firms, and institutions on their territories, protect citizens, and provide basic services. The restrictive measures undermine the notion of the city as a system.

3. Materials and Methods

The study started with two premises. First, an urban system depends on the efficiency and continuity of the flows between and within cities. Thus, well-connected, and flourishing flows can help achieve socioeconomic development and improve human well-being in cities. Second, an ill-connected urban system, where the flows are slowed, halted, or altered, is expected to experience a disrupted economy and social fabric, risking a collapse under continued disruptions and low resilience.

The present study examined the flows of people and goods, pre- and during the pandemic, to identify the extent to which the pandemic-associated restrictions impacted the flows. If the linkages are equal to pre-pandemic levels or slightly slowed down, then the pandemic would not lead to significant disruptions, which would indicate a high level of urban system resilience. However, if the flows are significantly less, then the implications on the urban systems could be severe, with significant negative consequences on socioeconomic development.

The study utilized a desktop research approach that involved gathering and analyzing relevant literature and secondary data from online sources. The method, shown in Figure 3, consisted of three iterative stages: (a) scoping, (b) collecting relevant resources, and (c) data analysis [46]. First, the scoping stage entailed identifying and defining the research problem to be examined. In the present study, the research problem is investigating how the COVID-19 pandemic has impacted the global flow of people and goods and their implications on the dynamics of urban systems. Relevant keywords were used to set the study scope and guide the literature search.

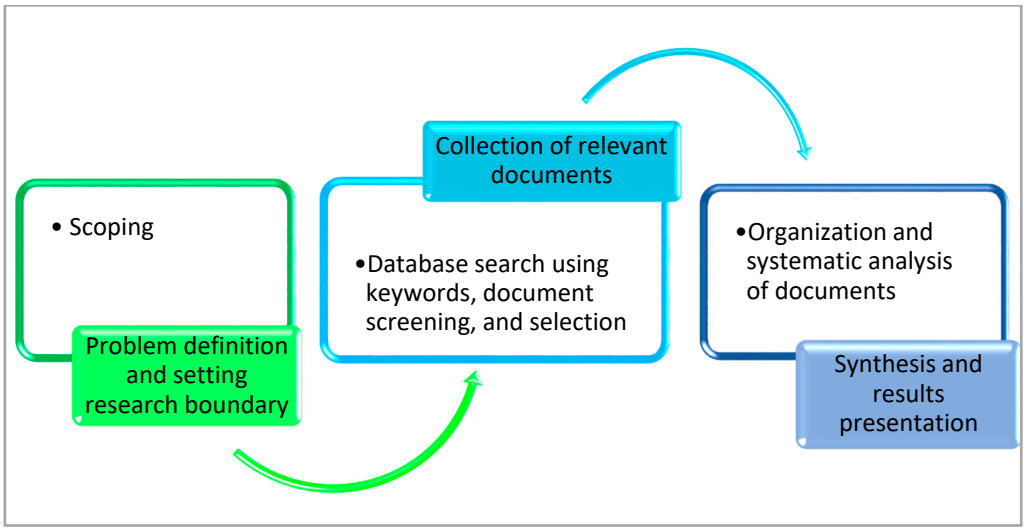

Figure 3. Research methodology flow chart (developed by authors).

The second stage involved searching and gathering relevant literature using online sources. The researchers used Google Scholar and Scopus to identify peer-reviewed academic works. The literature that satisfied the following three inclusion criteria were identified and downloaded: (1) it is a full-text journal article, book chapter, or conference proceeding; (2) it is published in the English language; and (3) it is recent and related to the study's objective, although some old documents about established theories were also consulted.

Similarly, the study utilized gray literature such as statistics and technical reports from the internet sites of international development organizations. The following are the key sources of secondary data used in this study.

- The World Bank's DataBank: https://databank.worldbank.org/home.aspx, (accessed on 25 November 2021).
- International Civil Aviation Organization (ICAO) https://www.icao.int/Pages/default.aspx, (accessed on 25 November 2021).
- International Organization for Migration (IOM): https://www.iom.int/, (accessed on 25 November 2021).
- Air Transport Action Group (ATAG): https://www.atag.org/, (accessed on 25 November 2021).

The last stage consisted of organizing and analyzing the collected literature. First, the downloaded literature was organized according to the similarity of topics, although some documents belonged to multiple categories. Then, each publication was thoroughly reviewed, and themes related to the research objectives were extracted. Finally, the themes were collated, synthesized, and harmonized.

