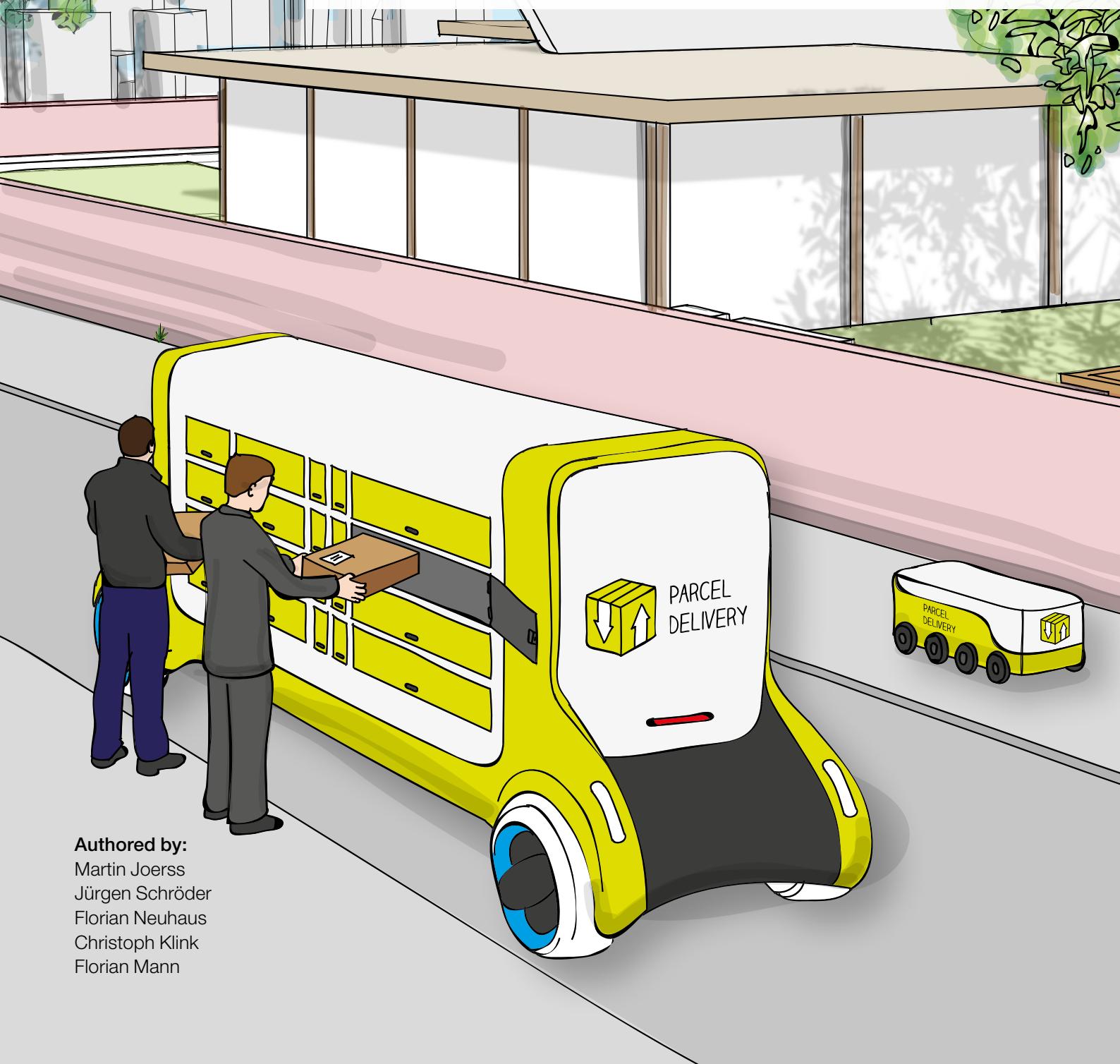


Parcel delivery

The future of last mile

Travel, Transport and Logistics
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Executive summary

Currently subject to significant disruption, last-mile delivery, especially of parcels, is getting a great deal of attention in the media and from investors – rightfully so. The cost of global parcel delivery, excluding pickup, line-haul, and sorting, amounts to ~ EUR 70 billion, with China, Germany, and the United States accounting for more than 40 percent of the market. However, the market is not just large, it is also highly dynamic, with growth rates in 2015 ranging between 7 and 10 percent in mature markets, such as Germany or the US, and almost 300 percent in developing markets such as India. This means that, in mature markets, volumes could double over the next ten years, reaching roughly 5 billion and 25 billion parcels per year in Germany and the US respectively.¹ The largest driver of this growth is not surprisingly e-commerce, which has shifted market share from the B2B to the B2C segment. B2C once made up ~ 40 percent of the market, but has since exceeded 50 percent in a number of countries, including Germany. In addition, the last mile's hefty share in total parcel delivery cost – often reaching or even exceeding 50 percent – makes it a key process step for those seeking to gain a competitive advantage. At the same time, it is precisely at the last mile that many incumbents are struggling, as they often shoulder significant labor cost disadvantages and therefore, all else being equal, competitive disadvantages.

Size, growth, and the difficult positioning of incumbents alone already provide ample grounds for studying the future development of the last mile. But there is one more critical factor supporting the case for taking a closer look: the last mile is seeing disruption from new business models that address customer demand for ever faster delivery, as well as new technologies that are likely to reach market readiness over the next ten years, including drones and autonomous ground vehicles (AGVs).

Before we jump into the details of our vision of the last mile, we would like to first summarize the three key hypotheses that we later develop and discuss in the remainder of this document.

1 A growing group of consumers desires faster home delivery, yet most remain highly price sensitive

To better understand consumer preferences, i.e., the rapidly growing X2C market, we conducted a large-scale survey in China, Germany, and the US with a total of 4,700 respondents (1,500+ in each of the three countries), which produced some fascinating results. Almost 25 percent of consumers are willing to pay significant premiums for the privilege of same-day or instant delivery. This share is likely to increase, given that younger consumers are more inclined (just over 30 percent) to choose same-day and instant delivery over regular delivery. However, the remaining ~ 70 percent of consumers still prefer the cheapest option of home delivery. These results are generally consistent across all three countries surveyed and across all product groups, but with different orders of magnitude. Chinese consumers, for example, are significantly more open to innovation than their North American or German contemporaries. Furthermore,

¹ Market volumes include domestic express segment

consumers' willingness to pay for fast delivery when purchasing groceries is markedly higher than, e.g., for apparel. To our surprise, only a minority of respondents indicated a willingness to opt for unattended delivery, e.g., parcel lockers, even at discounted prices.

