Logistics City Research Chair - Gustave Eiffel University (France)

Research report

Analysis of the spatial logics of Amazon warehouses following a multiscalar and temporal approach. For a geography of Amazon's logistics system in the United States.

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Summary

Introduction. Contribution to the analysis of warehouse location logics and the logistics sprawl process.

Logistics sprawl corresponds to the growth in the number of warehouses on the outskirts of large cities, particularly in peri-urban areas where densities are low, land is available and cheap and plot sizes are high (Giuliano *et al.*, 2013; Dablanc *et al.*, 2018). Urban renewal, land pressure, competition with other activities, have created a context that is less and less favorable to the development of logistics activities in dense areas (Heitz, 2017) while peri-urban areas offered logistics activities large plots of land and proximity to large consumer markets thanks to good road and highway connections. The availability of transport infrastructure in fact offers good accessibilityon two scales: firstly, local (to delivery areas) and secondly, regional or inter-regional (to other cities, to other countries for logistics facilities that have an extended *hub* role). Local public policies in favor of the development of logistics policies also influence the location of warehouses, with, for example, the creation of logistics zones on the outskirts to attract warehouses. The lack of regulation of metropolitan margins has favored the development of warehouses in peri-urban areas, fueling a process of *logistics sprawl* (Dablanc *et al.*, 2014), which shows that the geography of warehouses is concentrated in sparsely populated peri-urban areas (Bowen, 2008; Cidell, 2010). The intensity of logistical sprawl varies with the type of warehouse (higher for distribution centers, lower for courier terminals) and according to the type of strategy implemented by the actor considered. This logistics sprawl can also be explained by the evolution ofthe supply chain and the demand for logistical real estate (Hesse, 2008).

The lack of regional and metropolitan regulation of logistics has given way to logistics development on the margins of cities, contributing to logistics sprawl, the result of a negotiation between isolated peri-urban municipalities and real estate development actors integrated into international financial markets (Raimbault, 2014). The main negative impacts of logistics sprawl (congestion, pollution, land artificialization) contradict the objectives of the "sustainable city" which includes densification, functional mix, reduction of congestion and CO2 emissions, fight against land artificialization. These new sustainability objectives have led to a refocusing of the debate on the "last mile", rather than the development of logistics in the peripheries, as a compensatory measure to this sprawl. At the same time, private demand for warehouses in dense areas has emerged. Some logistics sectors, particularly those linked to e-commerce, have started to look for new urban warehouses. This new demand for real estate also corresponds to the public authorities' objectives of redeveloping logistics activities in city centers in order to limit logistics sprawl. Thus, on the one hand, we are seeing the development of peri-urban logisticscharacterized by the rise of large, standardized logistics buildings, mainly intendedfor logistics

service providers, mass distribution or industry (Heitz *et al.*, 2017). On the other hand, we are witnessing the rise of urban logistics made up of buildings that are still largely "tailor-made" and which are subject to particular attention in terms of urban integration. This dualization of the real estate market reveals two patterns of logistics real estate development: a peri-urban logistics that is in the majority and an emerging urban logistics that is in the minority. However, these two types of logistics can now function as a network covering the entire metropolitan area.

E-commerce is simultaneously creating a new retail landscape through digitalization and new consumption and distribution practices (virtual access to a wide range of products, instantaneity, omnichannelity) (Ramcharran, 2013; Hagberg *et al*, 2016) and a new *freight landscape* in terms of the structuring of demand, the location characteristics of warehouses and distribution centers, transport strategies (modal choices and nodal facilities) and the handling of the last mile in central urban areas (Bowen, 2012; Rodrigue, 2020). Jean-Paul Rodrigue (2020) has identified four major effects of e-commerce on the distribution of goods: effect on distribution structures (growth of B2C deliveries), effect on the real estate market (decrease in retail real estate and land footprint and increase in warehouse footprint), effect on logistics facilities (development of new types of warehouses - *e-fulfillment centers*, *sortation centers*, *urban logistics centers*), effect on business strategies (vertical integration, development of 3PL and 4PL services or own transport services by e-commerce *pure players*). E-commerce players are seeking to maximize access to urban markets and minimize delivery times by relying on significant economies of scale and density, particularly for their distribution centers (Houde *et al.*, 2017), developing their own urban logistics strategies for last-mile deliveries (Browne *et al.*, 2019) and promoting this vertical integration, of which Amazon is a pioneer company (Lieb and Leib, 2016).

The company Amazon embodies all of these developments in retail and e-commerce, being a dominant player in the e-commerce sector: in 2017, Amazon accounted for 37% of the total e-commerce market in the United States, reaching 39.8% in 2020. This share should exceed 40% in 2021. In the United States, Amazon's supremacy is clear: 40.4% of the e-commerce market in 2021, 7.1% for Walmart (^{2nd}), 4.3% for eBay (^{3rd}), 3.7% for Apple (^{4th}), 2.2% for Best Buy (5th)[1]. In the overall retail sector, Amazon is the second largest market player behind Walmart. The Covid-19 crisis has had an accelerating effect on Amazon's already spectacular growth with sales growth of 44.1% in 2020 - sales are expected to grow more than 15% in 2021 - and revenue growth of 38% in 2020 to $386 billion. This performance is based on a particularly successful vertical integration and a recognized efficiency in supply chain management, particularly in the last mile[2]. This management is based on a logistics system organized around an

[1] https://www.emarketer.com/content/amazon-dominates-us-ecommerce-though-its-market-share-varies-by-category [accessed on 12/11/2021].
[2] https://www.forbes.com/sites/shelleykohan/2021/02/02/amazons-net-profit-soars-84-with-sales-

interlocking network of warehouses and logistics equipment of different sizes and types, proprietary 3PL and 4PL services and proprietary transport services (air, trucking). At the beginning of 2021, Amazon purchasedeleven Boeing 767 aircraft converted to cargo planes to expect a fleet of 85 cargo planes by the end of 2022. For several years, Amazon has been shifting its strategy towards direct ownership and control of most aspects of the supply chain, to be less dependenton third-party service providers (UPS, FedEx). This has enabled it to reduce its *click todoor time* in 2020 from 3.4 days to 2.2 days on average (industry average: 5.1 days)[3].This research therefore focuses on the evolution of Amazon's logistics system and in particular the geography of Amazon's warehouses, marked by an expansion of the spatial coverage of the warehouses and by a functional specialization of this logistics system. The research has three objectives: to map these evolutions with a temporal dimension; to identify the logics of spatial coverage of the company in particular in relation to markets of different sizes; to distinguish these logics according to the type of warehouse; to analyze the strategy of the company and these spatial logics on a regional scale starting from the three largest consumer markets (New York region, Los Angeles region, Chicago region).

Sources and methodology.

The analysis of Amazon's warehouses in the United States was made possible thanks to an inventory of logistics facilities maintained by MWPVL International, a logistics and *supply chain* consulting firm. This inventory is regularly updated: here is the latest available inventory updated in September 2021 (**Fig.1**). This inventory is available on the company's dedicated website and is protected but authorized to be used for research purposes[4]. This inventory is the most complete available but it is possible that some projects are not referenced or that information is fragmented for smaller logistics facilities (especially *Prime Now Hubs*).

This research took place from April to July 2021, and is based on the May 2021 inventory - so some information (particularly in terms of warehouse projects) may have changed between May and November 2021. In order to represent the spatial processes in 2021 as simply as possible, the choice was made to take into account for the 2021 maps all the facilities including all the projects indicated as opening until December 2021. This database contains a geo-coding with for each facility: a specific code (3 letters and 1 number most of the time), the location by American state and then by address (precise or approximate especially for projects), the function and the type of warehouse, the surface area (expressed in *square feet*), the year of opening

hitting 386-billion/?sh=69d546a41334 [accessed on 12/11/2021].
[3] *Ibid.*
[4] https://www.mwpvl.com/html/amazon_com.html [accessed on 12/11/2021].

(estimated opening for projects), the status of the warehouse (open, closed, planned), the co-presence, if any, of another logistic or transport facility. Other information may appear in the warehouse function that is subject to cartographic processing, for example warehouse extensions or their total or partial robotization (**Fig.2**).

Figure 1: Screenshot of MWPVL International website (September 2021).

As of **September 2021**, to the best of our knowledge, Amazon operates the following global distribution infrastructure:

Flag	Country	Facility Type	Currently Active Facilities	Future Facilities	Active Square Feet	Future Square Feet
	United States of America	Fulfillment Centers, Supplemental Centers & Return Centers	264	106	184,832,548	71,582,958
		Pantry/Fresh Food FCs	22	1	5,537,381	240,000
		Whole Foods Retail Grocery DCs	12	0	1,457,036	-
		Prime Now Hubs	78	2	2,981,900	195,000
		Inbound Receiving Centers	22	17	12,435,707	9,996,348
		Outbound Sortation Centers	69	38	25,487,794	12,656,841
		Delivery Stations (Packages)	361	246	62,500,029	47,698,832
		Delivery Stations (Heavy/Bulky)	93	29	3,262,781	2,046,148
		Airport Hubs	17	2	4,105,193	280,750
		SubTotal USA	**938**	**441**	**302,600,369**	**144,696,877**

(Source: https://www.mwpvl.com/html/amazon_com.html ; accessed on 25/10/2021)

Figure 2: Screenshot and extract from the MWPVL database International (September 2021) on *Fulfillment & Distribution Centers* from Amazon.

The Amazon Fulfillment Center and Distribution Center Network in the United States

Currently Amazon operates a variety of different types of fulfillment and distribution centers in the United States including small sortable, large sortable, large non-sortable, specialty apparel and footwear, specialty small parts, returns processing centers, and 3PL outsourced facilities. A detailed listing of all existing and known Amazon Fulfillment and Distribution Centers appears in the table below. All figures provided are estimates based on our research. Please note that the square footage figures below exclude mezzanine areas.

State	Code	Location	Square Feet	Year Opened	Description of Operation
Alabama	BHM1	975 Powder Plant Road, Bessemer, Alabama, USA, 35022-5497	855,000	March 2020	Project Bluebird. Small Sortable.
Alabama	HSV1	7816 Greenbrier Rd, Madison, Huntsville, Alabama, USA, 35756	1,000,000	Q3 2021	Large Non-Sortable FC.
Arizona	PHX3	6835 West Buckeye Road, Phoenix, Arizona, USA, 85043-4428	1,009,400	September 2007	Legacy Sortable Fulfillment Center. Originally opened at 605,000 Sq. Ft and expanded by 400,000 Sq. Ft. in Dec. 2011
Arizona	PHX5	16920 W. Commerce Dr., Goodyear, Arizona, USA, 85338-3620	820,400	June 2008	Large Non-Sortable Fulfillment Center. Originally opened as PHX4 Delayed Allocation facility at 800,000 Sq. Ft. and expanded to 1.2 Million Sq. Ft by adding 2 x 230,000 sq ft mezzanines in 2011.
Arizona	PHX6/ TFC1	4750 & 5050 West Mohave Street, Phoenix, Arizona, USA, 85043-8305	1,205,600	October 2010	Large Sortable Fulfillment Center in one half of the building. Small Sortable Fulfillment Center in the other half.
Arizona	PHX7/ PHX8/ TEN3	800 N. 75th Ave, Phoenix, Arizona, USA, 85043-3101	1,267,100	September 2011	PHX7 is Large Non-Sortable
Arizona	PHX9	777 S 79th Ave, Tolleson, Arizona, USA, 85353-3140	-	October 2015	PHX9 is a Seasonal Supplemental FC within a Pepsi/Quaker building.
Arizona	TUS1	5333 West Lower Buckeye Rd, Phoenix, Arizona, USA, 85043	473,200	Q4 2017	Returns Facility
Arizona	TUS2	6701 S. Kolb Road, Tucson, Arizona, USA, 85756	857,400	April 2020	Small Sortable. Also processes returns, light assembly, 3-D printing and direct product pickup by customers from automated kiosks.

(Source: https://www.mwpvl.com/html/amazon_com.html ; accessed on 25/10/2021)

For the United States, the database lists a total of 302.6 million *square feet* of logistics equipment and warehouses, or 28.1 million square meters, and more than 144.6 million *square feet* of projects, or 13.4 million square meters planned (2021-2024). Amazon warehouses are listed from 9 warehouse categories:

- *Fulfillment and Distribution Centers*, which are large distribution centers that concentrate consumers' online orders, generally ranging from 500,000 to 2 million *square feet* for the largest centers. Many of these centers are undergoing full or partial robotization, as well as expansion (either through building expansion or optimization, or by expanding outside the building). Large distribution centers may also be specialized according to product type (clothing, jewelry, electronics, perishables - this information may be mentioned in the description of the functions of the database but has not been the subject of a cartographic treatment) or according to the type of handling and packaging ("*small sortable*" for small sortable products that can fit in packages of less than 10 kilos, "*large sortable*" for larger sortable products of 10 to 25 kilos; "*large non-sortable*" for heavy and/or bulky products that cannot be sent in standardized packages such as furniture or televisions).
- *Pantry/Fresh Food Fulfillment Centers* correspond to the same type of warehouse as the previous category, i.e. a large distribution center, but specialized in the management of orders for perishable and/or fresh food products as well as cleaning products.
- *Whole Foods Retail Grocery Delivery Centers* fit a very specific category with a limited number of facilities, the stores of the Whole Foods chain acquired by Amazon in June 2017 for $13.7 billion. These supermarkets also act as distribution and delivery centers for the chain and for online orders.
- *Prime Now Hubs* are local delivery *hubs* dedicated to express deliveries and Amazon's *Prime Now* premium service. These urban *hubs* respond to requests for very fast deliveries, less than 48 hours, and for instant deliveries. These small and medium-sized warehouses are located in dense areas of major metropolitan areas to be as close as possible to the demand and to cover the catchment areas in central and peri-urban areas.
- *Inbound Cross Dock Centers* correspond to processing centers for maritime containers loaded with goods imported into the United States, generally located near major multimodal *hubs* (ports, logistics platforms, rail *hubs*): *"IXDs are the point of entry for the fulfillment process in e-commerce by synchronizing inbound procurement logistics with the distributional capabilities of e-fulfillment centers*" (Rodrigue, 2020).
- *Regional Sortation Centers* are the intermediate regional links between several large distribution centers. They are used to sort packages for a given region from multiple Amazon distribution centers. Packages are sorted by zip code and then redistributed to local links in the supply chain, either to third-party

carriers (e.g., UPS) or to smaller delivery and last-mile distribution centers.

- *Delivery Stations (Packages)* and *Delivery Stations (Heavy/Bulky)* are two categories that represent small last-mile delivery centers that serve either as distribution locations for delivery drivers picking up packages or as final delivery locations for orders that are not intended for home delivery. These small facilities are the most local link in Amazon's logistics system and there are a large number of delivery and collection points in urban and suburban areas for third-party carriers, Amazon delivery agents and customers. Some of these delivery and distribution points correspond to *pick- up points,* in particular "*Amazon lockers banks*". The database used distinguishes these "*stations"* into two sub-categories: delivery points for small packages and those for bulky or heavy objects not packed in packages.
- *Air Gateways* correspond to facilities near or within an airport space that handle the cargo pallets of air cargo services from or to major distribution centers and large pooling centers. These services are designed according to the *hub-and- spoke* organizational principle (Rodrigue, 2020).

The most represented type of warehouse is the *Delivery Stations Packages & Heavy/Bulky*, of which the database lists 454 across the country and another 275 projects, reflecting the exceptional growth of Amazon's business in the United States and in particular its spatial coverage. The second type of warehouse is the distribution center, of which the database lists 264 facilities and 106 projects as of September 2021. Amazon's spatial footprint is largest with distribution centers: 184.8 million *square feet* (17.1 million m^2), or nearly 61% of Amazon's total warehouse space. Distribution centers account for 49.4% of the total planned space.

After recovering the database, which had to be transcribed in full in Excel spreadsheets since the database is in *open access* but protected from any automatic and complete copy, a work of standardization of the database was engaged as well as the extraction of certain characteristics in the description of the functions, in particular the robotization of certain installations or the distinction between the warehouses specialized in the management of the "*sortable"* and "*non-sortable"* products. The tables taken from the data retrieved from the website were scanned. Each facility address was geocoded from the provided address or approximate location (in these cases we chose either to represent the middle of the facility or to indicate a location in the nearest industrial area) *via* OpenStreetMap and Nominatim. This can lead to some approximation in the location of some warehouses and we proceeded to a manual relocation for the outliers using the GIS software QGis. The maps presented in the following study were produced using QGis, supplemented by processing in R software for statistical representations. The main difficulty was to account for and cross-reference several dimensions for a large number of warehouses in the database: location, size, distinction between general and

specialized warehouses, especially for large distribution centers, specificities of the warehouses (e.g. robotized warehouses and/or multi-story warehouses), the evolution of the warehouses over time.

An analysis of Amazon's US-wide logistics system deployment strategy.