4. Results and Discussion

Assessing the impact of the pandemic on the dynamics of the world system of cities should consider the global flows by all modes of transportation. However, civil aviation is the focus of the present study because it is the transportation mode hardest hit by the impact of the pandemic. Moreover, it is a good indicator of the pandemic's impact on the dynamics of urban systems because of its large share in the global flows and impact on the economy.

4.1. Flow of People: Significant Reduction Globally

Compared to pre-pandemic levels, the 2020 global air passenger figures for international and domestic routes dropped considerably (Figure 4). From 2019 to 2020, international passenger traffic dropped from 4.5 billion to 1.8 billion trips, indicating a sharp decline of 60%. The 2020 traffic figure was as low in 2020 as it was back in 2003, and the decline is debilitating to the sector that recorded an average annual increase of 6.07% during the pre-pandemic decade (2010–2019) [47]. Figure 4 shows that the decline in global air passengers is historically unprecedented within the last 50 years, as none of the other global crises within that period has created such effect. By the end of 2020, the cascading universal lockdown measures, border closures, and travel restrictions resulted in a 94.4% decline in the overall number of international and domestic passengers compared to 2019 levels [48]. According to the Economist Intelligence Unit, as of April 2020, commercial flight activities worldwide had fallen almost 75% below the 2019 levels [10].

Due to COVID-19, international migration in 2020 experienced about 2 million fewer migrants than expected [49], as nearly all other transport modes were completely or partially closed worldwide. Almost all transport modes were impacted in some way locally and globally. For instance, as of March 2020, the number of trips using public transportation in urban areas decreased by an average of 58% worldwide: 77% in the UK, 75% in Canada, 70% in the USA, 65% in Australia, 50% in Sweden, 35% in South Korea, and 30% in Hong Kong, with a complete shutdown in India [50]. Compared to business as usual, Canadian civil aviation activities fell by 71% [16]. In the European Union, restrictive mobility measures significantly affected rail transport demand in 2020 compared to 2019. By the second quarter of 2020, total rail passengers had declined to less than half in most EU member states (e.g., −90% in Ireland, −79% in the Netherlands, and −78% in France) [51]. For example, underground train trips in London saw an unprecedented 95% reduction [52]. In addition, the pandemic has severely impacted maritime transportation. Although some ports were open to cargo operations, which account for about 80% of global trade, majority of them remained closed to passenger traffic. This situation underscored the vulnerability of the maritime sector economy to restricted flows of people and goods [9].