2 Get ready for a world where autonomous vehicles deliver 80 percent of parcels

Three X2C delivery models are likely to dominate the last mile in the future, driven by consumer preferences and drop density (e.g., longer distances in rural areas significantly increase last-mile costs): AGVs with parcel lockers, drones, and bike couriers. Two of these three delivery models will be characterized by a high degree of automation and asset intensity. Autonomous vehicles including drones will deliver close to 100 percent of X2C and 80 percent of all items. Only ~ 2 percent will be delivered by bike couriers in the relatively small instant delivery segment.

Traditional delivery will account for the remaining ~ 20 percent of all items: big B2B customers with high drop factors (i.e., the number of parcels dropped per stop/recipient) and often special delivery requirements (e.g., hanging goods) will favor mostly human delivery as we know it today. The same is true for e-grocery delivery, as people will still want crates to be carried up to their apartments and returns to be handled directly.

3 This vision will become reality within the next ten years

The speed at which the outlined last-mile delivery scenarios can be reached will vary, depending on public sentiment, regulation, and labor costs. Early adoption of these new autonomous delivery models will concentrate in developed countries, where labor costs are high enough to make the return on investment significant. In the developing world, however, labor costs will likely remain low enough to prevent any major technology change impacting the last mile over the next five to ten years. In any event, regulation will need to change significantly (e.g., liability for damages caused by autonomous vehicles), but such regulatory challenges will be overcome in the next ten years, driven by the influence of the large automobile companies. At the same time, public opinion concerning autonomous vehicles including drones has already started to shift – with 60 percent of consumers indicating that they are in favor of or at least indifferent to drone delivery. Therefore, there is very little to suggest that the transformation will not kick in over the next ten years, at least in the developed world.

So what does that mean for any player in the market? If a company operates in a high-labor-cost country, it better starts thinking about the future of the last mile now, as key foundations in HR, IT, and the investment strategy need to be laid down. Companies that fail to act soon will forfeit their chance to be among the contenders for the last mile in the long term. However, before we jump to conclusions, let us look at our findings in detail.



1

A growing group of consumers desires faster home delivery, yet most are highly price sensitive

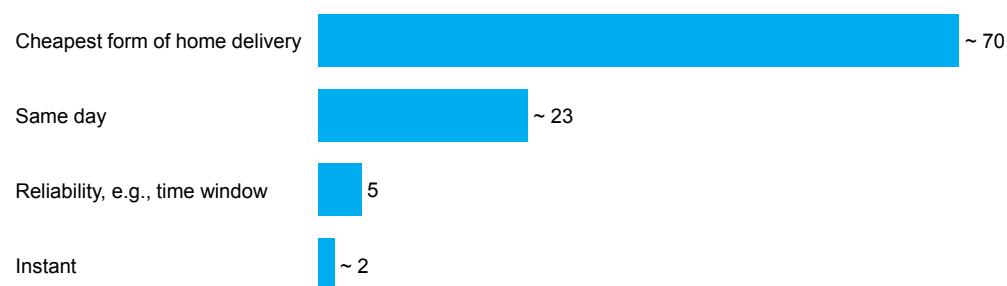
With the rise of e-commerce, consumer preferences have moved more and more to the center of attention in the formerly business-oriented parcel delivery market. Large e-commerce players as well as various start-ups have identified last-mile services as a key differentiator vis-à-vis their competitors. In fact, the variety of delivery options and the perceived quality of the delivery service are major decision criteria for online customers and hence directly impact e-commerce players' success in the marketplace. With this in mind, vendors are working hard to provide their customers with the best customer experience possible, especially by improving delivery times.

However, there still seems to be little consensus as to the kind of delivery services consumers actually desire and whether or not they are willing to bear the costs of added convenience. Hence, we conducted a comprehensive survey with 4,700+ respondents in China, Germany, and the US. We used a type of conjoint analysis to better understand consumer's relative preferences for different delivery options, including their willingness to pay. In the following, we present our key insights, which are summarized in Exhibit 1.

Exhibit 1:

Share of consumers choosing different delivery options

Percent of X2C volume



1.1 Same-day or instant delivery will grow to 20 to 25 percent of X2C volume

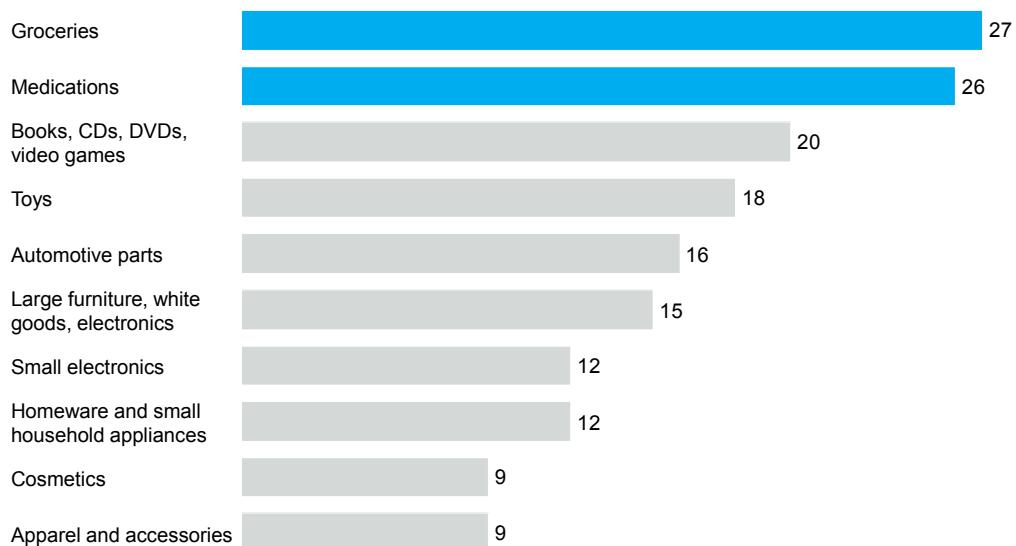
To differentiate themselves, many e-commerce players and start-ups are offering ever faster delivery, such as same-day and instant delivery enabled by improved fulfillment processes. In fact, 20 to 25 percent of consumers would pay significant premiums (up to EUR 3, RMB 20, and USD 3 in the respective region) to receive their items on the same day. However, only ~ 2 percent of all consumers are willing to pay much more than that for instant delivery (assuming the consumer would have to bear the additional cost of this extremely fast service). This is somewhat surprising, as many start-ups and some large e-commerce players target precisely this small niche with their offering. Given consumers' reluctance to pay, sellers or senders will probably have to pay the additional cost of delivery if the instant delivery segment is to significantly expand its share of total last-mile volume. In any event, same-day and instant delivery will likely reach a combined share of 15 percent of the market by 2020, as we have estimated in an earlier publication, and are likely to significantly grow further beyond this date thereafter, especially if the service is extended to cover rural areas to some extent.