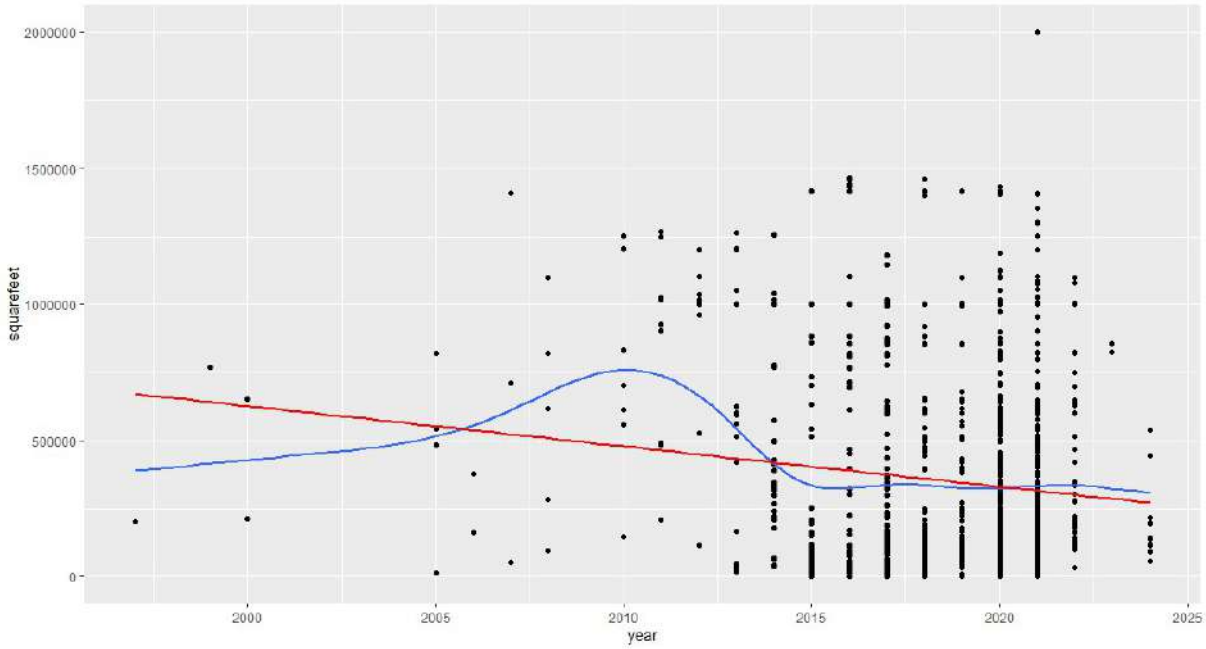
The exceptional deployment of Amazon's logistics system reflects the equally exceptional growth of Amazon's business. Jean-Paul Rodrigue (2020) has identified four phases of growth since the 1990s:

- The first phase corresponds to Amazon's entry into a niche market from 1995 onwards, at a time when the Internet economy was in its infancy and e-commerce represented only a tiny niche business. The company therefore had only a very limited number of medium-sized distribution centers. The business activity was limited to digital products.
- The second phase from the mid-2000s marks an evolution of Amazon's business strategy that rapidly diversifies the types of products available (electronics, toys, cosmetics, clothing). As a result, a first wave of expansion of Amazon's logistics system took place from 2005 to 2008 ensuring Amazon's deployment as an e-commerce platform: in particular the increase in the number of distribution centers and the opening of the first *Inbound Cross Dock* for imported goods.
- From 2010, the company is deploying an aggressive growth strategy, particularly through greater horizontal integration, in response to the rapidly growing demand for online shopping, especially in the United States. To achieve this, Amazon began opening a large number of distribution centers throughout the country, followed by the gradual specialization of warehouses with the opening of *Sortation Centers*, *Delivery Stations* and the first local *hubs* for the *Prime Now* premium service.
- Finally, since 2016, Amazon's logistics system has undergone three major changes: a change of scale with the opening of a very large number of warehouses, particularly large distribution centers, enabling Amazon to assert itself as the dominant player in the e-commerce sector in the United States; increasing specialization of its warehouses; and a strategy of vertical integration enabling Amazon to have greater control over the entire distribution and transport chain and to be less dependent on third-party carriers (UPS, FedEx).

The analysis of the MWPVL International database allows to represent Amazon's deployment strategy over time. The first graph below (**Fig. 3**) replaces the opening of Amazon warehouses over time (from 1997 to the projects planned until 2024). With this representation, we can distinguish these multiple phases of expansion, especially

the phase of massification of the activity and strengthening of the spatial coverage of the warehouses between 2015 and 2020. Nevertheless, the most interesting lesson of this graph is the decrease over time in the size of the warehouses opened especially from 2014-2015. Each point represents the creation of a warehouse (all categories combined) classified by date (x-axis) and area (y-axis). The concentration of points on the right shows the surge in the number of warehouses from 2013-2014, and also shows the multiplication of very large warehouses from 2010. We also show the curve and the linear regression line, which show that the average surface area of warehouses tends to decrease (the curve shows that it increased until 2010, then drops until 2015 and remains stable until today). The straight line and regression curve shown expresses this gradual decrease over time after a period of continuous growth from 1997 until 2013, with a short period of large warehouse openings between 2009 and 2013. This represents an evolution of Amazon's logistics strategy gradually shifting towards spatial coverage of urban spaces, requiring small urban warehouses (e.g. for fast delivery services) and many small delivery and parcel distribution points. It is also interesting to note that only a small number of large distribution centers are planned for the period 2021 to 2024.

Figure 3. Opening of Amazon's US warehouses over time relative to their size (expressed in *square feet*) and the right and left-hand curve of regression.



When the dynamics of warehouse opening are represented according to the type of warehouse, this confirms this process of functional specialization and this strategy of gridding metropolitan areas with logistics area for last-mile distribution. This graph allows us to make several observations:

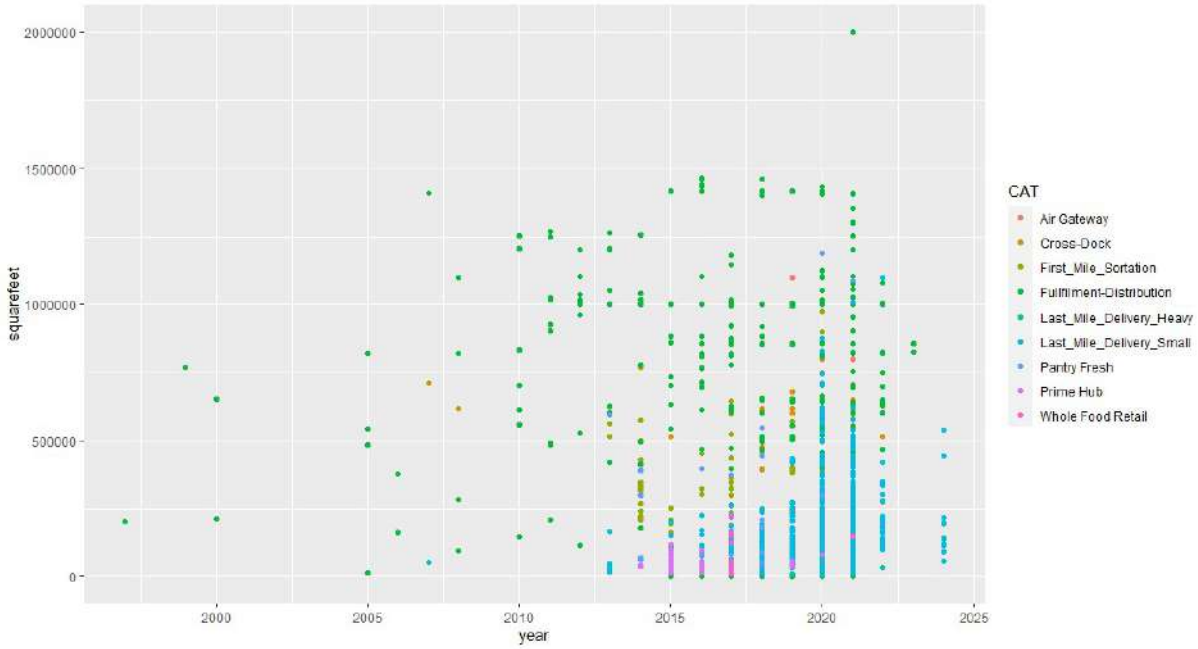
- Amazon's logistical development takes place in a short period of time, so this development has been exponential and extraordinary over a period of only 7 to 8

years (2014-2021).

- Amazon's strategy is based on diversification and functional specialization in both the size and type of warehouse. From 2013-2014, warehouses are much more numerous, can be large, medium or small. Although Amazon is mainly turning to the creation of small warehouses and last-mile logistics spaces from 2018 onwards, we still see the opening of particularly large distribution and fulfillment centers, several dozen of which reach almost 1.5 million *square feet* (130,000-140,000 m^2).
- The distribution centers constitute the main framework of Amazon's logistics system, but the spatial coverage of the distribution centers is expanding, including in the projects listed for 2022 to 2024. This framework is completed by a specialized regional framework (*Sortation Centers*, *Cross Docks*, *Air Gateways*) and by a relatively narrow local framework (*Last Mile Delivery*, *Prime Hub*).

The graph below (**Fig. 4**) provides a complementary representation of this spatial expansion over time based on the type of warehouse. This graph illustrates firstly, the relative weight of each type of warehouse in Amazon's global logistics system: the large distribution centers (*Fulfillment Centers*) represent the bulk of this logistics system, confirming exceptional spatial coverage of the US territory, particularly from 2014-2015 onwards, with a growing diversification in the size of distribution centers, and in particular medium-sized centers.

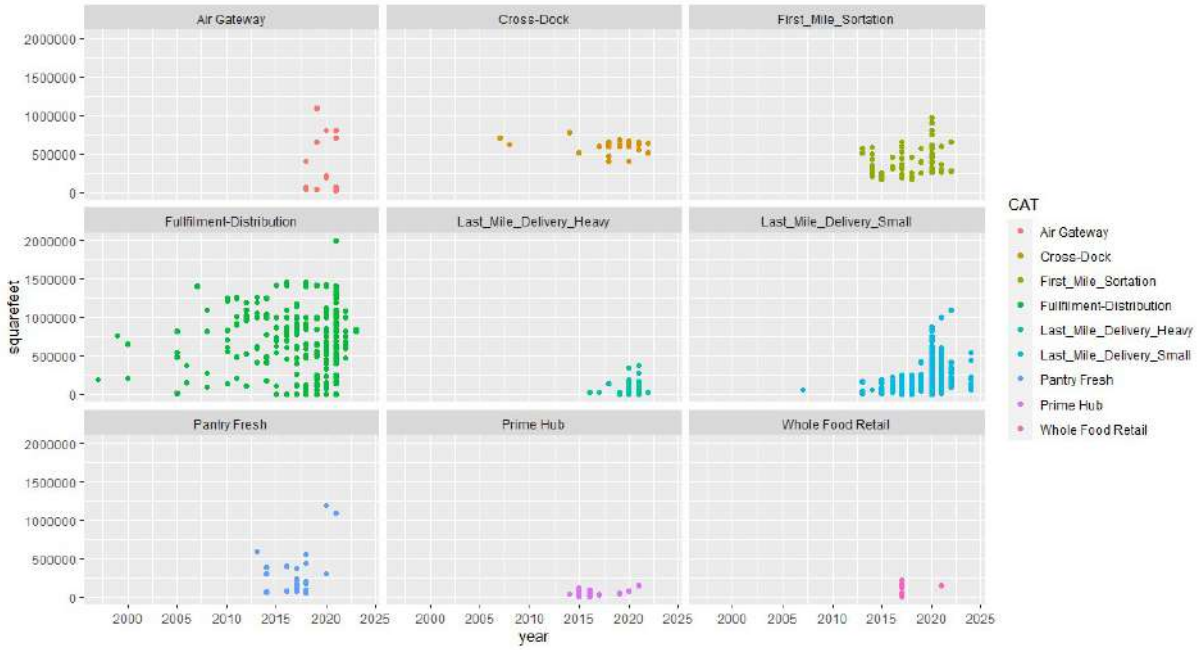
Figure 4. Opening of Amazon's US warehouses over time relative to their size (expressed in *square feet*) and the right and left-hand curve of regression.



The functional specialization of Amazon's warehouses can be clearly seen in this

graph, with numerous specific warehouse openings between 2015 and 2020: *first-mile sortation centers, last-mile delivery centers, Prime hubs, pantry/fresh centers*. This specialization also signals Amazon's strategy of vertical integration to reduce its dependence on third-party operators, as shown by the very rapid opening of air hubs (*Air Gateways*).

Figure 5. Opening of Amazon warehouses in the United States over time relative to warehouse type.



The mapping below allows to spatially represent Amazon's logistics system according to the type of warehouse or logistics equipment: "*air gateway*", "*inbound cross dock*", "*regional sortation center*", "*pantry and fresh distribution center*", "*whole foods retail or distribution center*" (**Fig. 6**). Several observations can be made:

- *Air Gateways* are few. They are generally not located in major airport *hubs* (except Dallas, Los Angeles), with Amazon appearing to take up positions either at medium-sized airports or at large airports that do not serve as a territorial base for a carrier or express carrier. As of 2021, Amazon's largest *hub* is located near Cincinnati in the city of Wilmington, while Atlanta (the largest US airport) or Memphis (FedEx's territorial base) do not host one. The situation in the Megalopolis is enlightening on this point: the two Amazon *hubs* are located outside the major metropolises.
- *IXDs* ("*Inbound Cross Docks*") correspond to processing centers for maritime containers loaded with goods imported into the United States, generally located near major multimodal hubs (ports, logistics platforms, rail hubs), which explains the high degree of territorial selectivity in the location of IXDs, which are located at major multimodal facilities.

- *Regional Sortation Centers* are the intermediate regional links between several large distribution centers. They are used to sort packages for a given region from several Amazon distribution centers. There are a large number of them, and each major or intermediate metropolis is served by one or more of these intermediate sorting and distribution centers.
- *Pantry and Fresh Distribution Centers* cater to developing trade services but still have a modest logistics footprint with few warehouses. These are generally small, with two exceptions in the east, and close to major urban centers, enabling them to meet the fresh/perishable and household goods orders of urban customers.

Figure 6. Opening of Amazon warehouses in the United States over time by warehouse type.

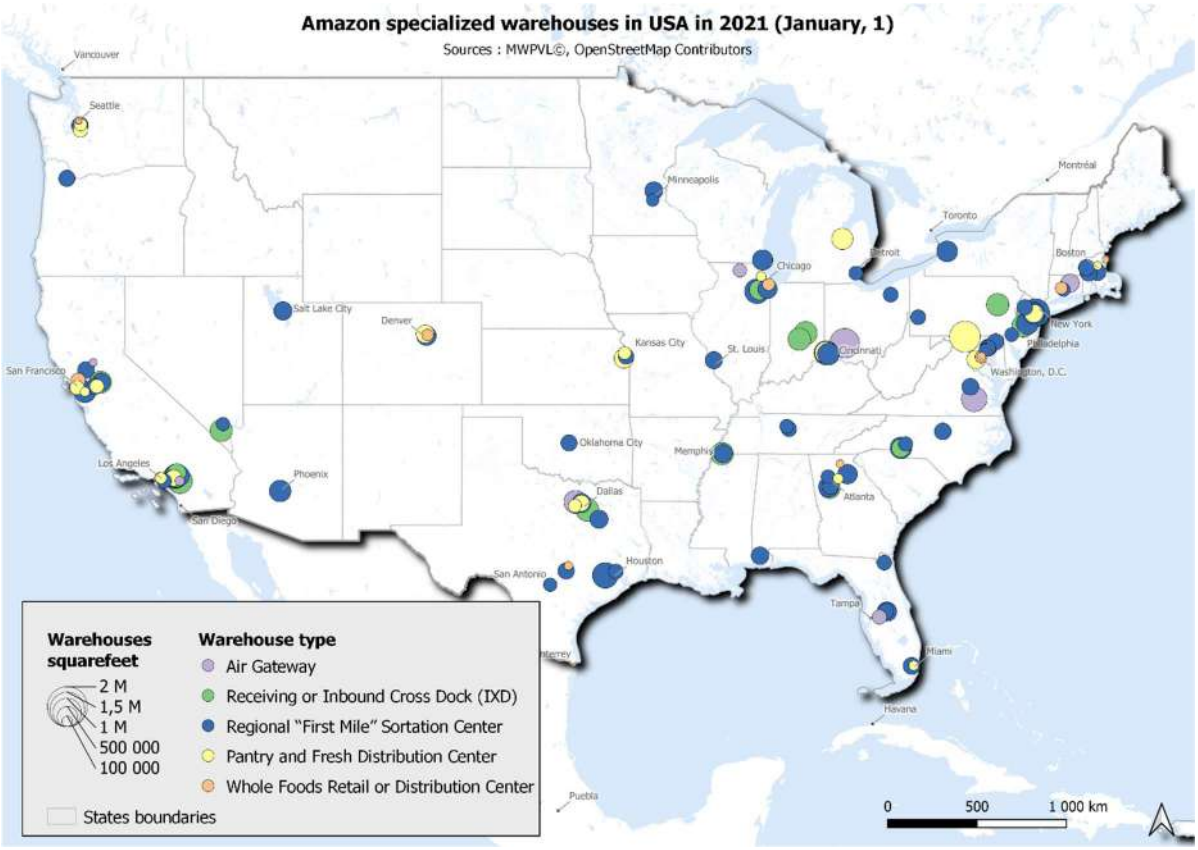
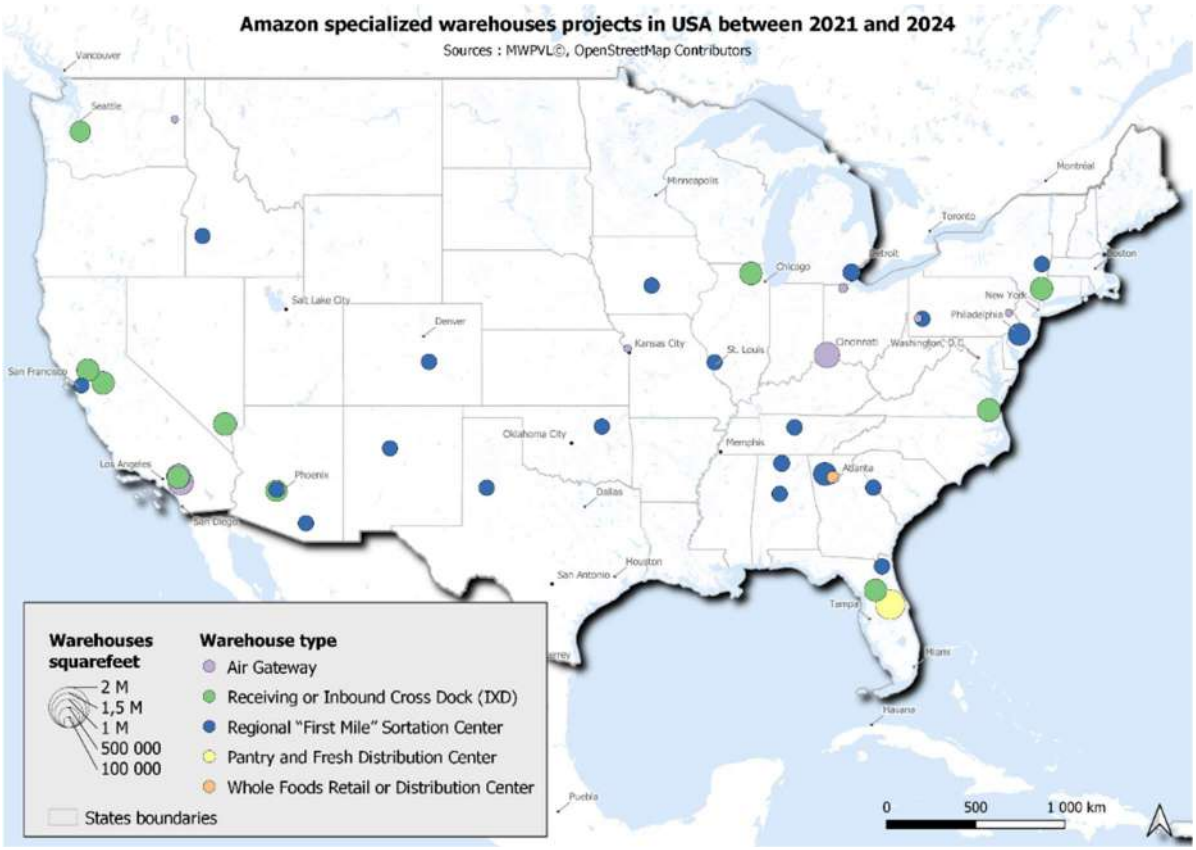


Figure 7. Amazon warehouse openings planned in the United States over time by warehouse type.