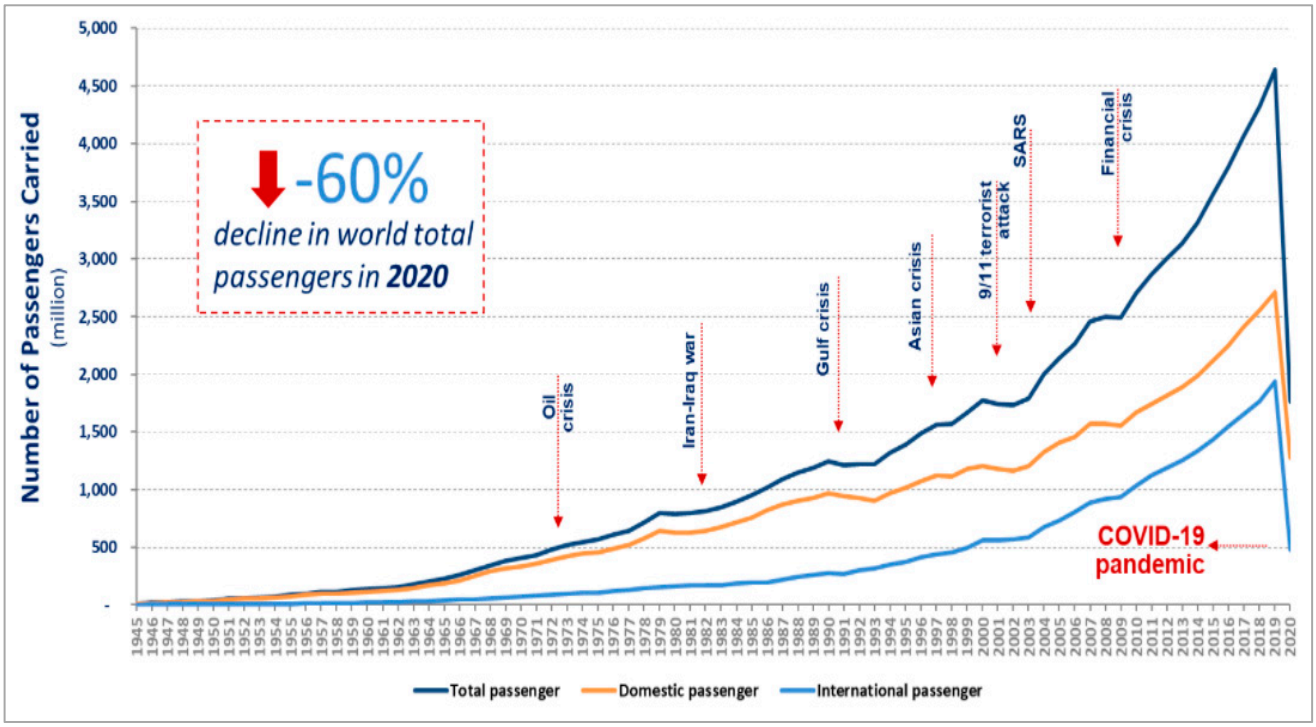

Figure 4. Global air passenger traffic trend, 1945–2020 (source: International Civil Aviation Organization [53]).

4.2. Flow of Goods: Downward Imports and Exports across All Industries

In the globalized economy, it is also conceded that the urban system significantly relies on commodity transfer where cities and towns play the role of assembly and transfer points (nodes). The flow of goods is determined by the nature of the transport network and the character of urban nodes. From 2019 to 2020, the global merchandise trade volume contracted by 5.3%, and the global GDP declined by up to 4.3% [54]. Specifically, imports and exports of goods and services have not been spared by the downward trends and impacts of COVID-19 globally. According to the World Bank data, from 2019 to 2020, global imports and exports of goods and services declined by 10.82% and 10.36%, respectively (Table 1). This trend contrasts sharply with at least a 19% cumulative increase in imports and exports from 2016 to 2019. In a world marked by close systemic interlinkages, the snowball effect of low flows and externalities is most likely to happen at various dimensions: temporal, sectoral, local, regional, and global.

Table 1. Trends in global flows of goods and services, 2016–2020 (balance of payment in billions USD).

Global Flows of Goods and Services	2016	2017	2018	2019	2020	Change	
						2016–2019	2019–2020
Imports	20.317	22.416	24.733	24.358	21.723	+19.89%	−10.82%
Exports	20.911	23.079	25.365	24.961	22.374	+19.37%	−10.36%

Source: World Bank [55].

Although air freight is crucial to the global flow of goods, vital connections were also affected at the height of the COVID-19 lockdown. Analyzing the Eurozone situation, de Vet et al. [56] found that, except the digital and healthcare industries that performed well, those sectors relying on human contact and interactions, such as aviation and cultural and creative industries, recorded a significant decline in the delivery of essential goods. These industries are likely to suffer for extended periods ahead, with slow recovery expected to start in late 2021. The global food systems have also been severely affected by the pandemic. The complex functioning of food systems poses cross-sectoral challenges, as any change in

one subsystem can cause stress in others. The interconnection of multiple subsystems in delivering goods and services that bring extensive opportunities for collaboration, mutual benefits, and diversity in the food chain and nutrient cycles has exposed these sensitive systems to huge disruptions and shockwaves, as proven by the disruptions in the global supply chains during the COVID-19 pandemic. For example, Guan et al. [57] reported a 46.7% fall in the export of beverages and tobacco products from the United States during the pandemic. The study highlighted the vulnerability of the food sector to lockdowns due to a large decline in demand and the spread of losses from upstream suppliers.

The decline in car production is another eloquent illustration of the impact of the restricted flows of input goods and raw materials. The shortage of parts, raw materials, and computer microchips forced many plants to shut down [58]. Although chips are just one of many other disruptions threatening automakers, there is a cascade of problems ranging from the logistical complications suffered by the supply chain to labor shortages. In a specific scenario analysis, Guan et al. [57] found that the pandemic's impacts on the supply chain of the German automobile industry included a 28.8% decrease in production, and 37.6%, 29.1%, and 22.3% decrease in car demand in China, the United States of America, and Austria, respectively. Millefiori et al. [59] assessed the effects of the pandemic on maritime mobility worldwide. The authors found that, apart from slow shipping mobility and changes in routes and operational patterns, there was a significant drop in cargo mobility: passenger traffic (−19.57 to −42.77%); container ships (−5.62 to −13.77%); wet bulk (−0.22 to −9.27%); and dry bulk (+2.28 to −3.32%).

In addition, the flows of fossil fuels and other industrial raw materials essential to global economies were also reduced, limiting the planet to its physical limits [60]. Although many measures have been taken to facilitate the importing and exporting of goods and help supply chains to continue to deliver [61], COVID-19 disruptions have impacted unevenly across countries and sectors.