The significant portion of same-day delivery suggests that e-commerce players would be unwise to neglect this segment, especially given that up to 27 percent of respondents claim that they preferred not to buy items online due to the long delivery times. Fast delivery is most relevant for groceries and medication (Exhibit 2).

Exhibit 2:

Share of respondents who did not purchase an item online due to long delivery times

Percent by category



1.2 For the majority of consumers, price remains the key decision criterion

Despite increasing customer demand for same-day and instant delivery, more than 50 percent of consumers choose delivery options merely based on price while another 20 prefer the cheapest available option of home delivery. That means that regular parcel delivery (delivery several days after the order), which is essentially the low-cost alternative to same-day or instant delivery, will continue to play a major role. This is hardly surprising, given how many people drive quite a few minutes further to shop at the cheapest supermarket, gas station, or electronics store, although savings are often insignificant.

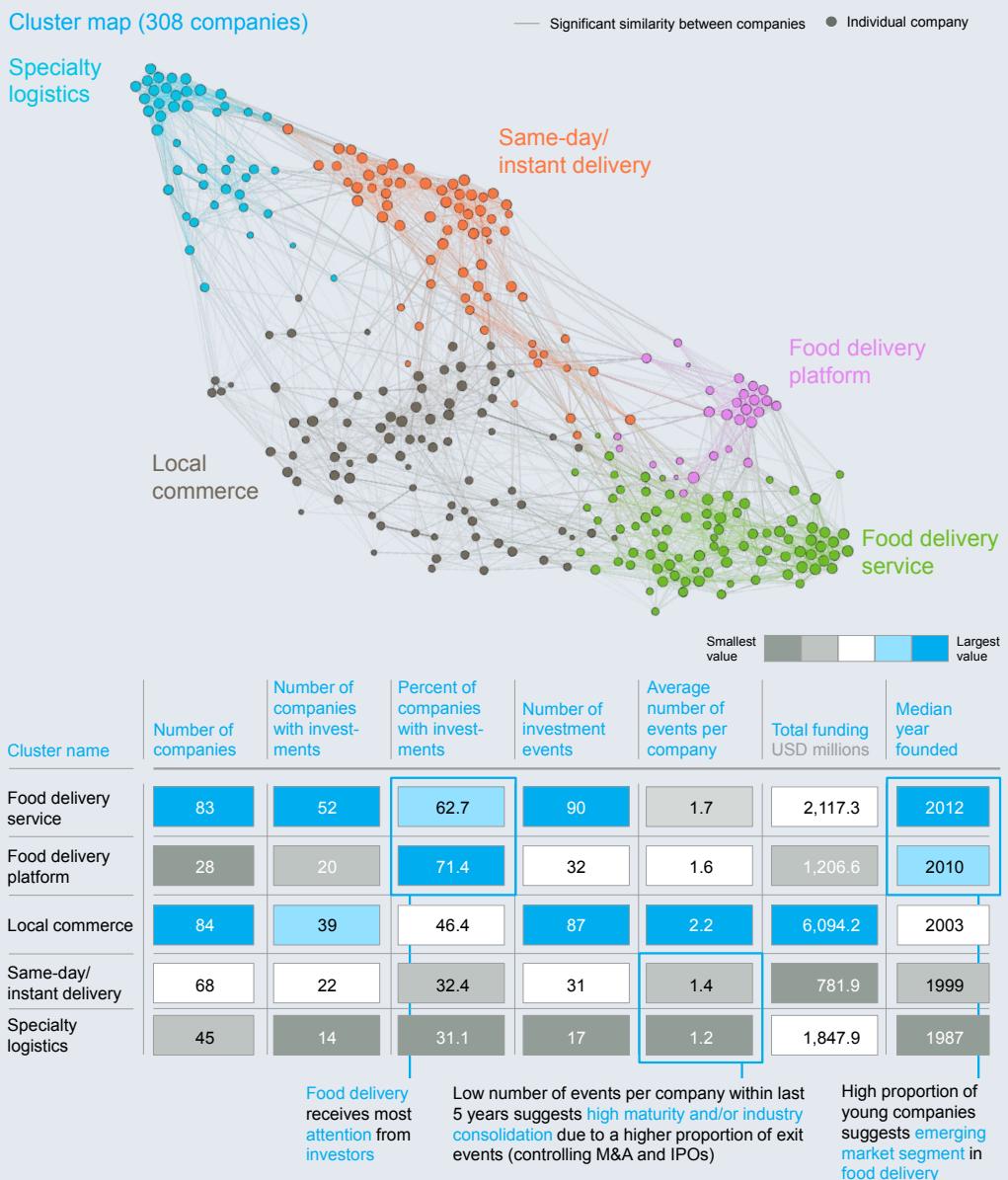
So far, we discussed that 20 to 25 percent of consumers choose same-day or instant delivery, more than 50 percent choose merely based on price and another 20 percent prefer the cheapest home delivery option – so what about the remaining ~ 5 percent? They prefer options that guarantee delivery within a specified time window of no longer than two hours, although they could wait until the next day or the day after, and would pay extra for a reliable service. This segment is likely to reach a critical size worth addressing, but will remain a niche market nonetheless. However, similar to the same-day and instant delivery segment, this niche's share of the market could be boosted if e-commerce players and senders were willing to bear the extra cost of time-window delivery.