When we look at the projects planned between 2021 and 2024 (**Fig. 7**), we see the strengthening of Amazon's logistics infrastructure, in particular with several *IXD* warehouses to increase handling capacity at seaports, dry ports and trading platforms, as well as with several *regional sortation centers*, particularly in new markets or territories not well covered by Amazon's logistics system (e.g., northern Texas, New Mexico and Idaho).

The other categories of warehouses have been mapped separately since they represent new urban logistics spaces as well as particularly numerous distribution points. For several years, Amazon has been offering fast (less than 48 hours), very fast (less than 24 hours) and even instant delivery services for certain types of products (within the day). These new services offered to consumers require, in addition to the logistics structures already mentioned, adapted and dedicated logistics equipment, in particular for the *Prime Now* paying service. In line with its overall strategy of horizontal and vertical integration, the company is therefore developing small urban warehouses that enable it to control the various links in the logistics chain, particularly the last mile (**Fig. 8**). These urban warehouses for *Prime Now* are very small compared to other warehouse categories and have a coverage space still fairly limited to the major metropolitan markets where demand for this type of delivery is highest - there are several warehouses in the Los Angeles, San Francisco, Dallas and New York City areas.

Figure 8. Location of small urban Amazon warehouses dedicated to *Prime Now* service as of January 1, 2021.

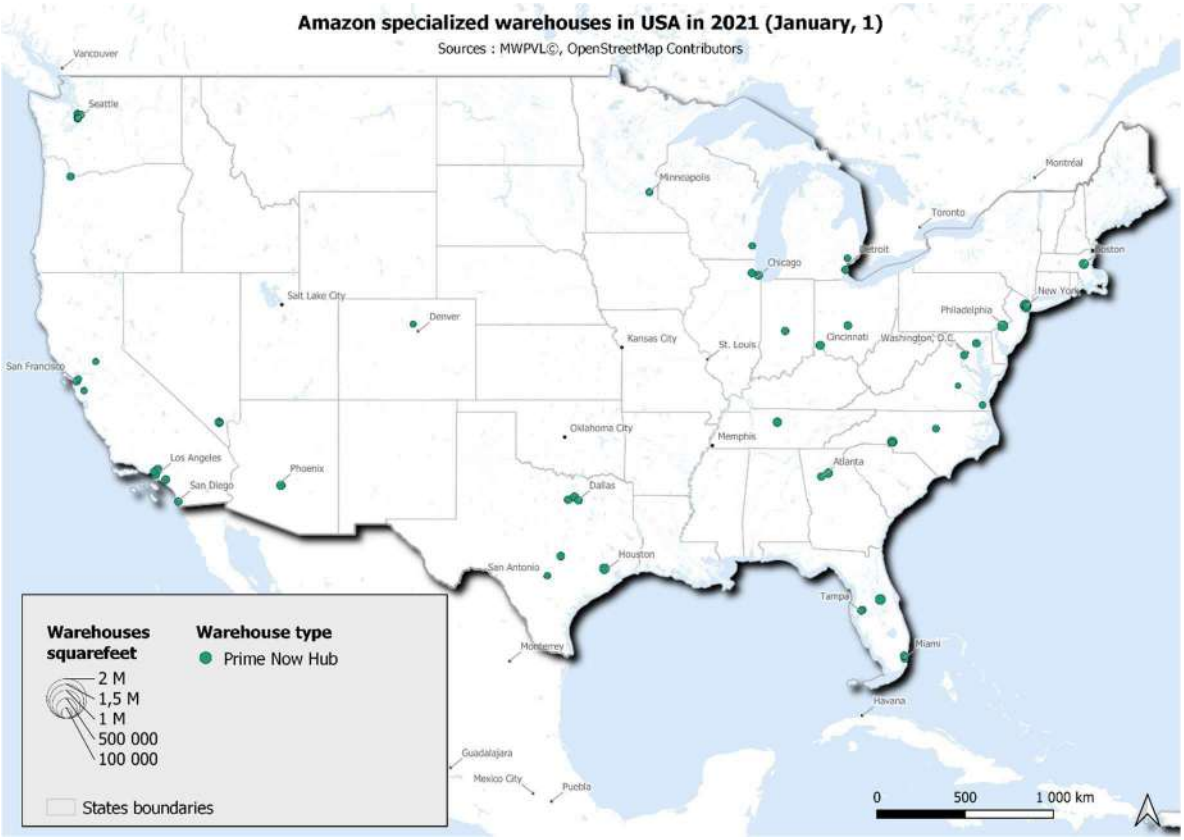
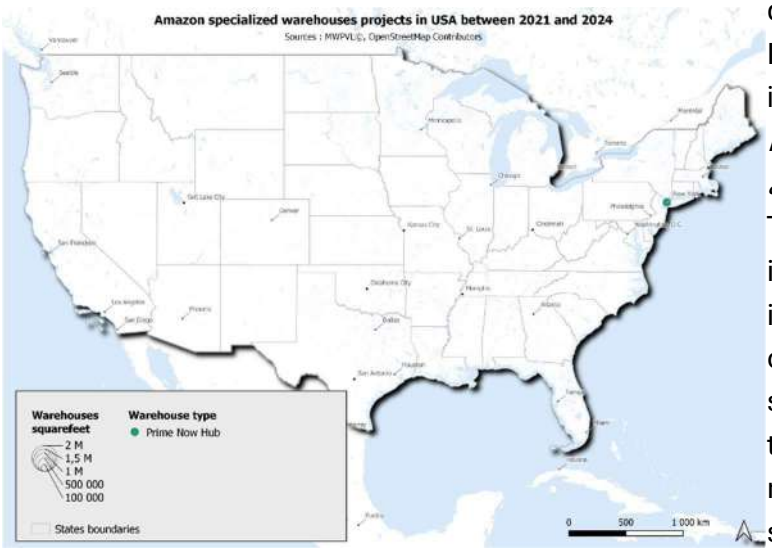


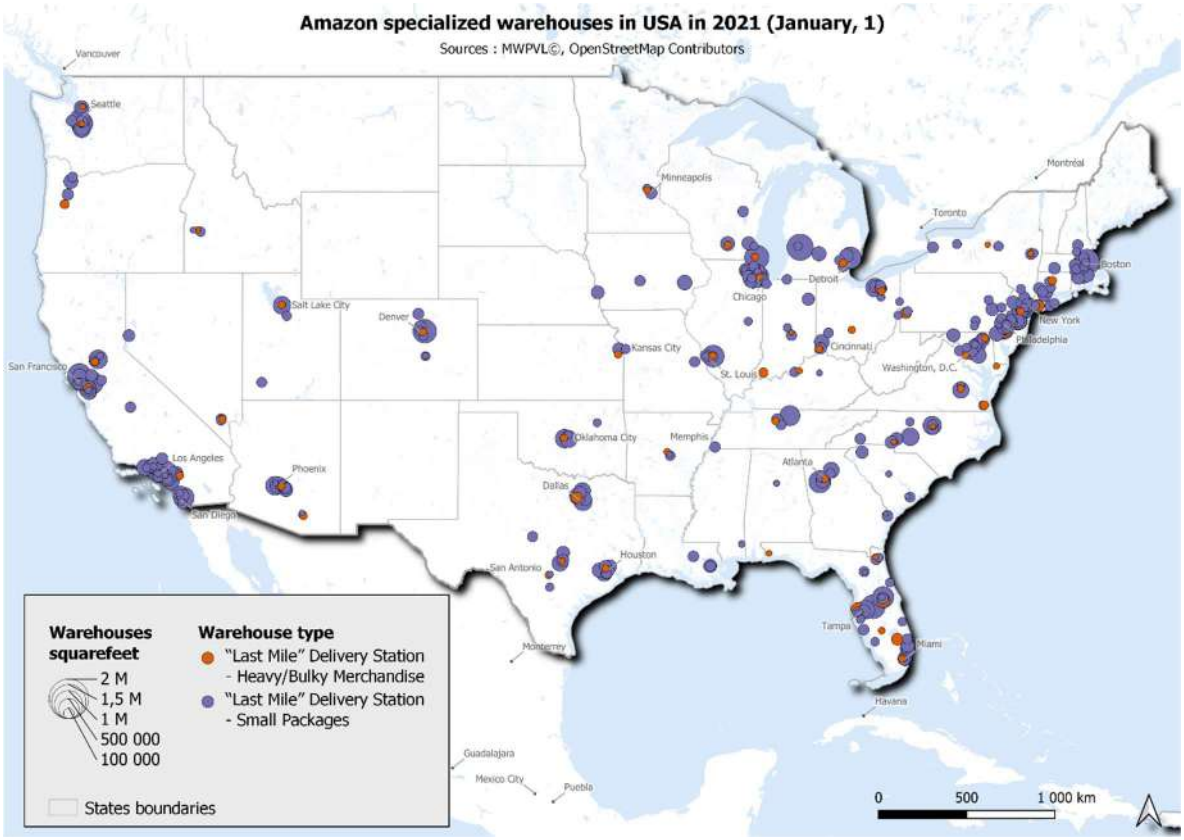
Figure 9. Scheduled opening of small urban warehouses dedicated to *Amazon Prime Now* between 2021 and 2024 in the US.

These dedicated urban warehouses are currently concentrated in metropolises at the top of the American urban hierarchy, although some intermediary metropolises are now involved (San Diego,Sacramento, Portland, Tampa, etc.). Nevertheless, we can see that in the database, onlyone project in New York City is identified for the period 2021-2024 (**Fig.9**). Is this a sign of Amazon's caution in deploying its ultra-fast and instant delivery commercial offer? Indeed, the company decided in 2014 to end *Prime Now* and *Prime Pantry/Fresh* as *stand-alone services in* the US. These two services were integrated in the same year into the multiple services offered by the Prime subscription, which was raised to $99 per year. In 2016, 44.8 million U.S. households signed up for Amazon Prime.



That number is expected to grow to 81.4 million by 2021 and 90.2 million by 2025, according to projections by consulting firm Insider Intelligence[5].

Figure 10. Location of *last mile* delivery sites in the United States as of January 1, 2021.



Last-mile delivery points are the most developed type of logistics equipment in Amazon's logistics system. They are used for last-mile deliveries, and their spatial coverage must be as extensive as possible to facilitate access to distribution and delivery points for carriers, delivery personnel or consumers. There are two types of points depending on the type of product: points for small parcels, which are the most numerous, and points for heavy or bulky goods. The map showing the location of these sites on January 2021 shows the extent of this spatial coverage (**Fig. 10**). Several observations can be made:

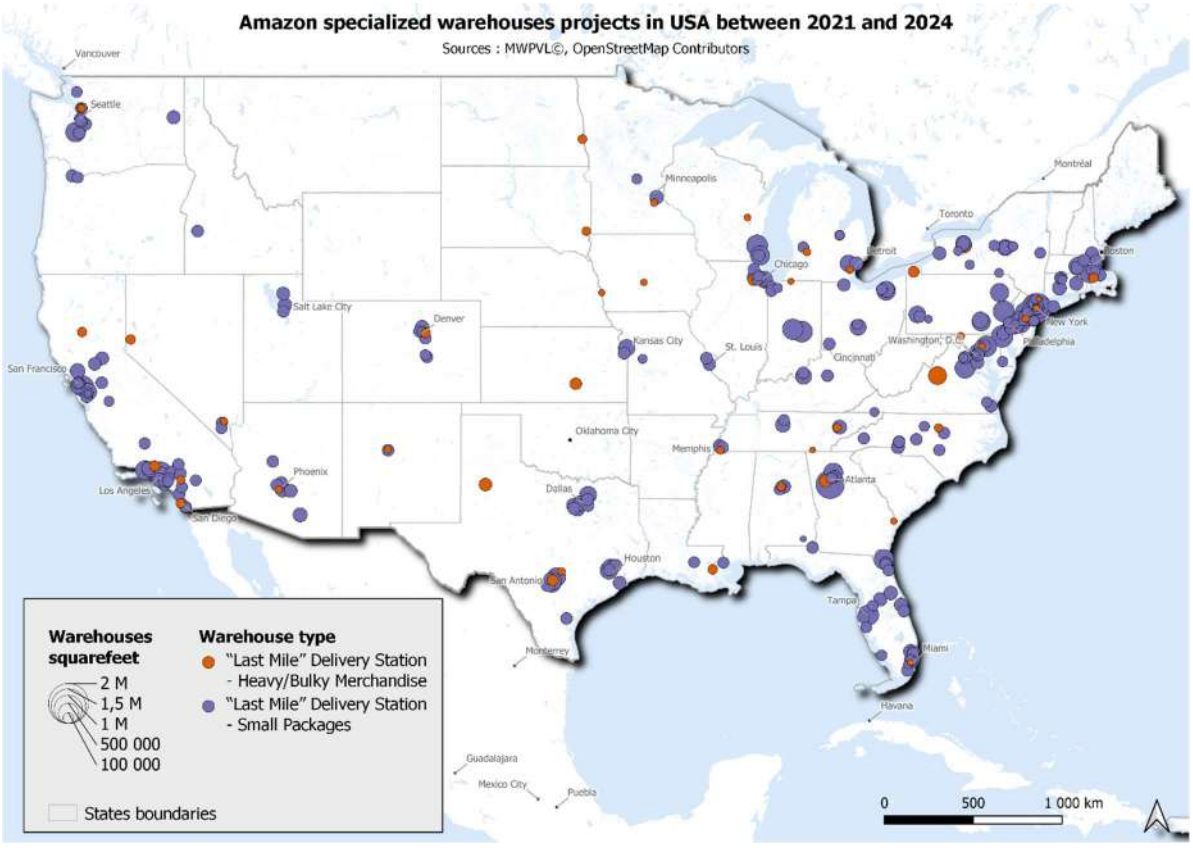
- A few megaregions concentrate the bulk of these last-mile delivery points: the Northeast region, the Great Lakes region, Florida, the Atlantic Piedmont, the Texas Triangle, Northern and Southern California, and the Northwest region.
- Some metropolitan areas have a very high density of delivery points, reflecting the adaptation of the logistics system to the most dynamic urban markets (New York, Los Angeles, Chicago).
- All major metropolitan areas and most intermediate metropolitan areas have this type of logistics facility, even where Amazon's market was developed the

[5] https://www.emarketer.com/content/forecast-just-how-big-amazon-prime-how-fast-will-grow [accessed on 12/11/2021].

latest in medium-sized cities like Boise, Idaho.

- The very strong dissymmetry between the delivery points ("*small packages*" on the one hand, "*heavy/bulky merchandises" on the* other) testifies to the pre-eminence of small packages in Amazon's commercial activity.
- The delivery points are relatively diverse in size: from small, intermediate-sized urban warehouses serving as collection and redistribution points for delivery personnel and third-party carriers to automated delivery points (e.g., *locker* type) in small, dedicated, covered spaces.

Figure 11. Location of planned *last mile station* projects in the United States between 2021 and 2024.



The map of delivery point projects listed for the period 2021-2024 (**Fig.11**) shows the exceptional dynamism of Amazon's commercial activity and the expected level of growth in deliveries. Here again, we see a dual movement of both concentration and dispersion: concentration in the megaregions and metropolitan areas that were already largely gridded before 2021 (particularly in the Megalopolis); dispersion by strengthening its network in territories that are still poorly equipped and in interstitial areas that do not have urban last-mile logistics spaces.