4.3. Impacts of Declining Flow on Civil Aviation and Tourism Sectors

The flows of people and goods are tied to economic development in two directly proportional ways: the inflow of population and commodities leads to a virtuous circle of cumulative growth and a multiplier effect. In contrast, the loss of human and commodity flows leads to declining urban economies. In general, increasing flows are expected to lead to a city's sustained economic growth and prosperity up to a certain threshold. However, under lockdowns and curfews, people could only buy groceries within the residential neighborhood or utilize essential services such as healthcare. With the near-total shutdown of the global system and muted business activity, most cities had empty streets.

The large share of civil aviation in the international transportation network makes it a major contributor to global economic growth because of its contributions to human and commodity mobility. Domestic and international air transport sectors, including airlines, airports, air navigation, catering, and cleaning service providers, create millions of direct and indirect jobs and facilitate an important international trade and tourism volume [62]. Estimates suggest that by 2036, the aviation sector would create 98 million jobs and generate USD 5.7 trillion in GDP, an increase of 110% from 2016 figures [47]. This sector also has other benefits, such as the economic activities generated by multinational corporations because of air travel and the inherent value that the speed and connectivity of aviation offers to domestic and international trade and tourism. Furthermore, the role of civil aviation is increasingly recognized as providing fundamental support for attaining sustainable development goals [47]. These direct and associated benefits would contribute considerably to global economic development, making the sector an indisputable lever of the world economy.

Prior to the pandemic, the sector created a total of 87.7 million jobs worldwide, of which 11.3 million are aviation direct jobs, with global economic impacts of USD 3.5 trillion and contributing 4.1% to the global GDP [48]. However, due to the pandemic, the drop in air travel demand started in January 2020, causing the paralysis of major air transport

activities. Despite the short upward trend—mostly resulting from international repatriation flights—the optimism in aviation jobs rebounding unfortunately quickly faded away as the second wave of infection inexorably triggered the tightening of restriction measures. The global and local lockdown of the air transport sector and the restrictions on flows of people, together with the cascading severe economic impacts, paralyzed the revenue streams, resulting in acute liquidity strains throughout the aviation value chain. As a result, the industry's fiscal sustainability has been seriously questioned as millions of jobs worldwide have been exposed to irrecoverable damage.

Data from ICAO, presented in Table 2, show a significant drop in gross airline passengers by half and USD 370 billion losses in revenues globally. The regional breakdown shows drops in passenger and revenue losses without exception. The highest revenue loss is in the Asia/Pacific region (USD 120 billion), followed by Europe (USD 100 billion), and North America (USD 88 billion), while the least is Africa (USD 14 billion).

Table 2. Change in passenger traffic and revenues by region, 2019–2020.

	Capacity (Percent)	Passenger (Million)	Revenue (Billion USD)
North America	−43%	−596	−88
Latin America and the Caribbean	−53%	−198	−26
Europe	−58%	−770	−100
Africa	−58%	−78	−14
Middle East	−60%	−132	−22
Asia/Pacific	−45%	−916	−120
Global	−50%	−2700	−370

Source: Authors' compilation from ICAO [54].

Civil aviation's vital role in fostering the prosperity of the tourism sector has been severely undermined. Table 3 shows that the aviation sector recorded a sharp drop in revenues and job losses in the first quarter of 2021, including 52.6% job losses and a 51.1% decrease in revenues globally. Under these losses, indirect, induced, and tourism-related jobs have seen a similar dramatic drop, with cascading negative effects on the sector's economic growth. Jobs in the hospitality and tourism sectors with a high proportion of casual labor at airports or in the immediate vicinity seem to have been impacted much more than jobs in airlines or airport operators themselves [47]. This negative performance contrasts drastically with that of the period before the pandemic (2010–2019), where an average revenue growth exceeding USD 37 million was achieved annually [46]. Airports and air navigation services providers are no exception, as they recorded further losses of USD 115 billion and USD 13 billion in revenues, respectively. In addition, lockdown restrictions caused airplanes to remain on the ground with rising parking and maintenance costs. Expectations of any improvement depend on pandemic management and vaccination roll-out effectiveness. These efforts suffer from clear geographical disparities due to international and domestic factors such as the differences in market size among regions, the resilience and speed of recovery to pre-pandemic levels, and the capacity to implement adequate and effective measures to alleviate liquidity and financial strains.