Current start-up activity in the last-mile market

Instant delivery is receiving considerable attention, spurring high start-up activity and attracting significant injections of funds from venture capital firms. Our comprehensive analysis of start-up activity (Exhibit 3) reveals that, among the new business models emerging, new ventures dealing with the integration of local commerce and delivery of prepared food are receiving the greatest support in the form of seed investment. In addition, the companies active in this field are among the youngest in the industry, signaling an acceleration of activity. Over the past five years, these companies have attracted funding just short of USD 10 billion.

Exhibit 3:

Results of semantic research in the start-up scene. Activity currently focuses on prepared food



The disproportionate focus on delivery of prepared food is not surprising as prepared meals are the most obvious product category for which instant delivery is required and demand already exists.

1.3 Trends are fundamentally the same in all countries and categories, with some noteworthy exceptions

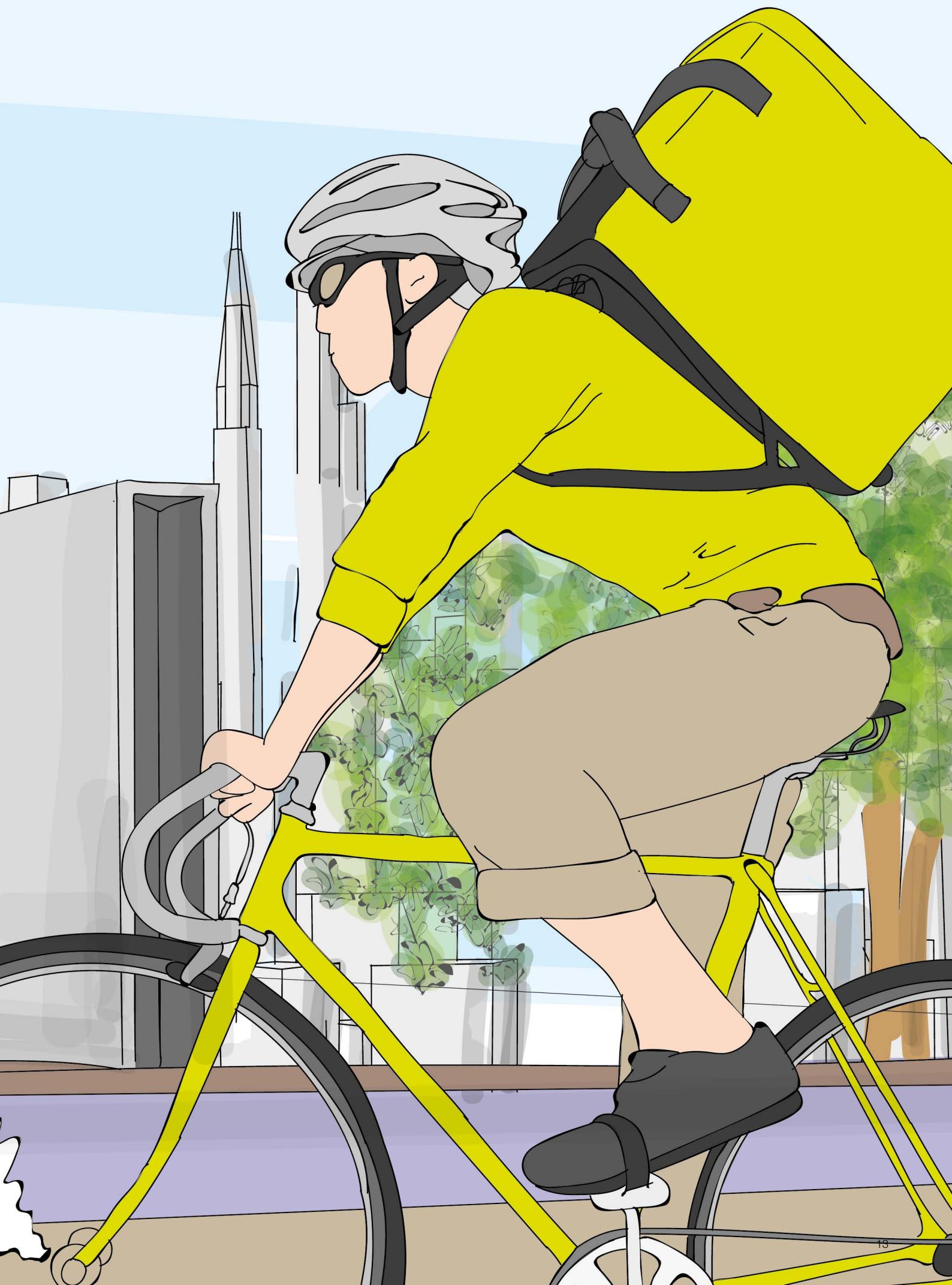
In all three countries surveyed, more than 50 percent of consumers choose a delivery option based merely on price. However, for ~ 30 percent of US consumers, home delivery is very important, while only ~ 15 percent of the Chinese feel that strongly about the point of delivery – German consumers are in between the two extremes. In contrast, more than 30 percent of Chinese consumers choose delivery based on speed (same day, instant) and timing reliability (delivery within a specified time window), compared with only ~ 15 percent of consumers in the US sharing this preference. These differences are most likely driven by the lower willingness to pay for higher speed of delivery of US consumers rather than a lack of demand for faster delivery. More than 50 percent of US consumers would generally pay extra for same-day delivery, but only ~ 15 percent would pay more than USD 1. Overall, we can conclude that the general tendencies and preferences are similar across geographies with minor differences in willingness to pay.