The two maps below show the location of Amazon's warehouses in 2021 (**Fig. 12**) (taking into account all existing warehouses at the time of the analysis in June 2021, as well as planned warehouses for the whole of 2021) and in 2024 (aggregating all existing and planned warehouses until 2024) (**Fig. 13**). The first map shows the main areas of concentration of Amazon warehouses: the Northeast coast (from Boston to

Washington D.C.), California around the San Francisco and Los Angeles areas, Florida around Miami, Orlando and Tampa, some cities in the Midwest (Chicago, Cincinnati, St. Louis), several isolated major hubs (Seattle, Phoenix, Dallas, Atlanta) and a set of secondary hubs (Salt Lake City, Denver, Houston, Kansas City, Memphis,San Antonio in particular). This distribution reflects a twofold process of concentration around large metropolitan areas and megaregions and the deployment of a fine grid over the whole of the United States, with the exception of the northern Great Plains.

Figure 12.Number of Amazon warehouses in 2021 (per 2,500 squaremeter).

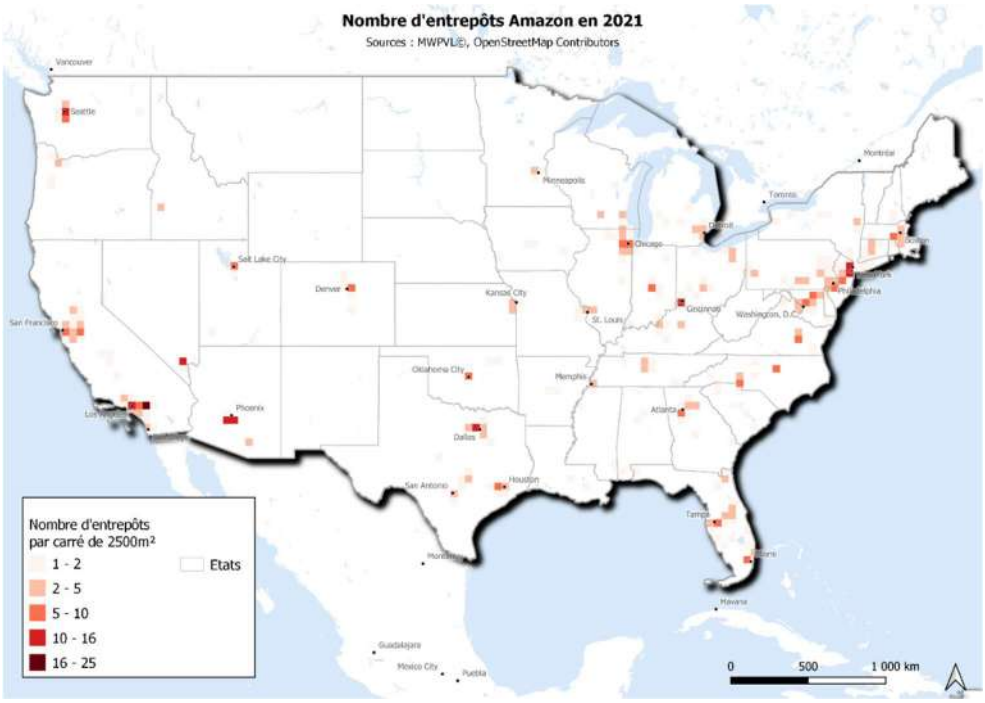
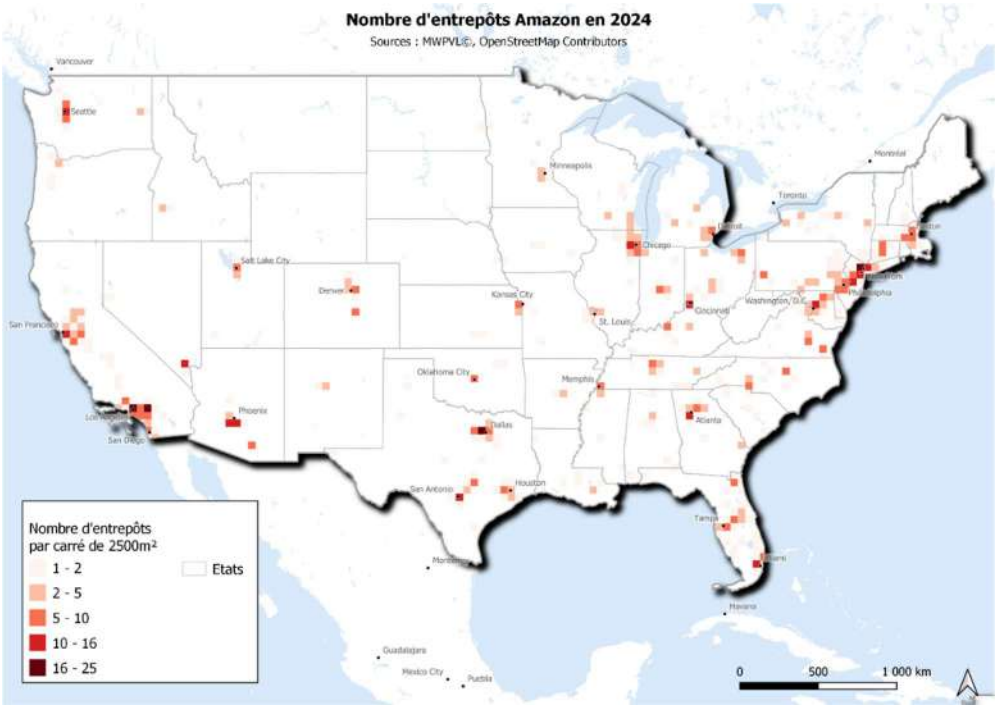


Figure 13. Number of Amazon warehouses in 2024 (per 2,500 squaremeter).



This map above (**Fig.13**) represents Amazon's spatial coverage in 2024 by aggregating all existing and planned warehouses. This shows what Amazon's logistics system will look like in 2024. Three observations stand out:

- Concentration continues in the main metropolitan areas, with a very high number of warehouses in the Megalopolis, California (Los Angeles, San Francisco), the Midwest (especially around Chicago), Florida (Miami, Orlando, Tampa) and in the main sparsely populated areas (Phoenix, Dallas, Atlanta, Seattle).
- A process of reinforcing the infrastructure in secondary centers with more warehouses (San Antonio, Salt Lake City, Memphis, Indianapolis, Detroit).
- A recent process visible in the post-2021 plans to tighten the logistics network in secondary cities of the urban framework, in particular in the Midwest, the Northeast and the Old South.

Figure 14. Amazon's Warehouse Density in 2021 (by grid area of the United States). The total area of a warehouse in the U.S. is divided into 50x50km squares - each square represents the sum of the area of the warehouses within it,expressed in *square feet*.

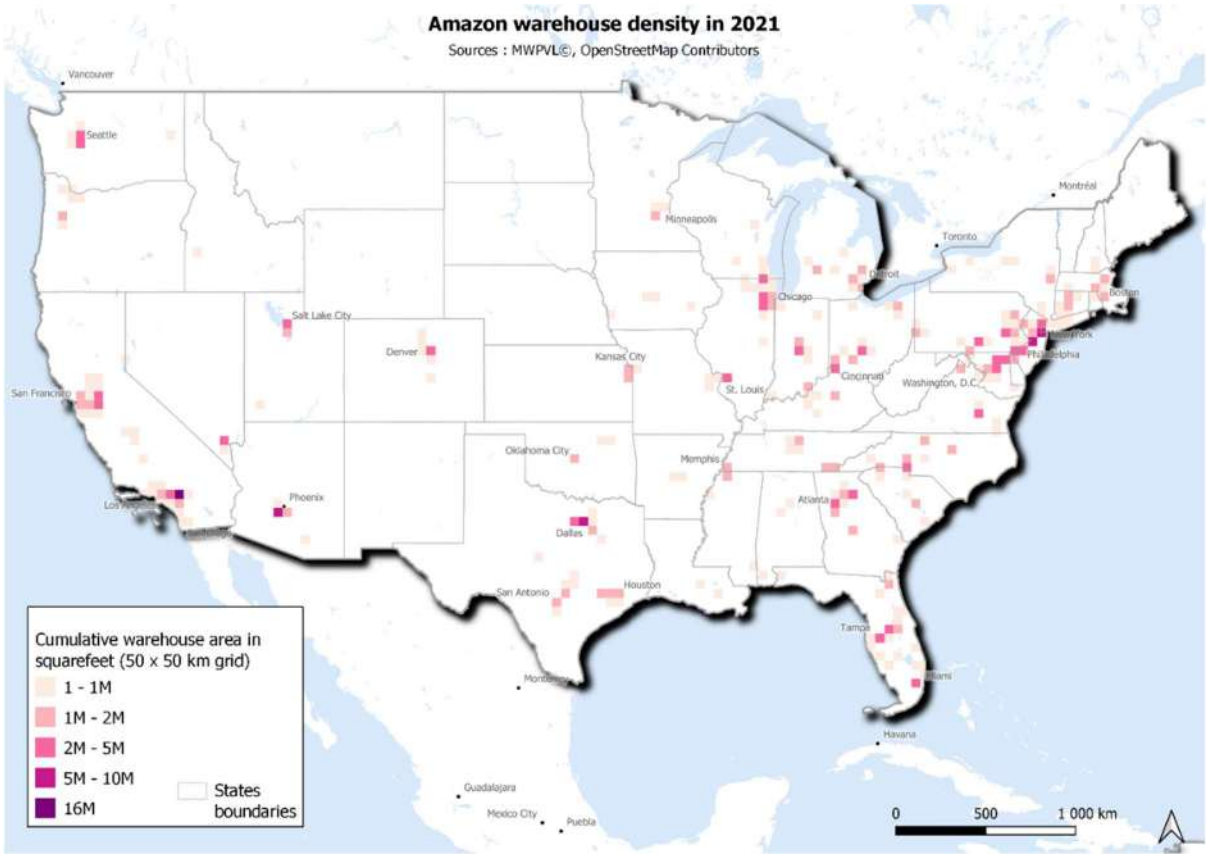
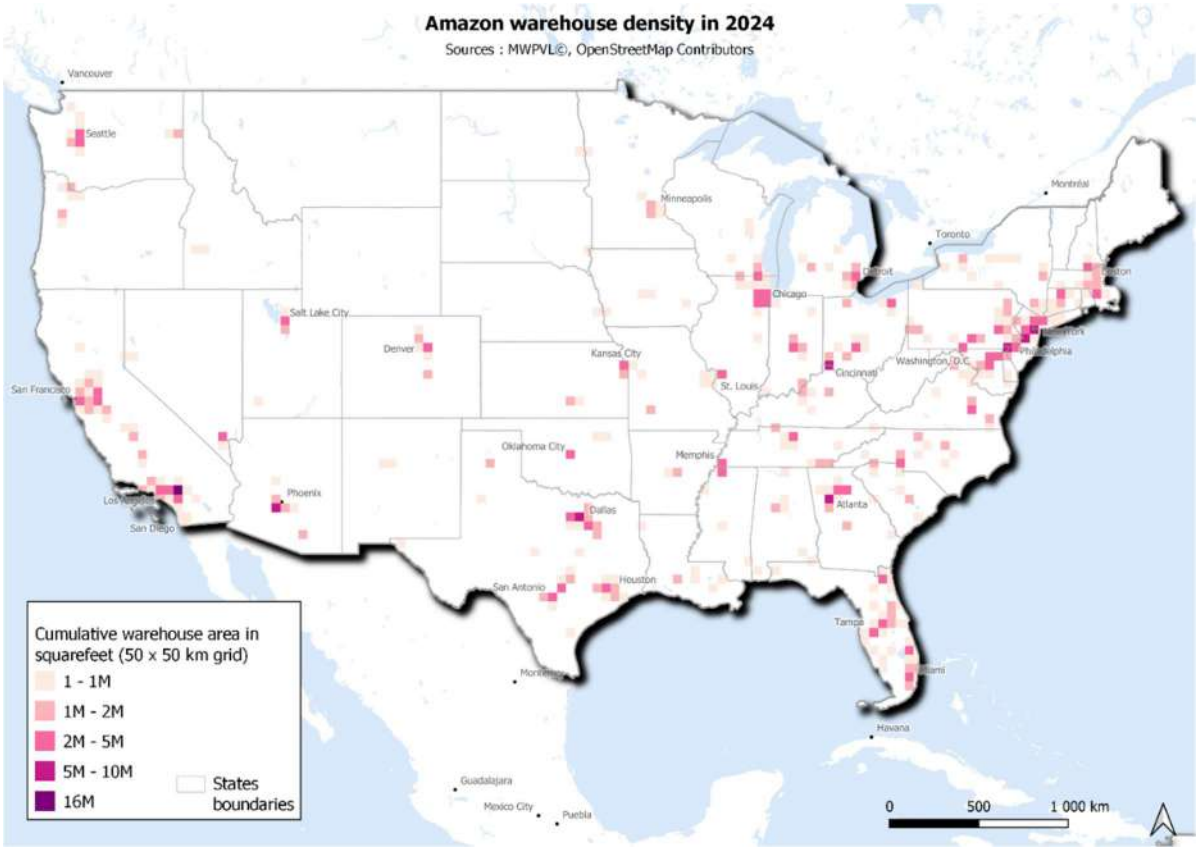
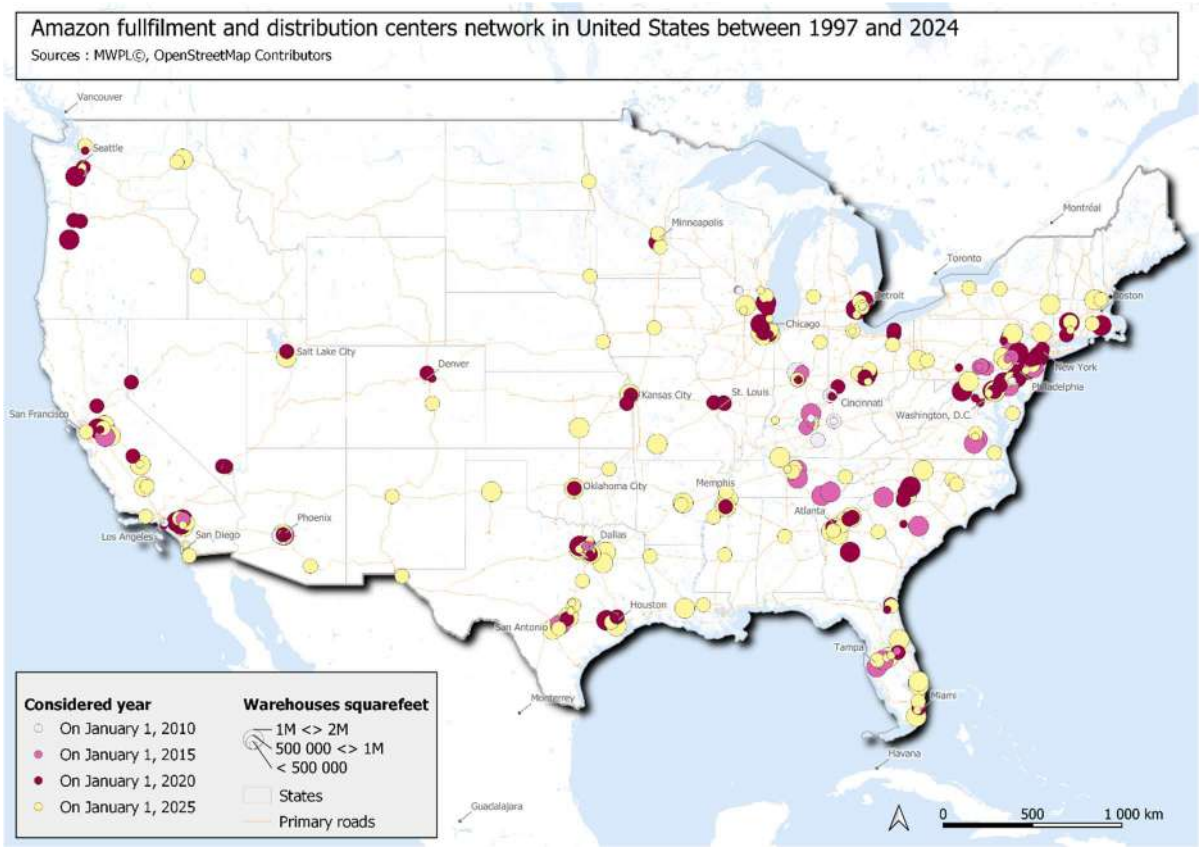


Figure 15. Amazon's warehouse density in 2024 (by grid area of the US). The total area of a warehouse in the U.S. is divided into 50x50km squares each square represents the sum of the area of the warehouses within it,expressed in *square feet*.



The two maps above (**Fig.14, Fig.15**) offer a complementary view to the two previous maps by calculating a density index to represent the density of Amazon warehouses in the United States in 2021, then in 2024 by aggregating all the projects identified in the database. These maps propose a grid of the United States (50km by 50km) so thateach square represents the sum of the surface area of all the warehouses located there (sum expressed in *square feet*). This method of mapping allows the "warehousearea" variable to be taken into account to show where the greatest number and largest warehouses are located. Again, several areas stand out: Southern California, especially around Los Angeles/Riverside, the Dallas and Atlanta areas, and the Northeast Coast. These areas have the most warehouses and the largest cumulative area of warehouses, with Los Angeles/Riverside standing out with a maximum value of 16 million *square feet* where the Riverside logistics zone is located. Taking into account other variables, an agglomeration effect could be identified. Where the markets are most developed and the agglomerations most developed, Amazon proceeds to concentrate logistics establishments (New York and the entire Megalopolis, Los Angeles, Chicago). Where metropolises act as “hubs” and “gateways” on a national and continental scale, there is also an agglomeration effect (Dallas, San Francisco, Atlanta, Miami, Seattle).