The impacts of restricted flows, whether for business, studies, leisure, or visiting friends and relatives, have severely affected global economic activities, reaching unsurpassed levels since the 2008 stock market and housing crashes. Lockdown measures to contain the pandemic have plunged the global economy into one of its worst recessions since 1900, with China's GDP dropping by 6.8% in the first quarter of 2020 [63], the United States by 34.3% [64], and the European Union by 12.1% in the second quarter of 2020 [65]. Over 50% of international tourists who used to travel by air were no longer able to do so. They remained stuck in their country with no choice but to turn to local tourism that also suffered the same fate. For instance, in Jamaica, Guan et al. [57] reported a 56.3% decrease in tourism due to the pandemic. In Kenya, in the first half of 2020, the tourism and

hospitality industry lost 80% of its revenue and 2 million jobs to the pandemic [66]. Thus, there is the need for more equitable and resilient mobility, "not only to fight the storm but to prepare for future catastrophes" [14].

Table 3. Impact of COVID-19 on aviation-related jobs and revenues.

	2018 (Pre-COVID-19)		Early 2021 (COVID-19)		Impact (2018−2021)	
	Jobs (Million)	Revenues (Billion USD)	Jobs (Million)	Revenues (Billion USD)	Jobs (%)	Revenues (%)
Tourism catalytic	44.8	1000	18.4	403	−58.9	−59.7
Induced	13.5	692.8	7.0	365	−48.1	−47.3
Indirect	18.1	816.4	9.7	439	−46.4	−46.3
Aviation direct	11.3	961.3	6.5	491	−42.5	−48.9
Total	87.7	3470.5	41.6	1700	−52.6	−51.1

Source: Authors' compilation from ATAG [48].

The civil aviation sector can provide insights into the fragility of the global economy by serving as a pointer to the extent of economic potentials and challenges. A closer look at some facts supports this assertion. As of 2020, about 58% of all tourists used air transport to reach their destinations [48], indicating the importance of civil aviation to the tourism and hospitality sector. Moreover, 51% of the global population lives within 100 km of an international airport, and 74% lives within 100 km of any airport [54], signifying the large-scale use of air transportation in towns and cities. Similarly, the volume of global air transport (over 400 scheduled commercial departures per hour in 2020) strongly facilitates people and cargo flows, thereby bolstering the socioeconomic development of different regions. Furthermore, innovations and technological advancements in the sector can transform mobility and impact development across industries and other modes of transport: when civil aviation coughs, the world catches cold.

5. Implications of Disrupted Flows on Dynamics of Urban Systems

An urban system owes its existence to the agglomeration and interaction of people, institutions, and firms at the microscale. The system also involves the interaction of cities at the macro scale. Thus, the significance of flows on the dynamics of urban systems is a subject of consensus among scholars [67–73]. Declining or disrupting the flows of populations and goods can significantly impact the productivity and interactions of these actors operating at various spatial and temporal scales that shape the dynamics of cities. As cities are expected to accommodate nearly 70% of the global population [64], disrupted flows will majorly impact urban dynamics. The pandemic disrupted a wide range of mobility modes, including multiple networks in space, on the sea, roads, and railways as physical linkages that facilitate flows and interconnect cities. Cities are also tied in time by the speed at which people and commodities travel through the network [74,75]. Due to continuous technological advancements in transportation modes, cities have been moving closer in time and space due to the spectacular decrease in travel time [76]. This time–space convergence perfectly fits the global village concept in a world interconnected by technology. Flows are at the foundation of the urban socioeconomic fabric, transforming and reinvigorating it [77]. As such, any disruption to the flows would undermine social connections, trade, and access to commodities and services such as tourism, healthcare, and education [78].

The strong connection between the nature of the urban system, rate of flows, and levels of socioeconomic development is widely recognized today, whether cities act as resource-orientated centers, breakpoints, or distribution centers and whether the connection is by road, air, rail, or sea [79]. Historically, developments in transportation and information and communication technologies have facilitated the flows of people, goods, services, capital,

energy, and information, thus stimulating cities' physical and socioeconomic growth. Railways, automobiles, ships, airplanes, the special modes of transporting energy and information, such as pipelines, radio, television, telephone, and the advent of the internet, all reflect the economic multiplier effects of flows on cities and their environs.

Nevertheless, flows are also a weak point—the "Achilles' heel"—of the same urban systems. Any disruption to them spreads like a tsunami, directly and indirectly affecting the components of the system in the short and long terms and beyond expectations. For instance, closing borders and restricting movements in one country or region could affect and leave footprints at the global level due to the trickle effects of decisions and actions. Similarly, flows can spread negative impacts that may lead to problems within and beyond national borders with multiplier effects on the dynamic of urban systems. These impacts can be positive or negative and are based on cause–effect relationships. The pandemic is the cause of disrupted flows, while the effects are the potential impacts summarized in Table 4 and discussed under the following sub-headings.