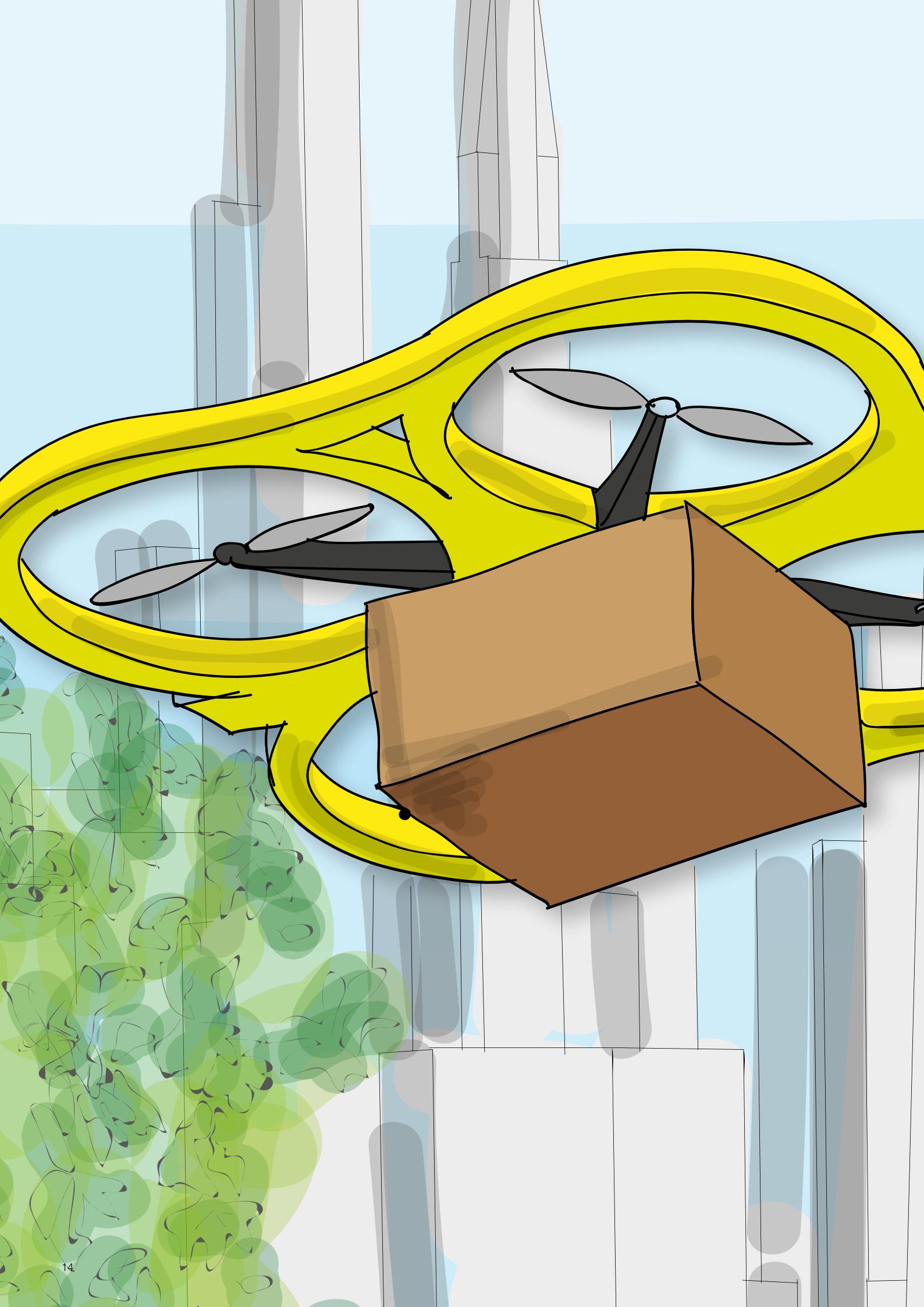
Consumers also do not seem to differentiate significantly across product categories¹, with the share of consumers willing to pay extra for speed (up to EUR 1, RMB 5, or USD 1 in the respective region) ranging from 35 percent to 40 percent, for example. Groceries, small electronics, and automotive parts stood out with the highest consumer willingness to pay for fast delivery, with up to 45 percent willing to pay extra. For these categories, 9 percent of consumers are willing to spend EUR 5 (or RMB 25 or USD 5) on top of regular parcel delivery prices, while none of the other categories reach 5 percent. So there is clear evidence of demand for an instant and same-day delivery offering, at least for some product categories.

1.4 Customers want direct delivery to their home

Somewhat surprisingly, unattended delivery, e.g., to parcel lockers, does not really appeal to consumers despite the possibility of picking up their parcel 24/7. Only if home delivery were to cost EUR 3 (or RMB 20 or USD 3) more than a pickup at the parcel locker, about 50 percent of respondents would prefer to use parcel lockers – emphasizing again the high value consumers assign to home delivery. As costs for parcel-locker delivery are often not significantly below regular parcel delivery costs, due to high real estate prices, it is reasonable to assume that this form of delivery is unlikely to take off or have much of an impact in the market. That said, the ability to send certain items to a parcel locker, i.e., the offering in itself, clearly adds value, and consumers appreciate having a variety of delivery options and the resulting additional flexibility.

¹ Categories surveyed included the following: books (including DVDs), small electronics, small household appliances, apparel, cosmetics, medication, toys, groceries, and automotive parts.





2

Get ready for a world where autonomous vehicles deliver 80 percent of parcels

Out of the seven general home delivery models identified (see box on page 20), four delivery models clearly dominate the others, when it comes to cost and fulfilling customer preferences, i.e., regular parcel, high reliability of timing, same-day and instant delivery: AGVs with lockers, drones, bike couriers (or potentially droids), and today's model. It is already evident from our current cost estimates¹ that drop density plays a major role in the cost of different delivery models. We have therefore introduced drop density as a second dimension to our matrix, along with general customer preferences (Exhibit 4).