Figure 16. Evolution over time (at four selected time steps) of *fulfillment and distribution centers* all categories combined across the United States.



Finally, to complete this overview of Amazon's logistic organization on a national scale, we have represented the spatial distribution of all distribution centers (**Fig. 16**), all categories included. For this purpose, we have chosen four time steps, including one in anticipation allowing to take into account all the inventoried projects, to visualize the spatial deployment of Amazon warehouses. Three remarks can be made:

- Until 2015, the establishment of large distribution centers is very selective geographically, being concentrated in certain major economic regions of the country (California, Atlanta region, Northeast region). It is interesting to note that other major regions and metropolises of national importance are not concerned by the establishment of distribution centers before 2015 or else by a distribution center of modest size (Texas metropolises, Chicago, St. Louis, Miami, Detroit, Boston). This may reflect Amazon's strategy of locating in a few key areas with a mature or strong e-commerce market and favoring a location near major "gateways", as illustrated by the situation in the East-south around Atlanta.
- From 2015 to 2020, Amazon's spatial presence is expanding very significantly, reflecting the massification of its activities and its dominant position in the e-commerce sector. All major metropolitan areas now have one or more large distribution centers, forming clusters of warehouses in the most urbanized regions (North East, Great Lakes region, Atlantic Piedmont, Texas Triangle, California). In addition, previously ignored inland regions and mid-sized cities are seeing the

arrival of fulfillment centers (Salt Lake City, Denver, Las Vegas, Phoenix, Kansas City, Oklahoma City, Portland, Minneapolis etc.). This global evolution signals the company's horizontal integration strategy during the 2010s aimed at economies of scale and cost reduction through the multiplication of warehouses and the development of a tight network of large distribution centers and specialized warehouses.

- The projects listed from 2021 to the end of 2024 reflect a threefold strategy of the company:
    - continued horizontal integration with a sharp increase in the number of distribution centers in the United States;
    - tightening of the network in the best-endowed megaregions (Great Lakes, Northeast, Texas Triangle, California, Florida, Atlantic Piedmont, Northwest region);
    - the deployment of an interstitial strategy aimed at filling "the gaps" in less densely populated territories with projects planned in medium-sized cities and in states or regions that do not have a major metropolis (Idaho, North Dakota, South Dakota, New Mexico) as well as in smaller cities in states that already have them.

Diversification and functional specialization of Amazon's warehouses.

An analysis of the spatial location strategies of distribution centers can also provide insights into the process of functional specialization of warehouses. The company Amazon has engaged from 2014-2015 a vertical integration strategy to control several components of the global supply chain, from importing goods, to chartering air assets for distribution over continental distances to the last mile. This diversification strategy is represented in the following series of maps (**Fig.17 to 21**) in which the distribution centers are listed according to their main characteristic specified in the database: "*sortable*" (for sortable goods that can be sent in parcels), "*non-sortable*" (for non-sortable goods that cannot be sent in parcels), "*specialized or seasonal*" (for warehouses taking care of a specific type of goods or warehouses that are used only for particular periods such as Christmas or Thanksgiving), "*other or unknown*" (for warehouses that do not have a specific characteristic mentioned). It should be noted that some of the information contained in the database was not mapped, in particular the specialization of certain warehouses for specific types of goods (e.g. toys, furniture, jewelry).

This mapping confirms the rather late, but very effective, rise of this specialization of Amazon's logistics system. In 2010 (**Fig.17**), several warehouses were already oriented towards specialized product categories, mainly in the Midwest. The year 2015 (**Fig.18**) testifies to this rapid change in scale of Amazon's logistics organization corresponding to both its strong growth and its horizontal integration strategy.

Several observations can be made:

- The so-called "*sortable*" distribution centers are generally of intermediate size and most often close to major urban centers (Los Angeles, Philadelphia, San Francisco, Dallas, Tampa, Chicago).
- The so-called "*non-portable*" distribution centers are of fairly diverse sizes with contrasting geographical locations: relatively close to urban centers in the west (San Francisco, Phoenix, San Antonio) and conversely far from the major urban centers in the east (Atlantic Piedmont region).
- Specialized distribution centers or centers temporarily mobilized for exceptional commercial periods are generally large and in ex-urbanized locations, especially in the Northeast, Midwest and Atlantic Piedmont. These centers are smaller in size in the west and relatively closer to urban centers, as shown in the case of Los Angeles/Riverside.

Figure 17. Location and specialization of *fulfillment and distribution centers* in the United States in 2000.

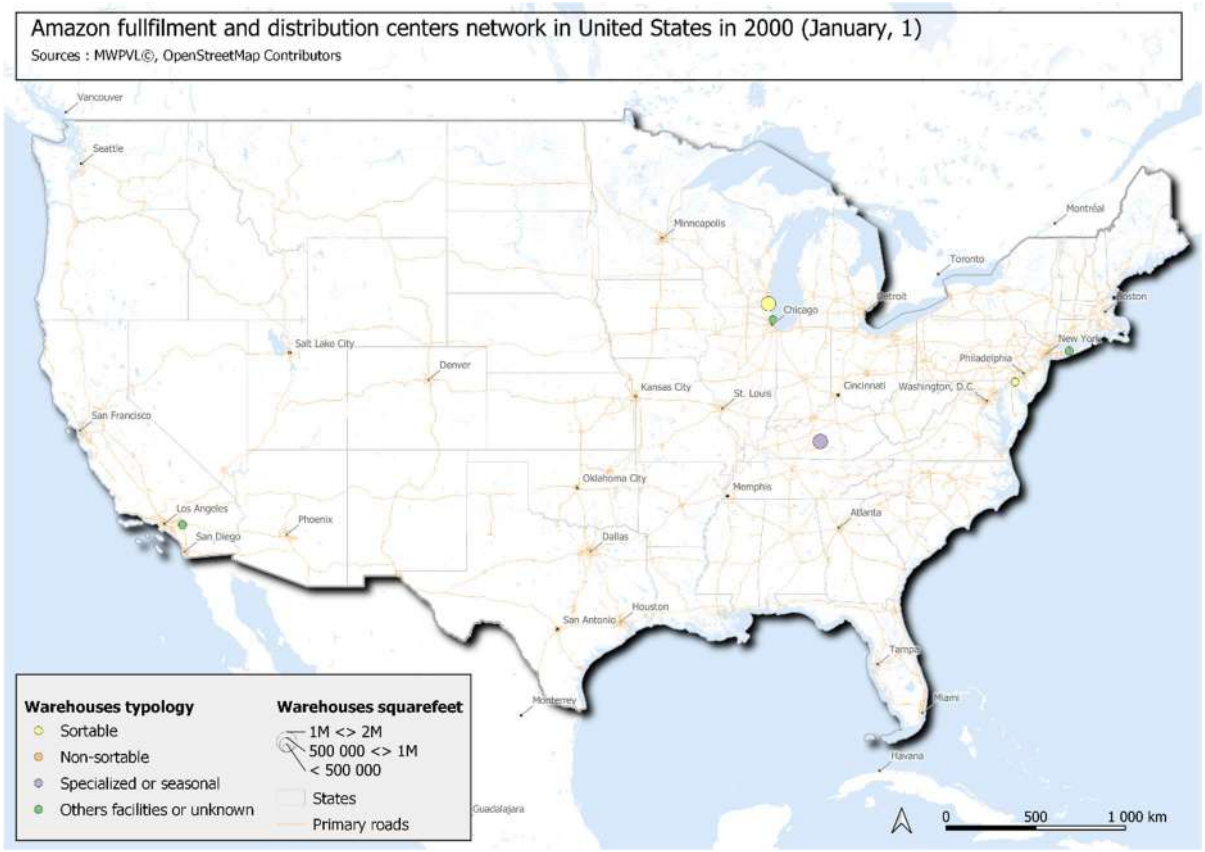


Figure 18. Location and specialization of *fulfillment and distribution centers* in the United States in 2010.

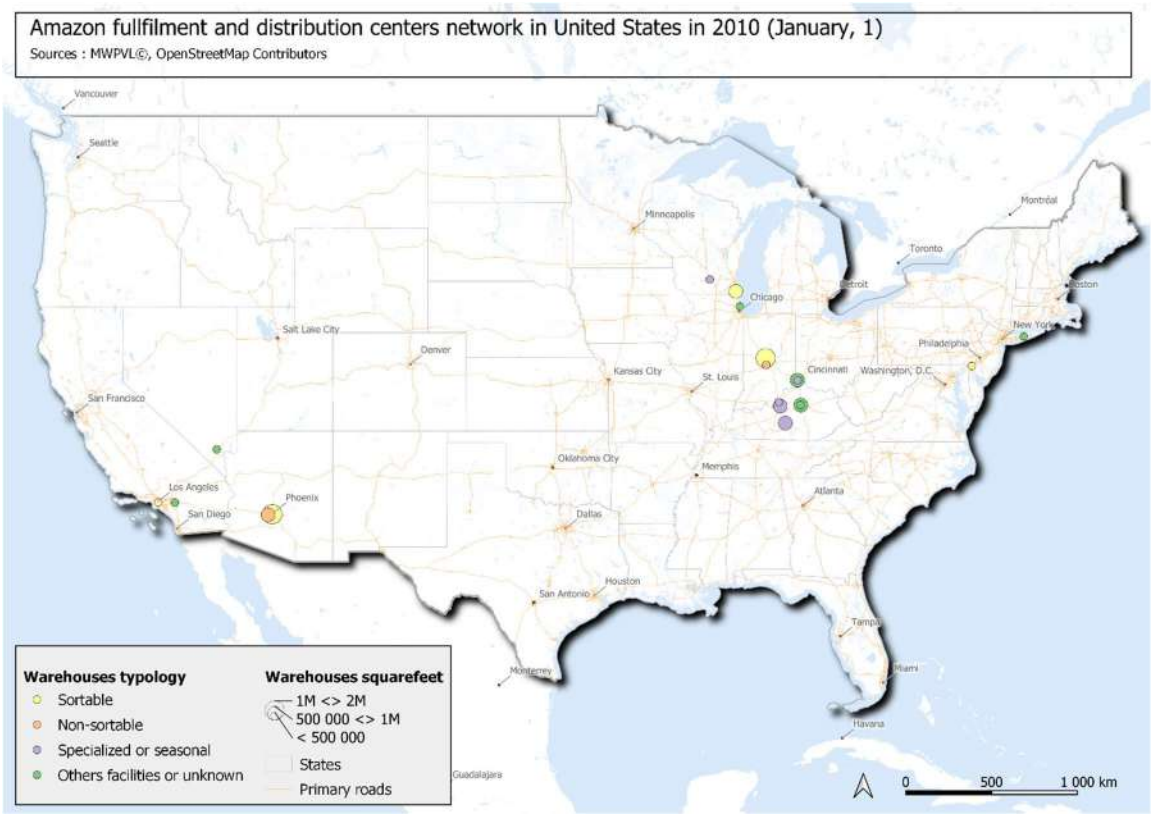


Figure 19. Location and specialization of *fulfillment and distribution centers* across the United States in 2015.

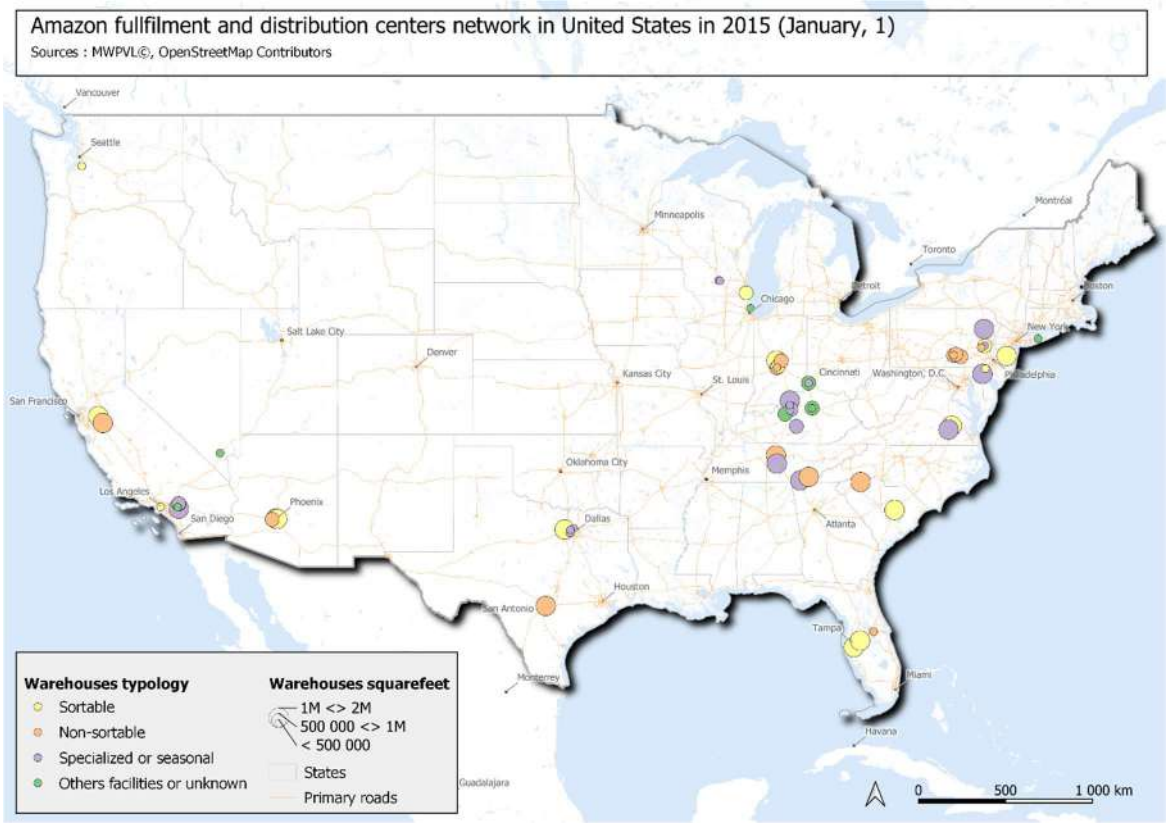


Figure 20. Location and specialization of *fulfillment and distribution centers* across the United States in 2020.

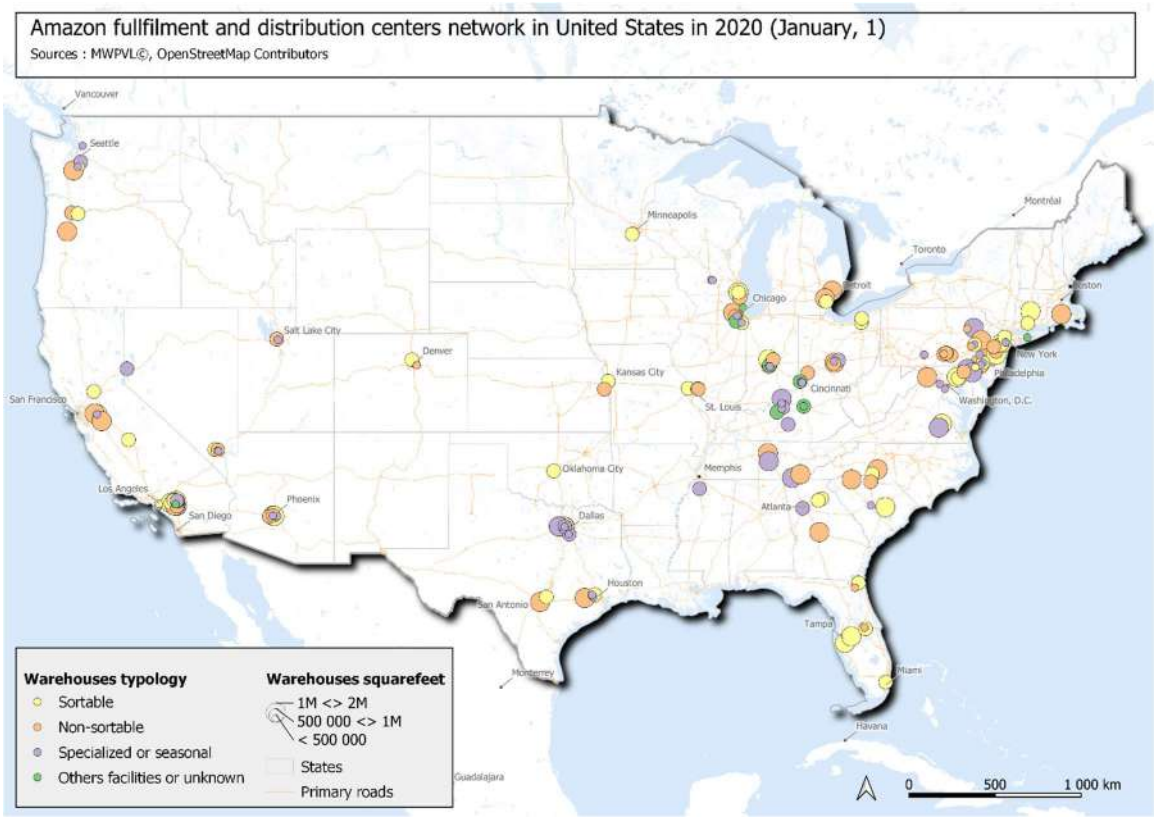
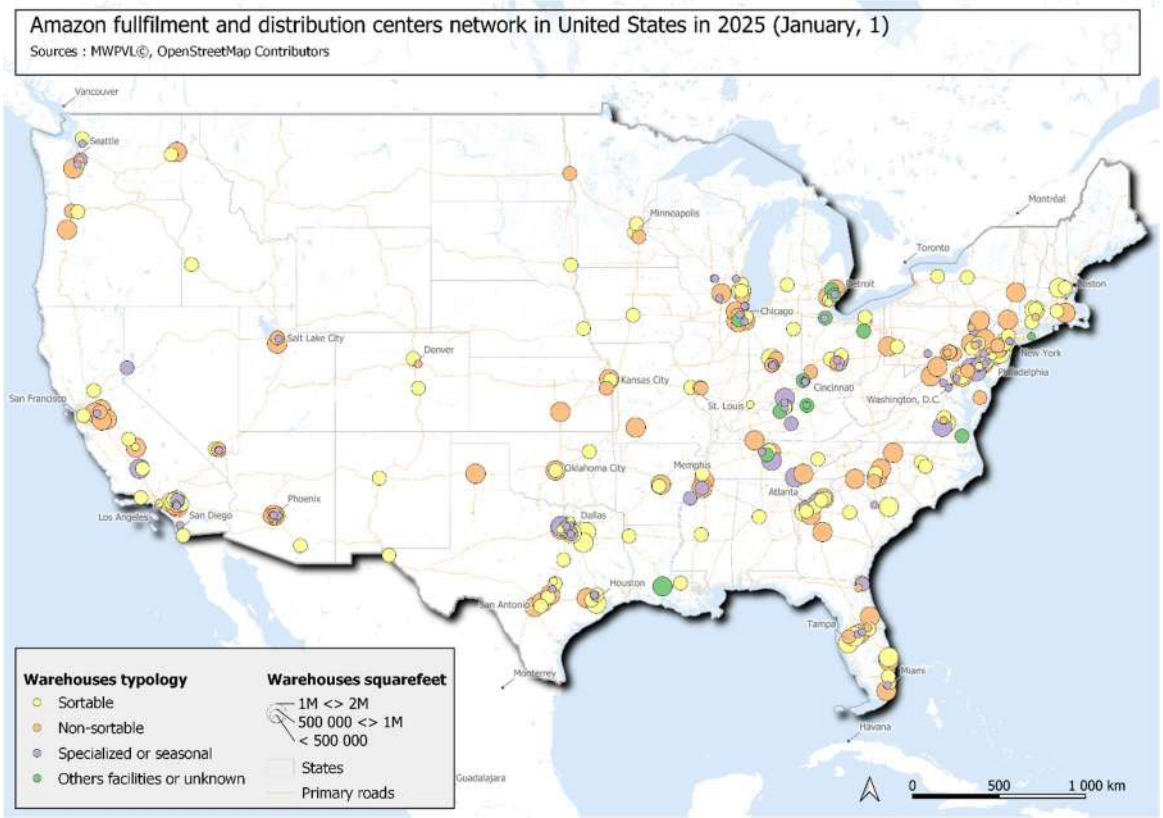