Table 4. Summary of the potential implications of disrupted flows on the dynamics of urban systems.

Impacts of Disrupted Flows on Urban Systems	Flows			
	People	**Goods**	**Capital**	**Information**
• Population decline (temporary and permanent)	🟢	🟡	🟡	🟡
• Low supply of essential goods and services that keep cities functioning	🟢	🟡	🟢	🟡
• Inequality, unemployment, poverty, and low quality of life	🟡	🟢	🟢	🟢
• Reduced local revenues through low tax yields, foreign investment, and personal remittances	🟢	🟢	🟢	🟡
• Low access to urban services and infrastructure for human wellbeing and socioeconomic activities	🟡	🟢	🟢	🔵
• Limited technology transfer, knowledge dissemination, innovations, creativity, and research and development	🟢	🟢	🟢	🟢
• Decreased dynamism and vitality of public spaces, cultural diversity, social learning processes, and their connectiveness	🟢	🟡	🟢	🟡
• Reduced urban hierarchy (absolute and relative) and complementarity between urban centers	🟡	🟡	🟡	🟡
• Undermined mutual understanding, trust, and sharing between urban social and economic actors	🟡	🟡	🟡	🟡
• Improved environmental quality through energy savings, low carbon footprint and air pollution, and road safety (through reduced accidents)	🔵	🔵	🟡	🟢

Key: 🟢 Direct relationship. 🔵 Relationship under certain conditions or relying on supportive policies. 🟡 Indirect or induced relationship.

5.1. Exchange of Knowledge and Innovation

Urban systems consist of cities connected by diverse sociocultural and economic interactions. Because cities are nodes in mobility networks and do not exist in isolation, disrupted flows undermine their interdependency in exchanging information, the diffusion of ideas, and innovation [18]. These interurban dependencies, exchanges of economic activities, and extensive transportation and information networks shape the dynamics of urban systems [65]. The exchange of ideas by populations of different origins, through

increased mobility, represents a key source of human capital or talent that plays a prominent role in feeding economies with both skilled workers and prospective entrepreneurs. The need to create, attract, and retain talent—a crucial resource in the knowledge-based economy—depends on the local quality of life, the attractiveness and condition of the environment, the quality of schools, and the richness of cultural facilities. It also relies on the mobility of talent and the ability to transfer technologies and know-how for sustained and shared prosperity.

For example, Salvati and Serra [76] studied the drivers of transformations of complex urban systems in 115 municipalities in Greece. They found that, out of 30 indicators, human talent inflow is the most important indicator of the rapidity of transformation in urban form and functions. Effective and streamlined flows of skilled people can spur innovations and enrich cultural economies by endowing cities with distinctive forms of cultural capital. In addition, this human resource can unfold social learning processes, reducing uncertainty, building trust, and enhancing knowledge sharing between local and global economic players [78].

5.2. Commuting for Work, Shopping, and Leisure

Several studies observed that passenger mobility for work, shopping, and leisure suffered severe setbacks due to the pandemic. In India, for example, Saha et al. [67] investigated the effects of the COVID-19 lockdown on public mobility in Indian states and union territories. The study found that daily commuting for work, recreation, and shopping reduced by at least two-fifths, including retail and recreation (−73.4%), shopping for groceries and pharmacy items (−51.2%), visits to parks (−46.3%), transit stations (−66%), workplaces (−56.7%), and visits to residential places (+23.8%) [67]. Similarly, there was lower mobility in Italy and France than in the USA, the UK, and Canada [68]. In the USA, mobility restrictions were less effective in curtailing people's mobility in the long term because it is a vital part of their daily life [12]. In British Columbia, Canada, the disrupted flows severely impacted travel routines for shopping and work, as well as short and long-distance travels [53]. In addition, the pandemic containment measures caused a sharp decline in mobility across all categories of commercial shipping worldwide [59]. Globally, increased trade costs affected the movement of people, tourism, and global supply chain industries. Impaired mobility also disrupts the production of goods and services. It causes low consumer demand, as people cannot visit business establishments and purchase the usual volume of goods and services they consume [70].

In Canada, Fatmi [69] studied daily travel activities before and during the pandemic travel restrictions in the Kelowna region. The study found that while outdoor activities declined by over 50%, work-related travel for those in the healthcare, government, community, and sales and services sectors increased. The mobility for recreational and social activities was higher in older adults than younger adults. High-income households were more involved in teleworking for longer periods, while low- and middle-income groups were predominant in leisure activities.