Exhibit 4:
Delivery models

		Increasing drop density/decreasing cost		
		Rural areas with low to average density ²	Urban areas with average density ³	Urban areas with high density ⁴
X2C	Regular parcel ¹			
	High reliability, e.g., time window			2.1 AGVs with lockers (e-grocery with today's delivery model)
	Same day	2.2 Drones (same day, if fulfillment times feasible)		
	Instant	Fulfillment (likely) not possible at economical cost levels		2.3 Bike couriers (or droids)
B2B		2.4 Today's delivery model		

1 Between D+1 and D+4 2 Below 50,000 inhabitants 3 50,000 - 1 million inhabitants 4 Above 1 million inhabitants

2.1 AGVs with parcel lockers will dominate regular parcel delivery as well as time-window and same-day delivery in urban areas

Our calculation shows that AGVs with parcel lockers will replace current forms of regular parcel delivery. This is due to cost advantages of 40 percent and more over today's conventional last-mile delivery – especially in rural, but also in urban areas – assuming labor costs of ~ EUR 20 per hour. Note that the cost advantage only holds if labor costs are no lower than EUR 10 to 12 per hour. To emphasize the magnitude involved: a 40 percent saving in delivery costs would translate into a 15 to 20 percentage point increase in profit margin or (more likely given that price is the key decision criterion in this market segment) into a 15 to 20 percent cut in prices. In an industry with margins ranging between 2 percent and 5 percent, this is substantial. With wages likely to continue to rise, the advantage of autonomous delivery forms will increase further. At the same time, last-mile delivery will become significantly more asset intensive.

¹ The cost estimates are based on a proprietary McKinsey tool designed to calculate last-mile cost. The tool takes into account a number of variables, including drop density and delivery depot density, and has been successfully applied at various clients – cost estimates deviated less than 5 percent from real cost. Furthermore, we worked closely with our McKinsey Design-to-Value Lab to better understand production costs of new technologies, e.g., drones and complementary items such as batteries.

Apart from regular parcels, AGVs with lockers will also prove the delivery model of choice for same-day and time-window items. A key prerequisite for same-day delivery is a fast fulfillment process, but even more importantly, the logistics center needs to be close to the recipient to allow coverage of the last mile within a reasonable time. Speed likely restricts any form of driving-based same-day and time-window delivery to larger urban areas. Same-day items will probably require a separate network from regular parcels though, as regular delivery tours have typically long left the depots by the time same-day delivery items are ready for dispatch. In contrast to same-day items, the regular parcel network can be leveraged for time-window parcels, as they arrive sufficiently early in the delivery bases and detours in urban areas are small.

Drones turned out to be surprisingly cost-competitive in rural areas, at only ~ 10 percent above the cost of today's delivery model. With their higher speeds they are even better suited for same-day and time-window delivery of smaller items in rural areas (see next section).

As outlined in section 1.2, more than 70 percent of customers favor the cheapest home delivery option. Together with time-window delivery, the network for these two products will carry 75 percent of all X2C last-mile items in the future, i.e., by far the largest network by volume. Of course, many companies will want to play a major role in a combined segment this size. However, to do that, they will need to get quite substantial prerequisites in place. First of all, they will need a fully fledged parcel network that allows for a high degree of consolidation. To get a sense of the scale involved, we are talking about 50 to 60 million parcels a day in the US alone in this sub-segment in 2025. Secondly, they will need to have an IT infrastructure in place that can handle several thousand AGVs and guide them through daily traffic while regularly optimizing the routes. And last but not least, a couple of thousand qualified employees will be needed to supervise the fleet. So recruiting and/or retaining the experts needed will be critical.

Just like regular parcels and time-window items, same-day delivery will also rely on AGVs with lockers, but the same-day vehicles will leave their bases later and product streams will not mix. Roughly half the demand for same-day delivery – totaling ~ 20 percent of X2C parcels – stems from urban areas. Although urbanites represent a lower share of the population (35 percent in Germany), they make up for it with a 50 percent higher inclination to order such products. In view of the few offerings in this space at present, same-day delivery will present a good way for e-commerce players to differentiate their offering and fuel growth. The relative infancy of this segment also makes it a good target for new players who would face relatively low barriers to entry – only a small number of potentially automated depots would be needed from an infrastructure perspective. It remains to be seen whether incumbents can leverage their existing size, infrastructure, and market knowledge to defend this promising segment or whether e-commerce players will capture this opportunity to enter the delivery market on a larger scale.

Beyond the delivery services we have discussed so far, AGVs with lockers enable service providers to create superior value for customers and earn additional rents from new services, e.g.:

- **Overnight pickup.** AGVs loaded with parcels that could not be delivered during the day could park in their delivery districts and serve as regular parcel lockers, from where customers could pick up their items overnight. That would also allow parcel service providers to save on the high real estate cost of today's parcel lockers.
- **Sunday delivery.** AGVs could provide Sunday delivery, even in countries with tight labor laws such as Germany, where work on Sundays is forbidden in most professions.

2.2 Drones will deliver all time-window and same-day items in rural areas

As already indicated, in rural areas, it is extremely costly to offer delivery within a specified time window or on the same day with any kind of driving vehicle due to the large distances that need to be covered to be in the right place at the right time – even for two-hour time windows. For smaller parcels, drones could offer a solution. However, they have two profound disadvantages: firstly, they currently only transport parcels of up to ~ 5 kg. Even if this weight limit was raised to 15 kg, a full-service operator would need an expensive overlay network to deliver the remaining items (more than 5 percent of items weigh between 15 and 30 kg). Secondly, drones are very big, especially those designed to fly long distances at low cost, and would therefore require landing areas of at least 2 m². Granted, technology will improve, but even for smaller drones it will be hard to find suitable landing sites in urban areas. These key disadvantages can be overcome if the drone service is restricted to small parcels and to rural areas, where it is easier to find suitable landing sites. If the number of parcels is limited to time-window and same-day services, the number of drones required would likely be ~ 250,000 in 2025 in the US, for example. This might meet with acceptance from regulators and the general public, although a question mark remains on this point. On the other hand, there is no alternative, as fulfillment centers are simply too far away from recipients – ~ 75 percent of all recipients in the US live in cities with less than 50,000 inhabitants – and all other delivery models are far too expensive or not feasible. So drones may be the only solution to offer same-day and time-window services in rural areas, and we are certain consumers in these areas would appreciate the offering.