Figure 21. Location and specialization of existing and planned *fulfillment and distribution centers* in the United States as of January 1, 2025 across the United States.



The map for 2020 (**Fig. 20**) shows, in addition to the strong increase in the territorial coverage of distribution centers, a continuation and even a deepening of this strategy of diversification and specialization. Several observations can be made:

- The eastern United States has a greater number of warehouses, varying in size but with many large warehouses, spread over a much larger number of locations. In the western United States, there are fewer locations and they are concentrated in the largest metropolitan areas that also serve as gateways for goods (ports, airports) (Seattle-Tacoma, Portland, San Francisco-Oakland, Los Angeles-Long Beach-Riverside).
- Several regions concentrate the bulk of warehouses in all categories (Megalopolis, Midwest, Atlantic Piedmont, California). These regions are home to many "*sortable"*, "*non-sortable"*, "*specialized or seasonal*" warehouses.
- *Non-sortable* warehouses are generally large in size, with locations near urban centers (Los Angeles, New York, Chicago), in the inner suburbs ofmetropolitan areas (San Francisco, Seattle, Phoenix), or in ex-urbanized areas within megaregions (Piedmont Atlantic, Northeast).
- *Sortable* warehouses are generally of intermediate size and are located relatively close to urban centers, sometimes forming clusters of warehouses within the same metropolitan area (Los Angeles, Chicago, Tampa, Northeast).
- *Seasonal* warehouses are fewer in number and more selectively located throughout the United States, with two main areas of concentration (Midwest and Northeast).

When we take into account all the projects planned up to the end of 2024 (**Fig.21**), we can see that the territorial coverage of all categories is clearly improving: the clusters of "*non-sortable*" warehouses are clearly getting stronger (Northeast region, Atlantic Piedmont, Midwest, West Coast) with new locations in the interior of the country; the "*sortable"* warehouses are the ones whose spatial coverage is changing the most, with a very large number of new intermediate and small locations (especially in Texas, the Great Plains, the Atlantic Piedmont, as well as in California and Florida). In addition, the company has embarked on a strategy of diversifying its logistics equipment to incorporate the latest innovations in the field of warehousing (multi-story warehouses, robotic warehouses) (**Fig.22,23,24**).

Figure 22. Location of distribution centers (*fulfillment and distribution centers*) in 2015 based on functional specialties.

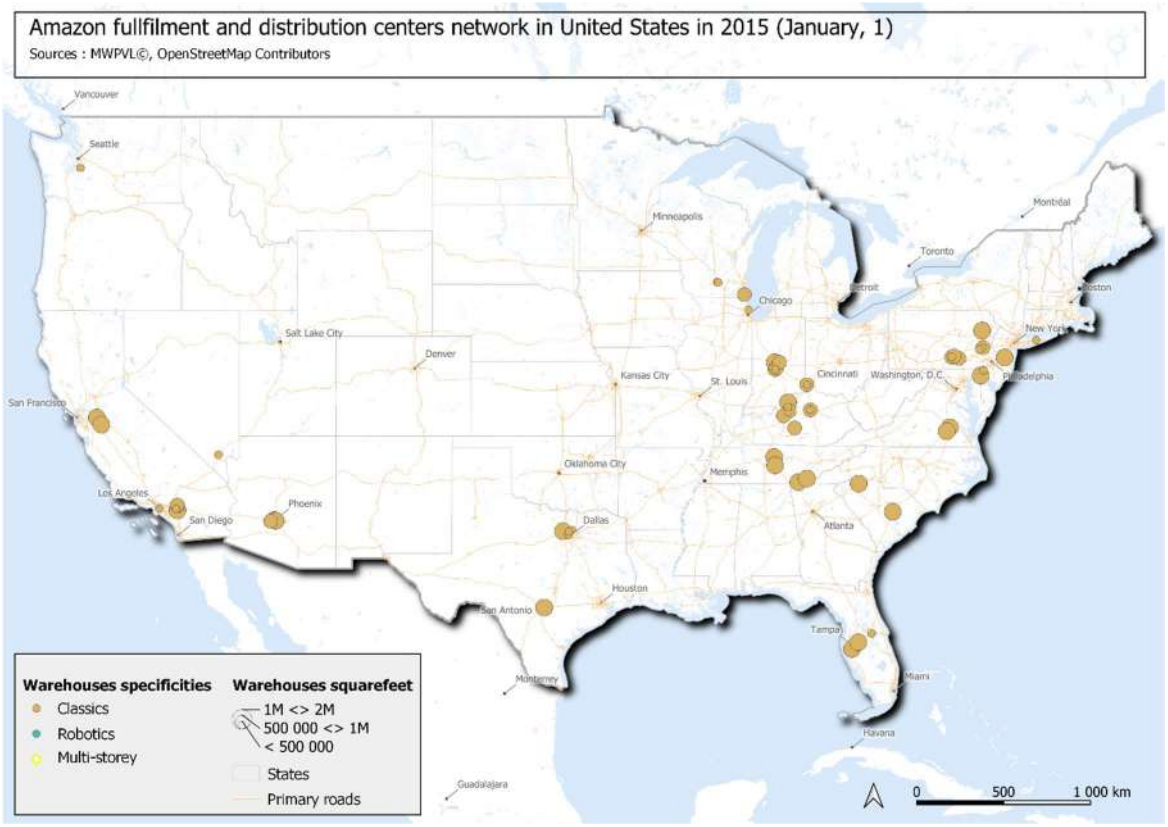


Figure 23. Location of distribution centers (*fulfillment and distribution centers*) in 2020 based on functional specialties.

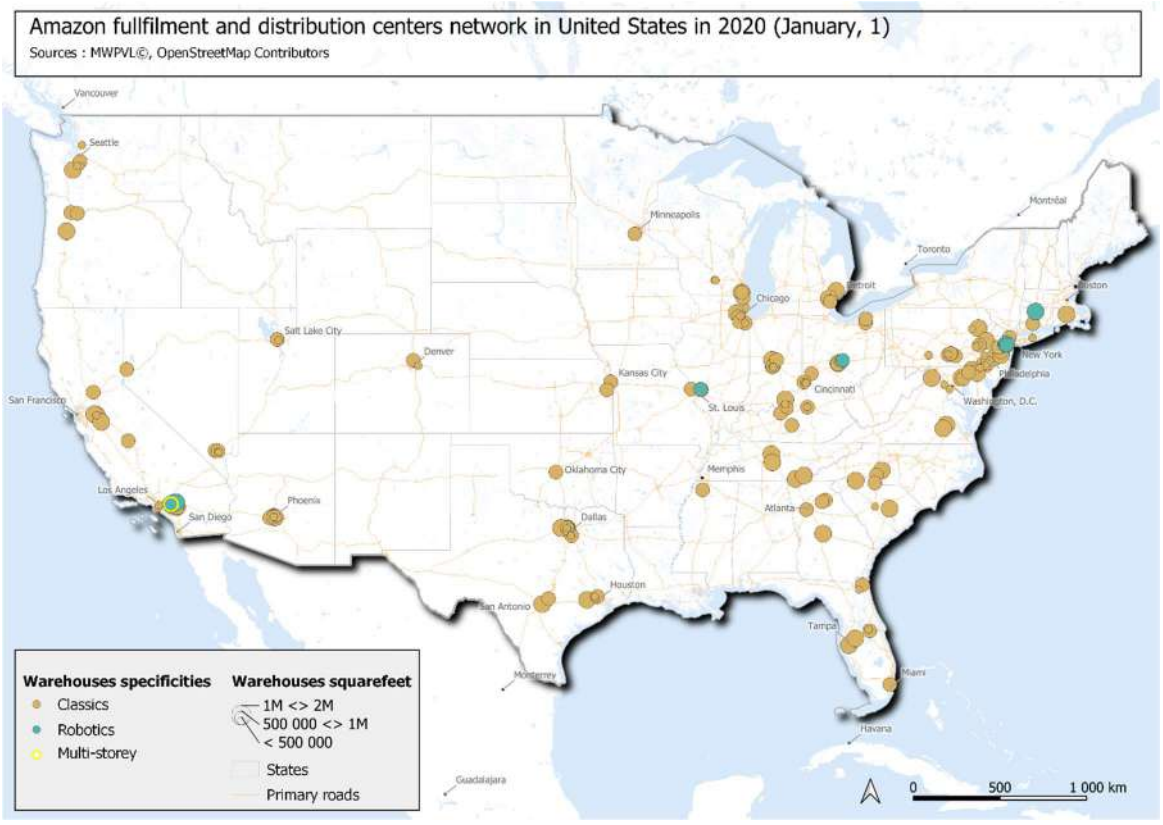
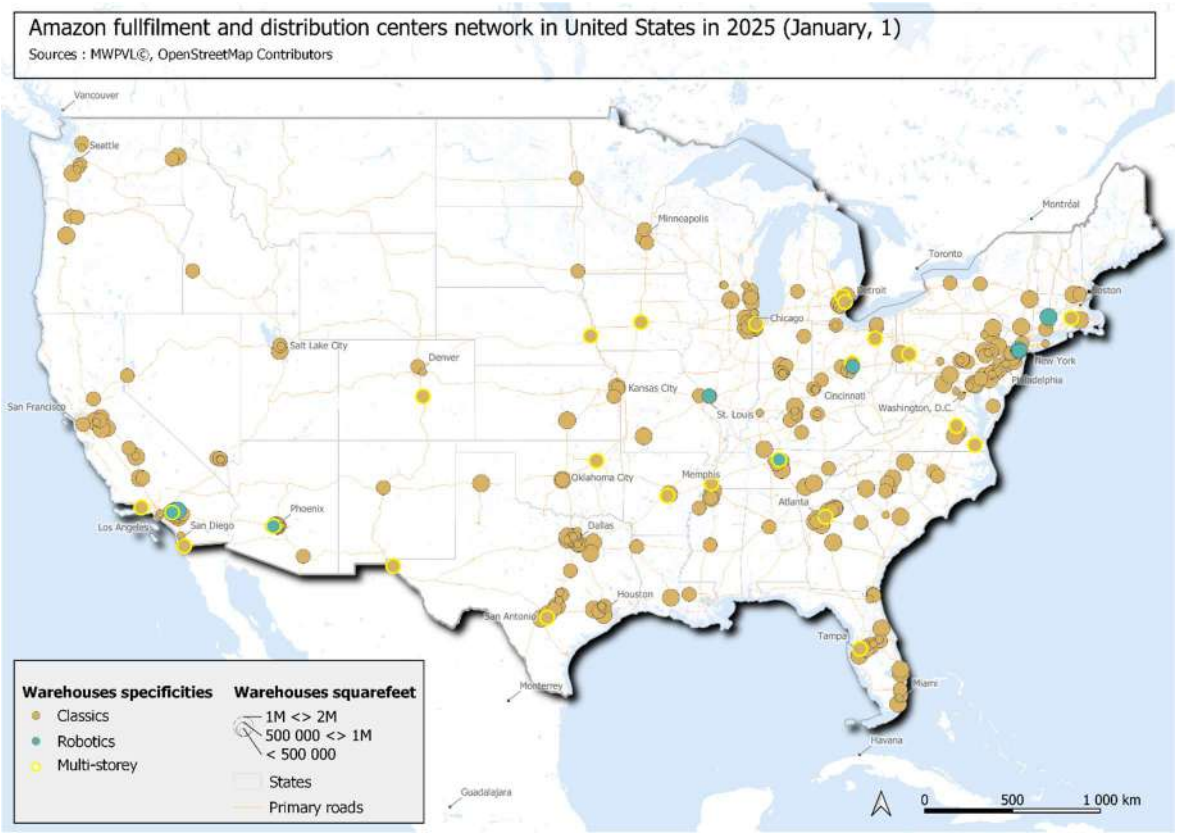


Figure 24. Location of distribution centers (*fulfillment and distribution centers*) by 2025 based on functional specialties.



The map for 2015 (**Fig. 22**) shows the presence of classic distribution centers and the absence of innovative forms that are only being deployed in the warehouse market in the last few years. On the other hand, the database distinguishes from the period 2010-2015 warehouses according to specific types of goods supported, marking the process of functional specialization of Amazon's logistics system. The map for 2020 (**Fig.23**) shows the spread of these innovations: several robotized warehouses(totally or partially) are open (it appears that some traditional warehouses have been transformed, not necessarily new creations). These robotic warehouses are located in major metropolitan markets (Los Angeles, New York) as well as, more surprisingly, in the Midwest (St. Louis) and in Columbus, Ohio. As of January 1st 2020, only one multi-story warehouse is shown in Riverside in the Los Angeles metropolitan area reinforcing the absolutely decisive role of this metropolitan area in Amazon's logistics system. The map for 2025 (**Fig.24**) taking into account all the projects shows that Amazon will deploy a strong strategy of innovative warehouses in the coming years:

- Robotic warehouses are expected to be deployed but will remain very few in number, reflecting a strong geographic selectivity in the implementation of this type of innovative warehouse, concentrated in three regions: the Northeast, the Midwest, and the Southwest around Los Angeles and Phoenix.
- Multi-story warehouses are expected to be more widespread than robotic warehouses, as they may signal the need for more massive order processing, particularly in the major metropolitan markets (Los Angeles, Phoenix, Atlanta,

Chicago, Detroit, San Antonio) as well as in the central areas of the Midwest, the Great Plains and the Mississippi River Valley. It is interesting to note the presence of two multi-story warehouse projects on the US-Mexico border, including one in Otey Mesa (California) which will be located in the immediate vicinity of the new Tijuana mega-warehouse on the Mexican side[6]. Following this initial cartographic representation, it would be interesting to examine this point in greater depth using other methods to determine the location choices for these multi-story warehouses (land use, costs, location in the urban area, proximity to transport infrastructures, etc.).

A regional and metropolitan approach: 3 case studies (Northeast, Los Angeles, Chicago).

The analysis of the spatial footprint of Amazon's warehouses on a national scale requires a cross-section of scales in order to understand how Amazon's regional and metropolitan network is organized. We considered a relatively large regional space (the Northeast region, in particular the region between Washington, D.C. and New York City) and two broader metropolitan areas (Los Angeles-Riverside and Chicago). New York, Los Angeles and Chicago are among the three largest consumer markets for e-commerce and are the top three metropolitan areas in terms of the number of logistics warehouses according to the U.S. Census Bureau's County Business Patterns data. Los Angeles and New York, and secondarily Chicago especially as a rail hub, are major gateways for international and domestic trade as well as powerful multimodal trade and logistics hubs (Rodrigue *et al.*, 2017).