5.3. Urban Economic Activities

Improved and continuous flows are expected to positively impact and stimulate economic growth with significant implications on urban dynamics as cities generate more than 80% of the global economic output measured in GDP [74]. Park et al. [70] explored the pandemic's economic impact on commodity mobility globally, which was partially or completely shut down except for a few essential services like grocery stores, banks, medical facilities, logistics companies, and certain public services. The study concluded that disrupted flows resulted in low cash flow, diminishing rates of return, and labor displacements. Tröster and Küblböck [73] examined the effect of restricted flows of people and goods on commodity-dependent countries. The study found low expert earnings, price hikes, and drops in the supply of crude oil, metals, and agricultural produce, significantly increasing the volatility of all types of commodities. Another study reported that some

cities recorded a marked decline in city tax revenues, income of residents and migrant workers, and revenues from hospitality, tourism, small- and medium-sized enterprises, and food supply chains [79].

Due to disruption to the flows and logistics that enable effective movements of goods at local and global levels, commercial activities as locational factors of production, such as the access to good natural harbors or proximity to raw materials and energy sources, become difficult to meet [70]. The era of globalization, a lever for economic prosperity, enables firms to expand their activities and operations and make profits and investments while maintaining strong linkages to their initial centers or headquarters through branch operations, labor mobility, and a variety of other connections. However, cities that often host local and international tourists are likely to experience shrinkage.

5.4. Socioeconomic and Gender Inequalities

Reduced mobility due to the pandemic affected minorities and low-income people the hardest, exacerbating gender and inter-generational inequality and poverty in cities [55]. For example, Barbieri et al. [11] compared people's mobility patterns for all transportation modes in ten countries across six continents. They found that women in Italy, Spain, and Portugal have reduced mobility because they stay at home to provide childcare, undermining their employment opportunities. Caselli et al. [71] analyzed the uneven effects of the pandemic in Spain, Italy, and Portugal. The study found that the lockdown affected the mobility of women and younger age groups more than men and older cohorts. Campisi et al. [72] investigated the impact of the pandemic on the perceptions and needs of road users in Sicily, Italy. They found that females have 1.5 times higher odds of reducing their walk frequency than males. Kim and Kwan [12] examined changes in people's mobility during the COVID-19 pandemic in the US. The authors found that the rates of mobility change are significantly associated with poverty level, political partisanship, and the strictness of mobility restriction policies. Similarly, students from low-income households also faced the challenges of online education due to a lack of access to the internet and computers [4]. In developing countries, where most people work in the informal economic sector involving daily mobility and close social interactions, restricted flows can deepen inequalities and push them into poverty [80].

5.5. Access to Urban Services and Infrastructure

The containment measures during the pandemic also impacted access to basic public services such as waste collection, education, healthcare, transportation, and drinking water, which can put the whole urban system at risk of collapse. For example, quarantine measures increased the generation of domestic, inorganic, and medical wastes. Cai et al. [68] found that lockdown measures sharply increased the waste generation in France and Italy, such as by 9% for Trento and 12% for Montreal, making waste collection and disposal more challenging because of the increased volume and the risks of spreading the virus. Moreover, many households that rely on community-based piped water and sanitation facilities and public buses could not access them due to restricted flows [24]. For example, in sub-Saharan Africa, 56% of urban populations live in slums with poor housing and basic services such as piped water, roads, and open spaces, and 35% lack access to garbage collection services [74], which expose them to high risks of exposure to COVID-19 [81]. Similarly, the negative attitudes towards public transportation, as buses are perceived as one of the riskiest modes of spreading the COVID-19 virus, have increased overreliance on personal automobiles, thereby marginalizing low-income people who rely on public transport for urban mobility and livelihoods [24]. Lastly, access to parks and gardens for recreation, pedestrian walkways, and bicycle lanes were impacted by restricted mobility during the pandemic.

5.6. Environmental Quality

The lockdown measures that restricted travel helped lessen noise and air pollution levels, including the emissions of GHG and particulate matter that generally emanate from transportation. This resulted in improved air and water quality in cities, with clear skies, rivers, and ponds [68]. For example, Shan et al. [15] estimated the impact of the pandemic on global GHG emissions from the transport sector. The authors found that from 2020 to 2024, emissions could decline by up to 5.6% in 79 countries, compared to a non-pandemic baseline scenario. Sharifi and Khavarian-Garmsir [24] documented surface and groundwater quality improvements during the lockdown. Their review of the literature found that reduced human activities during the lockdowns have led to better water quality by lessening the contamination of upstream and downstream water sources by solid waste, bacteria, and chemicals. Thus, restricted flows and anthropogenic activities have significant environmental impacts, suggesting a wake-up call to embrace sustainable urban development pathways.