If same-day and time-window delivery with drones in rural areas proves feasible, roughly 13 percent of X2C parcels will be delivered in this way, the majority of which would be same-day deliveries. This is a sizable market: Based on the estimated total market size in Germany, 13 percent equates to ~ 500 million items in 2025. Clearly this segment cannot be neglected. To capture a significant slice of this pie, companies will need powerful IT capabilities to control all of these drones, a few thousand supervisors and technicians, as well as a large number of starting bases to reduce the flight time. Ultimately, that means that the requirements are not all that different from the AGV with lockers network.

2.3 If droids do not become significantly cheaper, bike couriers are likely to be the best delivery form for instant delivery in urban areas

The outcome in the instant delivery market is probably hardest to predict. A number of business models have emerged so far, differing in terms of their monetarization models as well as their positioning along the value chain of last-mile services. However, costs for this service are relatively high, and our research suggests that consumers' willingness to pay significant premiums for higher service levels is fairly low. Consequently, successful models for tapping into additional sources of revenue that subsidize delivery cost will likely prove a differentiating factor in this field.

From a cost point of view, instant service can only be economically viable if the right product is available in the proximity of the recipient, which excludes many rural areas from this service. For longer distances – more than roughly 5 to 10 km – costs are simply too high and willingness to pay is too low. Due to the high variability of demand and the point-to-point characteristics of the service, crowdsourcing has often been touted as the most likely operating model. However, in section 2.5 below, we present several counterarguments that contest this. Irrespective of the employment model, bikes seem to be the vehicle of choice. Bikes do not have any speed disadvantage over short distances in many urban areas compared to cars, but cost significantly less. Furthermore, it is easy to employ bike couriers on a part-time basis given the limited level of training and investment required. Therefore, the most likely scenario is a dedicated bike courier model, similar to that already used by many prepared-food start-ups.

This is true at least as long as droids do not become significantly faster (30 km/h rather than 5 km/h) or the current operating costs cannot be significantly lowered (two to three times cheaper). If they do become faster, they will probably look very different from what we see today, as they would need to use regular streets and would no longer be able to cruise along pedestrian areas and sidewalks. However, we have not seen any developments pointing in that direction so far.

E-commerce players entering the space may prove successful at increasing the product range relevant for instant delivery beyond prepared food, which is typically the focus of current services. However, we believe that activities will remain concentrated in major metropolitan areas. That would still be a sizable market with a potential of up to 100 million items per year in Germany in ten years from now – equivalent to ~ 2 percent of all X2C volume. Or to put it in other words: almost 300 thousand items delivered instantly (i.e., within two hours) in a handful of major German cities every day. A major game changer, especially in instant delivery, may come from the introduction of subsidies. E-commerce players could apply these to premium delivery options, such as same-day or instant delivery, and thereby differentiate themselves from the competition. In major cities close to fulfillment centers, this segment might thus significantly outperform our predictions. However, the subsidies would need to be substantial and have a major impact on e-commerce economics.

2.4 Traditional delivery is still unmatched for high-drop-factor B2B and e-grocery delivery

Besides customer preferences and drop density, the drop factor plays a major role in delivery cost. Exemplary recipients including larger business customers or high-rise buildings with mailrooms, which make up roughly 10 to 20 percent of the total volume, receive a large number of parcels each day. The increase in drop factor and the mode of exchange significantly

alter the advantages and disadvantages of the different delivery models. AGVs with parcel lockers no longer seem suitable as only few recipients will be willing to open ten or perhaps even significantly more lockers to pick up all of their parcels. Besides the likely issue with customer acceptance, costs per parcel shift. In regular delivery, multiple parcels can be loaded onto roll containers and later be exchanged in a matter of seconds, while the lockers mounted on AGVs would need to be filled individually. Based on our calculations, the break-even point between the two models is reached at an average drop factor of ~ 10 to 15 parcels per location, assuming personnel cost of ~ EUR 20 per hour as used in previous calculations.

In addition, large business customers often require value-adding services, e.g., transporting hanging goods or sorting items into small store rooms, tasks that AGVs simply cannot handle. Therefore, as long as there are no solutions that allow varying volumes to be securely dropped off at low interaction costs at the recipient and the rendering of value-adding services, we believe that the current practice of exchanging roll containers is superior.

Besides large business recipients, e-grocery shoppers will likely continue to interact with delivery personnel, especially for larger deliveries including crates of beverages. AGVs may not be suitable for grocery deliveries subject to cooling restrictions and, more importantly, services highly valued by customers, such as having heavy crates carried up several flights of stairs.

2.5 Crowdsourcing will only play a minor role in the future of the last mile

As indicated above, crowdsourcing may not play a significant role in instant delivery, despite easing the ability of companies to cope better with fluctuating demand, to leverage resources for different uses (e.g., parcel delivery and taxi services), and to get access to cheaper, less regulated labor – since almost anyone can drive a cab or deliver parcels. Many start-ups complain about quality and reliability issues. As drivers often sign up with multiple crowdsourcing companies, it can sometimes be difficult to ensure sufficient capacity in peak periods. Furthermore, legal requirements often limit the use of crowdsourcing. In Germany, for example, the self-employed status of many drivers, which has the benefit of lower social security costs and a lower tax burden, is often contested as false and thus deemed illegal.

However, crowdsourcing still has its *raison d'être*: business models can be scaled up quickly without major capital investments, e.g., in vans, which makes it extremely attractive as a model for market entrants. Furthermore, crowdsourcing may well play a role in managing ultra-peak demand, e.g., in the run up to Christmas. Some companies have already shown how some of the quality issues might be overcome. Take for instance taxi services in developing countries, which have established high security standards thanks to quick feedback mechanisms. Even if quality issues and legal boundaries restrict the use of flexible resources, the IT backbone for matching requests with drivers and the mechanism for collecting fast feedback remain extremely valuable. We will deal with the advantages and disadvantages of crowdsourcing in more detail in a separate paper we intend to publish later this year.