In the case of the Northeast megalopolis, we focused the analysis on the central and southern part of the megalopolis, from New York to Washington D.C., taking into account the warehouses in the *hinterland* in relative proximity to the major maritime, air and logistics gateways. Based on the map of the system's network of Amazon's logistics operations in the region on January 1st 2021 (**Fig. 25**), most of the warehouses will be located in the urban continuum of the Northeast region following a linear pattern and the region's major transportation corridors. Several observations stand out:

- The large distribution centers are mainly located in the outskirts of the major metropolises (Baltimore, Philadelphia, New York). Moreover, several of the largest centers are located in exurban areas, such as the three between Baltimore and Wilmington and the four between Philadelphia and New York at Trenton.
- In addition, a second hinterland arc would provide a supporting function to the main arc of the megalopolis with a cluster of several distribution centers in the

[6] https://www.latimes.com/business/story/2021-09-14/amazon-facility-tijuana-nueva-esperanza [accessed on 12/11/2021].

Harrisburg and Allentown suburbs and a large warehouse to the southwest in Winchester. The mismatch between the size of the logistics location and the size of the surrounding market might suggest that these hinterland warehouses are either servicing logistics facilities for the core consumer markets, or are facilities that mesh with many intermediate-sized inland markets.

- Many warehouses are located on the fringes of the metropolitan area, on the edge of the *urban areas* shown on the map: there is a correlation between the size of the warehouse and its location in the urban area, confirming the search for low-cost land available for large warehouses.
- The large logistics warehouses that do not fall into the "*fulfillment and distribution centers"* category - *Inbound Cross Dock*, *Regional Sortation Center*, *Pantry and Fresh Distribution Center* - are positioned in two ways in the region, either on the periphery of the metropolitan fringe or in a pericenter position relatively close to urban centers (Trenton, Newark, Baltimore). This pericentral position could confirm the role of these warehouses as an intermediate link in Amazon's global logistics chain.
- Finally, there is a second level in this logistical network, which is an urban and local network with a multitude of small urban logistical spaces ("*last mile delivery stations*" and "*Prime Now hubs*"). There is a fine network of urban delivery points that is particularly well developed in the two major cities considered in the study area: Philadelphia and especially New York. The other two cities further south have a much weaker network, reflecting the relatively strong geographical selectivity of e-commerce and urban deliveries. The other urban logistics areas appear to be scattered throughout the region under consideration, with a multitude of points in suburban areas, illustrating the strategy of penetrating suburban consumer markets. The *Prime Hub* service and its small urban hubs dedicated to these rapid delivery services are marked by a selectivity even larger geographic area with a single deployment market in New York City, apart from a small *Prime* warehouse in Philadelphia.

Figure 25. Amazon's logistics network in the Northeast region (Washington D.C.-New York City) in 2021.

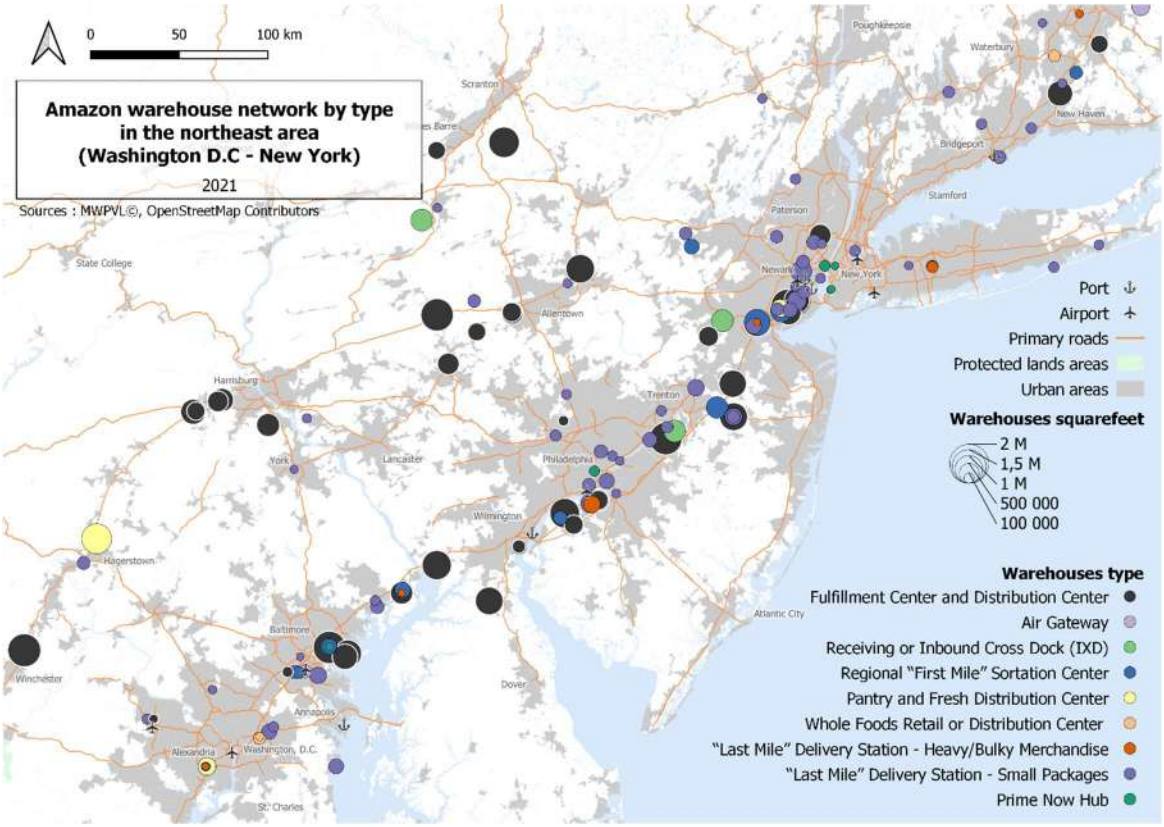
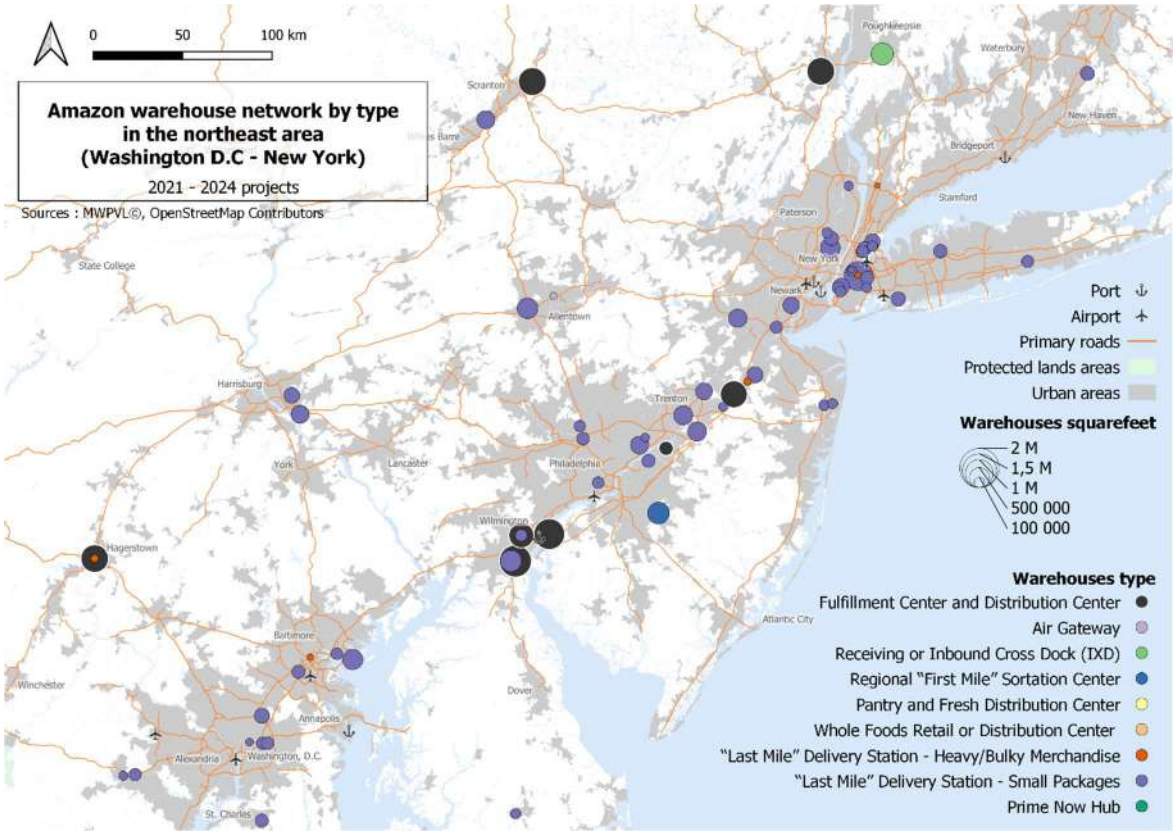


Figure 26. Amazon's proposed logistics warehouses in the Northeast region (Washington D.C.-New York City) listed from 2021 to 2024.



When we look at the location projects (2021-2024) (**Fig.26**) in this same regionalspace, we see essentially two phenomena:

- First, there is a clear strengthening of the network of small urban logistics warehouses in dynamic markets that are already served (New York) and in under-serviced markets (Washington D.C. and Baltimore for the major cities, as well as Wilmington, Harrisburg and Trenton). In addition, certain types of warehouses are not involved in any plans to locate: *Whole Foods Distribution Center*, *Pantry and Fresh Distribution Center*, *Prime Now Hub*;
- Then the more limited reinforcement, in a geographical context where large warehouses are already very numerous, of the logistical backbone of the distribution centers. It is interesting to note that the new *fulfillment centers* planned are located on the outskirts of the megalopolis' second largest cities (three near Wilmington, southwest of Philadelphia, one near Trenton, south of Newark).
- The Megalopolis considered here appears to be highly polarized around a corridor that stretches from Wilmington to New York, passing through Philadelphia and Trenton and Newark. Conversely, the south of the region appears to be in retreat with a Amazon's warehouse network is much weaker (the Baltimore- Washington D.C. conurbation).

When we look at the Los Angeles metropolitan area in all its spatial extent (**Fig. 27**) (including Long Beach, Irvine, Anaheim, Riverside, San Bernardino), there is a very strong dualization of Amazon's logistics network, with large warehouses (*fulfillment centers*, *IXDs*, *regional sortation centers*) in the east around Riverside and San Bernardino, andsmall warehouses and urban logistics spaces in the west, both in the urban center and on the western coastline. Beyond these two poles, a few scattered logistics facilities exist in the other peripheral poles of the area (in Irvine to the south and Burbank to the north-west). The Los Angeles-Riverside metropolitan area is one of the main markets for Amazon and one of the pillars of its logistics system. The logistics infrastructure is particularly well developed there, with a particularly visible concentration effect in Riverside and especially San Bernardino, which are areas marked by transport activities (airport, rail terminal or depot, logistics platforms), logistics (exceptional concentration of warehouses) and trade. The area around the Ontario International Airport and the Interstate 15 and 10 interchanges and the area around the San Bernardino International Airport and the Interstate 10 and 215 interchanges are urban landscapes deeply marked by logistics with hundreds of warehouses. These areas benefit from excellent accessibility (airports, federal highways, expressways, rail network for freight serving the more distant hinterland and the connection with the port of Long Beach).

Figure 27. Amazon's logistics network in the Los Angeles metropolitan area (Los Angeles-San Bernardino-Riverside) in 2021.

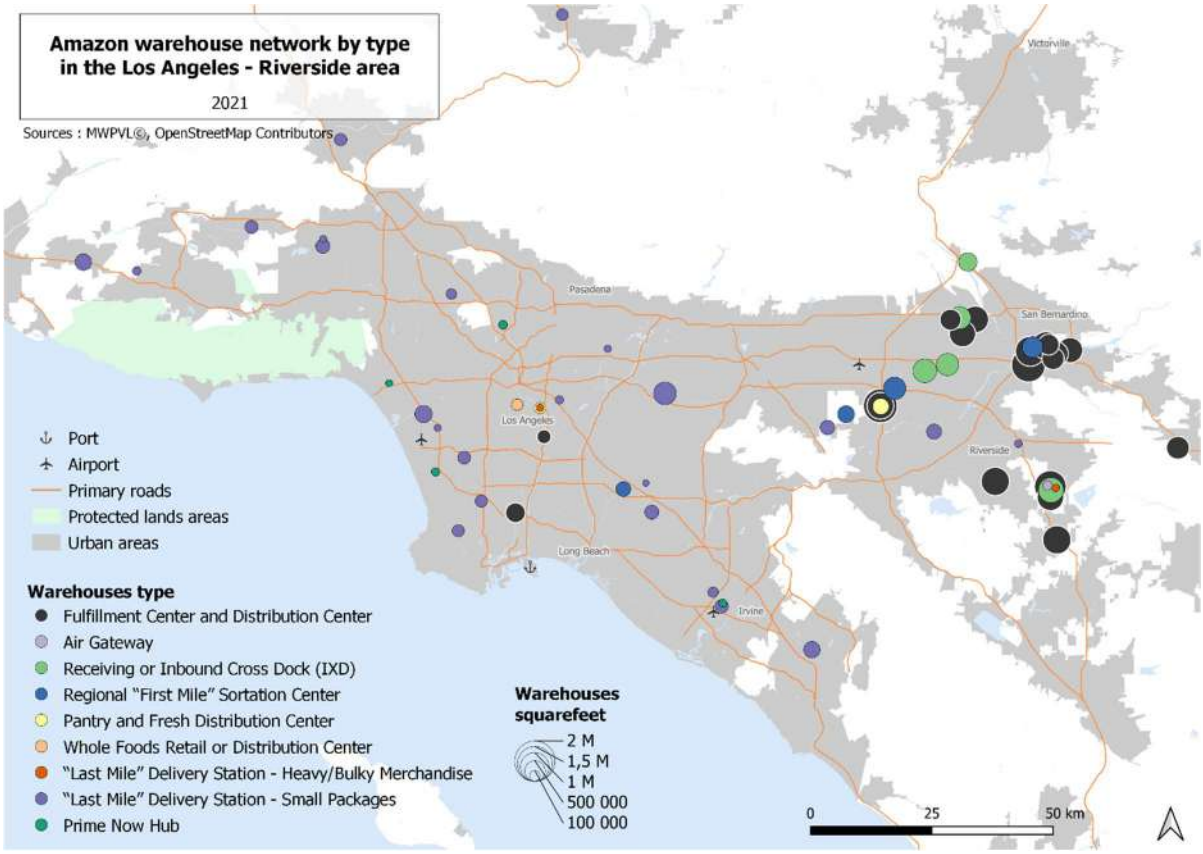
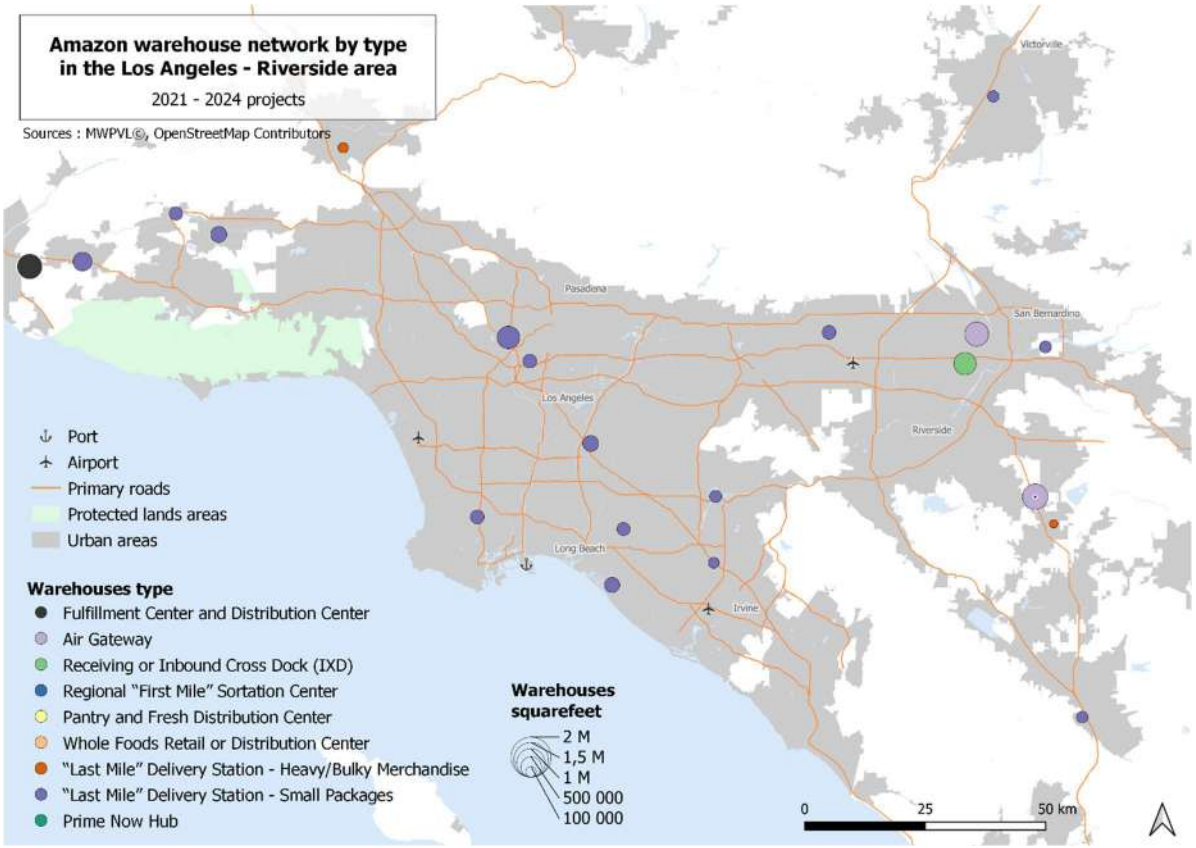