6. Recommendations and Conclusions

Since their inception, cities have been physical entities with strong socioeconomic and cultural linkages. They contain a complex mixture of tangible and intangible elements and identities, increasingly overlaid with experiences and histories. Cities across the globe are interconnected by flows of people, goods, services, capital, and information that overlap, link, and drive urban development. These flows constitute the dynamics and lifeblood of the urban systems as an array of towns and cities held together by these flows at various scales. Notably, the increased sensitivity of cities to disasters such as pandemics has made their linkages susceptible to disruption. The COVID-19 pandemic has spread globally, regardless of national borders, impacting all aspects of people's daily lives, industries, and commercial and education sectors, with devastating social, economic, and financial losses. Through the flows of people and goods, cities have been the scene and setting of major social, economic, and political changes throughout human history. Cities continue to be loci of prosperity for entrepreneurship and innovation, serving as hubs for socioeconomic development and providing flourishing conditions for knowledge and information sharing. The link between population mobility and socioeconomic activities allows cities to be major hubs for global trade, multinational corporations, higher education, sports, and cultural events. Thus, flows play crucial roles in sustaining urban system integrity and functioning, and shape the socioeconomic development of the system of world cities.

However, as the present study indicates, restricted flows could negatively impact the dynamics of urban systems by slowing and disrupting the linkages between cities, and the interaction of people, firms, and institutions within cities, which are the major determinants of the dynamics of urban systems. However, an urban system can recover after the pandemic to foster the lives of its residents. The following recommendations can help urban systems to overcome the major impacts of disrupted flows and foster economic development and resilience.

First, resilient urban planning is vital to urban system resiliency. Post-pandemic urban planning and landscaping should underscore the significance of the urban realm in improving human wellbeing by offering healthy and sociable outdoor life experiences [20]. It should emphasize walkable streetscapes, green infrastructure, and public open spaces as dynamic places where diverse socioeconomic activities take place with less risk of spreading COVID-19 [43]. Urban design should emphasize biophilic design that incorporates nature into it, and building designs that pay more attention to ventilation, indoor air quality, and other comfort-related design issues [42]. In addition, a balance should be struck between density, urban design, and landscaping, as well as a trade-off between compartmentalized and integrated land uses.

Second, disaster risk reduction, environmental management, horizontal and vertical coordination among state agencies, tailoring policies and programs to reflect the public interest, building trusting relationships with people, and consultations with various urban

stakeholders are essential for the better planning of urban areas [25]. There should be more collaboration between urban planners and landscape architects in designing cities that better respond to natural and human-made disasters such as the COVID-19 pandemic. Such urban systems that can respond better to the impacts of pandemics and emerge stronger are those with good governance, robust city planning, a culture of equity, and human socioeconomic development [26].

Third, good governance, including strong institutions, efficiency, transparency, consultation, and accountability in service delivery, is vital to city resilience and revival. There is a need for positive change consisting of decentralization, public participation and feedback, creativity, and trying new initiatives, such as providing social safety nets, improving equity in terms of access to urban service delivery, and poverty alleviation [39,40]. Urban actors and stakeholders, such as policymakers, institutions, firms, organizations, and citizens, should collaborate and create a relationship of support and solidarity for urban system resilience [20] and sustainable urban environments [44,82].

In conclusion, lockdown measures have halted and disrupted the flows of people and goods, influencing the differential socio-spatial aspects of the global system of cities. The world system of cities within the global political economy underscores nations' interdependence through continuous flows of people, goods, services, energy, knowledge, and information. This interdependence has emphasized the significance of considering the complexity of the existing linkages within the world's system of cities. Flows could help transform world cities into distinctive niches due to their role in connecting political and financial control centers. However, COVID-19's restrictive measures have undermined this vital role.

Given that it is too early to measure the full impact of the pandemic on the dynamics of urban systems, the role of disrupted flows of people and goods in shaping cities is likely to remain the main area of future studies. Future studies can empirically assess the level of correlation between the types of flow and their impact on specific components of urban systems, such as income/jobs, healthcare, access to water and sanitation, education, and public spaces. Achieving resilient linkages for people, commodities, capital, ideas, and information, combined with strong supply chain networks, is critical to sustaining the structure of urban systems worldwide. The pandemic presents urban systems with the prospect of a momentous 'reset' that can drive the development of more resilient, livable, inclusive, and sustainable urban areas.

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