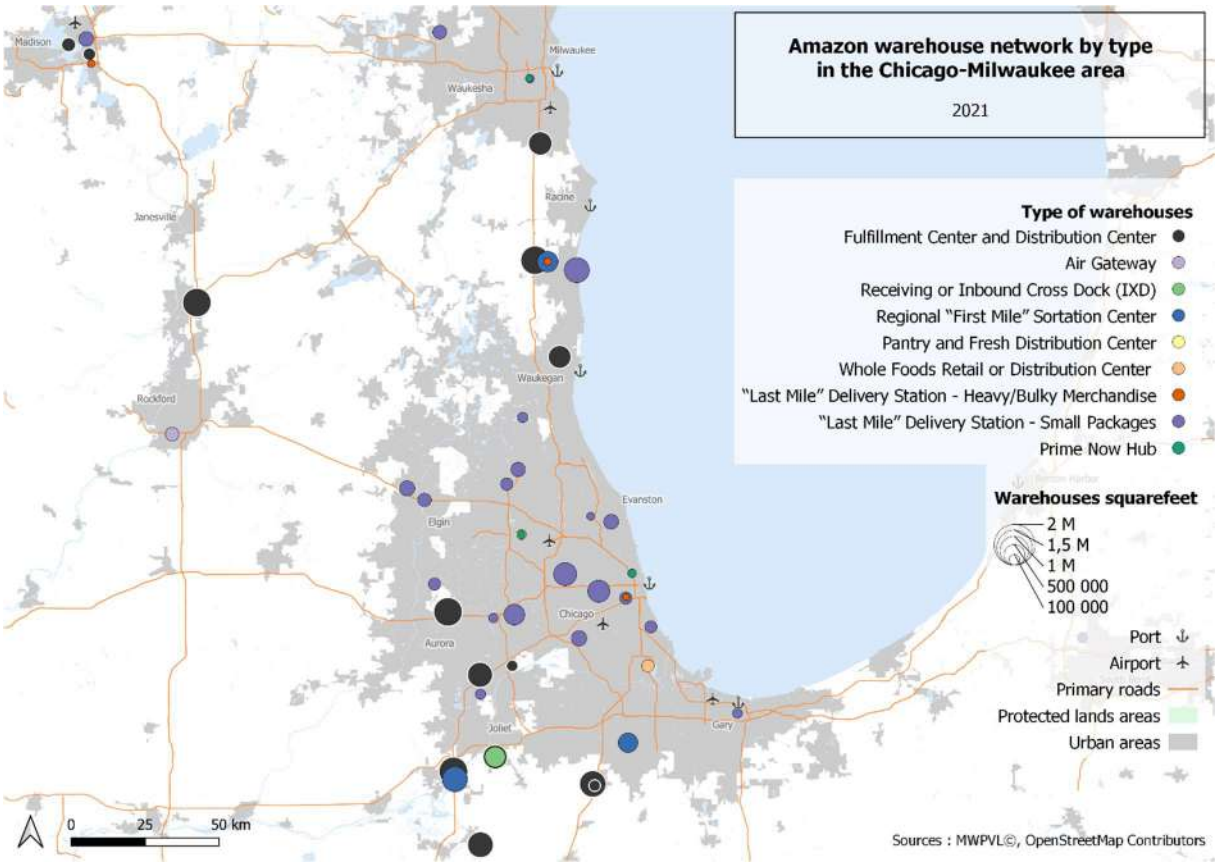
Figure 28. Amazon's logistics warehouse projects in the Los Angeles metropolitan area listed from 2021 to 2024.



This part of the metropolitan area is a territory that serves all scales, due to the power of the logistics system set up by Amazon. There are more than ten distribution centers, some of which are considered XXL, especially around San Bernardino airport and south of Riverside. These large distribution centers are themselves complemented by a large logistics network with several *Inbound Cross Docks* (*IXDs*) and several *Regional Sortation Centers,* as well as by a large specialist network, as demonstrated by the existence of a large *Pantry and Fresh Distribution Center*. In the east of the conurbation, there are in fact only four small urban logistics areas. The network becomes more distant when we leave this easternpart, where the mapping of warehouses reveals the importance of the Los Angeles urban market, with a large but not completely polarized network of local delivery points and three *Prime Now* hubs in the high-income residential areas of the west nearthe coast (Gardena, Inglewood) and near the Los Angeles International Airport.

When we consider the projects planned between 2021 and 2024 (**Fig. 28**), the new locations primarily concern urban logistics spaces, with a multitude of delivery and last-mile distribution points in the city of Los Angeles, in the perimeter areas and in the more distant peripheral centers, reflecting the strengthening of Amazon's offer in all the ramifications of the Los Angeles metropolitan area.

Figure 29. Amazon's logistics system in the Chicago metropolitan area in 2021.

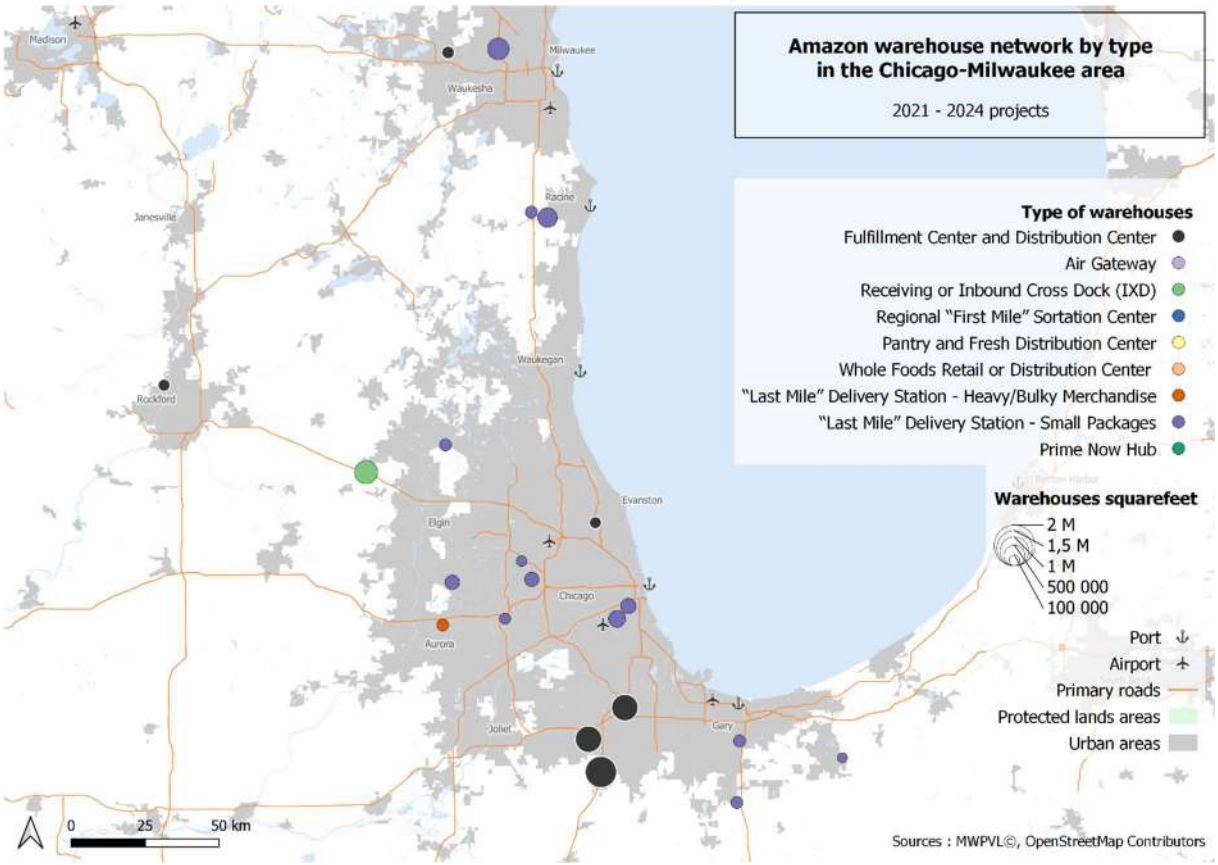


The large-scale logistics network will only be expanded by a single *fulfilment center* in the far west and an *IXD* near San Bernardino airport in the east. It is interesting to note

the establishment of two large air hubs in the coming years, which illustrates the regionalization of the company's vertical integration strategy. The projects listed do not reflect a process of concentration in space, but rather a further meshing of areas that are still poorly endowed with small local logistics areas, although the logistics hub around San Bernardino-Riverside continues to be strengthened. Amazon's logistics network in the Chicago metropolitan area, extended as far north as Milwaukee since there is an urban continuum between the two metropolises, presents a different picture from the other two metropolitan areas studied (**Fig. 29**). Indeed, the concentration effect around a few main logistics centers does not seem to exist or to be clearly visible in Chicago. The structure of this network here is classically based on the polycentric city with small logistics facilities in the center and large facilities in periurban areas.

The last-mile local distribution centers are concentrated in the city center (plus a few structures in some suburban areas in the north and north-west) and the large distribution and processing warehouses in the western, southern and northern periphery. The large distribution centers as well as a large *IXD* and two *regional sortation centers* are concentrated in the south-western part of the conurbation. Another area of concentration is to the north of the Chicago metropolitan area and to the south of the Milwaukee metropolitan area around the city of Kenosha with several large warehouses near an Interstate 41 interchange and the Kenosha Regional Airport.

Figure 30. Amazon's logistics warehouse projects in the Chicago metropolitan area listed from 2021 to 2024.



The projects listed for the period 2021-2024 (**Fig. 30**) confirm the trends observed previously, with a strengthening of small logistics spaces in the city center and in certain residential peripheries, and a strengthening of the large warehouse network in the south of the conurbation with three new distribution centers planned as well as a new *IXD* in the west. This temporal projection confirms the dualization of the metropolitan area between the city center and the peripheral belt.

Conclusion and discussions. Confirmation of a double movement of concentration and dispersion? Does Amazon contribute to logistical sprawl?

From the analysis of Amazon's logistics system, we understand how strong the spatial footprint of e-commerce is and we can confirm some of the major processes affecting the e-commerce sector and more broadly the retail sector:

- The process of specializing logistics facilities to support the company's vertical integration strategy (distribution centers and local delivery points for products that can be packaged and for products that cannot be packaged, robotic warehouses, multi-story warehouses, Amazon's own airport hubs, small logistics spaces for the *Prime Now* service or to ensure the last mile);
- The process of diversification of facilities both in terms of the size of the warehouse and its location characteristics (location in the dense urban area or in the dense peri-urban area, location in peripheral territories or even in the metropolitan fringes);
- The process of dualization of logistics markets and the warehousing sector, with the largest peripheral warehouses (*fulfillment centers*, *inbound cross docks*, *regional sortation centers*) on the one hand, and intermediate or small urban logistics areas (*last mile delivery stations*, *Prime Now hubs*) on the other;
- The process of taking direct control of the various links in the global logistics chain, allowing control of flows and distribution routes and less dependence on third-party carriers or shippers, particularly for long and medium-distance operations.

This cartographic analysis makes it possible to identify several spatial logics for the establishment and extension of Amazon's logistics system:

- A dual spatial rationale of networking and concentration of logistics warehouses, with the development of clusters of warehouses around major transport infrastructures (motorway interchanges, regional or international airports, ports, rail freight network) and the creation of a more or less fine mesh of warehouses, particularly urban logistics areas. This dual logic makes it possible to obtain broad market coverage even in secondary markets and to reduce processing and delivery times, while at the same time achieving

economies of density. This dual logic can be found both at the national level (concentration in the main megaregions and progressive networking in new market areas) and at the metropolitan level (concentration in clusters of peripheral warehouses and deployment of a network of urban logistics spaces);

- A dual spatial rationale that focuses both on the outskirts of metropolitan areas and on dense urban centers. This work confirms the emergence of a dual logistics real estate market with, on the one hand, large peri-urban or even ex-urbanized warehouses that structure logistics chains on an international, national and regional scale (Heitz *et al.*, 2017) and, on the other hand, small urban warehouses or urban logistics spaces designed to serve metropolitan areas and the last mile and final delivery chain. In this last mile chain, new logistics spaces are built to support the development of new market segments, in particular "instantaneous deliveries" (Dablanc *et al.*, 2017). The growth of e-commerce and the increase in goods flows that it brings with it have led to an interest in developing urban logistics space. E-commerce *pure players* are among the drivers of the logistics real estate sector, seeking to meet their growing needs for logistics space by turning to new asset classes, ranging from XXL warehouses of one hundred to two hundred thousand sqm to small urban warehouses of a few hundred or thousand sqm. This dual entry into the logistics real estate market is well illustrated by developments in Amazon's US locations.
- The process of expansion of the spatial coverage of warehouses, which contributes to the phenomenon of logistics sprawl that relies on the multiplication of warehouses in peri-urban spaces and more broadly in low-density spaces (Giuliano *et al.*, 2013; Dablanc *et al.*, 2018). The lack of regulation of metropolitan margins has favored the development of warehouses in peri-urban spaces. Several location-related relationships already identified (Dablanc *et al.*, 2018) are confirmed by this empirical study on the case of Amazon: logistical sprawl is positively related to the availability of large parcels in peripheral areas and the intensity of logistical sprawl varies with the type of warehouse (higher for large distribution and processing centers, more limited for courier terminals). Amazon therefore contributes to logistics sprawl in the United States, both through the location of large distribution warehouses in suburban areas and even on the outskirts of cities, and through an increasingly dense network of warehouses that accentuate Amazon's land and property footprint, which is quite far from urban centers. Moreover, despite the dualization of the logistics real estate market and the renewed interest in central and peri-urban areas, this has not been to the benefit of limiting or mitigating logistics sprawl. The case of Amazon is interesting in confirming this point: the strong growth in the number of peri-urban warehouses is coupled with a strong growth in urban logistics spaces, thereby increasing Amazon's urban footprint. One could therefore speak of a contradictory process of

logistics sprawl, both centrifugal and centripetal, or of a process of contradictory logistics sprawl that doubles as a process of expansion of the urban footprint of the logistics sector. If warehouses of various sizes were to multiply in central and peri-urban areas in parallel with the peri-urban logistics system, this would contribute to increasing the urban footprint of warehouses. This raises regulatory, land, real estate and environmental issues in terms of urban planning and development, as well as vehicle flow management and management of the negative externalities of urban logistics.

- The logistics sprawl to which Amazon's logistics system contributes can be explained firstly by a change of scale in Amazon's level of activity (explosion of e-commerce and strengthening of this trend during the Covid-19 crisis (Dablanc, 2019), Amazon's dominant position on the US market) and secondly, by the overall evolution of the global supply chain (Hesse, 2008). Indeed, Amazon's logistics real estate strategies follow the major trends observed in this global logistics real estate market: development of a logistics real estate offer that meets the needs of logistics operations (mutability, automation, need for space and large single plots, modern equipment); consideration of the logistics building as a financial and real estate asset (Fender *et al*, 2016); a process of vertical integration that relies on direct control of several links in the *supply chain* to be less dependent on third-party actors (3PLs, shippers, carriers) and on the development of a real system that takes advantage of this dual but potentially complementary logistics real estate market and generates economies of scale and density.
- Finally, Amazon's warehouse location strategies need to be observed on a finer scale in order to fully understand their spatial logic. After analyzing the three case studies, it appears that regionalized logistics strategies are being deployed, with several important common characteristics (concentration of large warehouses on the outskirts of metropolitan areas, deployment of a fine network of urban logistics spaces, development of intermediate logistics links, particularly *regional sortation centers*, importance of accessibility and location near transport infrastructures). Nevertheless, it also appears that these regionalized strategies reveal differentiated systems, apparently taking into account territorial arrangements and socio-economic and urban dynamics: the case of the Chicago metropolitan area shows a logistics system built according to a classic model of distinct radio-concentric areas (large warehouses on the outskirts, urban logistics spaces in the city center, with the exception of a few rare urban logistics spaces in peri-urban areas). The case of Los Angeles, onthe other hand, reveals a polycentric logistics system reflecting the polycentric organization of the metropolitan area, with several major clusters of peri-urban warehouses far from the city center, another cluster near the port infrastructures of Los Angeles/Long Beach, and a scattering of urban logistics spaces in the main and secondary residential and employment centers which are structuring this vast metropolitan area. Finally, the case of the southern part of the Northeast region, from the New York metropolitan area

to the Baltimore and Washington D.C. shows a new form of spatial organization, linear this time, following the long urban and infrastructure corridor that structures the megalopolis, with, for example, several clusters of peri-urban and ex-urbanized warehouses on the outskirts of the major cities, but also in the secondary centers and in the interstitial spaces. Moreover, this linearity is beginning to split further north with a second arc of warehouses beginning to form in the hinterland. These initial findings require further study, particularly in other US urban regions, to understand whether the spatial logic of Amazon's location adapts to pre-existing territorial arrangements and legacies in addition to (or in parallel with) market logic (land availability, costs, etc.).

This work could be complemented by further research in a context of strong development of Amazon's logistics system and continued growth of the e-commerce sector, particularly during the Covid-19 crisis. Other analyses of Amazon's locations in other urban regions and large agglomerations could be conducted in order to refine the initial findings on the regionalization of Amazon's logistics system and to identify other regionalized logics. In addition, two lines of research could be pursued: first, a multifactorial analysis (transport, land, traffic flows and congestion, socio-demographic and economic factors, environment, etc.) on the location logic of Amazon warehouses in order to understand its urban footprint and negative impacts; second, an analysis of land and real estate costs in order to understand the impact of these costs on the location of warehouses and the extension of the warehouse network and to deepen the understanding of the differential relation between warehouse location (in urban areas and in peripheral areas) and real estate and land costs (Oliveira, Schorung, Dablanc, 2021).

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