Identified delivery models

We thoroughly investigated the start-up scene¹ and scanned for new technologies², which led us to identify seven operational models:



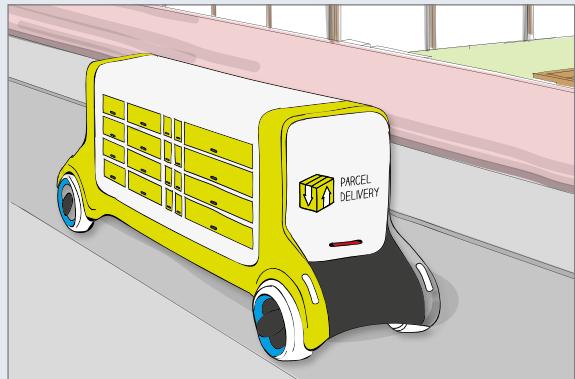
Today's model. A dedicated delivery person employed by the parcel delivery service provider picks up the parcels at a consolidation point, e.g., delivery base, and delivers them directly to the recipients. Large vans are typically used as delivery vehicles.



Drones. Autonomous aircrafts, e.g., copters or vertically starting planes, carry parcels (up to 15 kg) to their destination along the most direct route and at relatively high average speed. Like droids and AGVs, they too need to be supervised. We believe that one supervisor per roughly eight drones is a reasonable assumption.



Crowdsourcing. Any member who has signed up as a driver to the crowdsourcing network can choose to complete a specific delivery order. The advantage of this model is its flexibility in supply, especially in covering peaks and troughs, the multi-purpose use of certain assets such as cars, as well as the low investment requirements for parcel companies. Furthermore, some companies hope to create synergies beyond regular parcel delivery, e.g., with taxi services.



Autonomous ground vehicles (AGVs) with lockers. AGVs deliver parcels without any human intervention. Customers are notified of the exact arrival time. Upon arrival at their door, customers are asked to pick up the parcel from the specified locker mounted on the van or truck – picture a mobile parcel locker. Granted, such vehicles would need to be supervised. We assume that a central supervisor could manage roughly eight to ten AGVs.

¹ We reviewed ~ 300 start-ups, identified based on a semantic search in major databases such as Capital IQ, CB Insights, AngelList, and CrunchBase, to uncover new operational models.

² We searched through patents filed, leveraging a semantic search of more than 2,000 published articles.



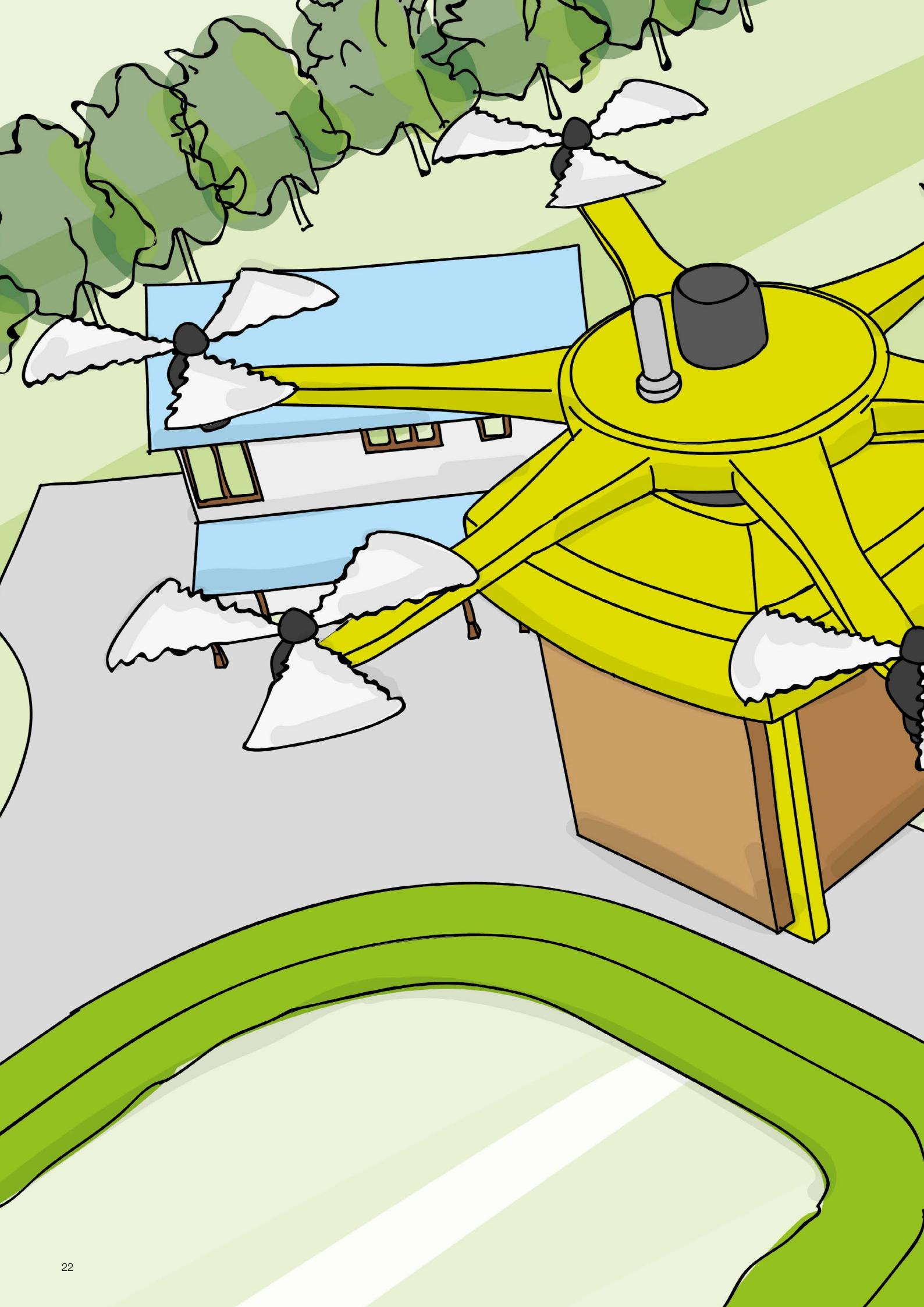
Bike couriers. Couriers employed by the parcel service provider deliver a small number of parcels by bike. Today, this is often seen in point-to-point delivery, especially for B2B documents and prepared food.



Semiautonomous ground vehicles. A delivery person is still required, but could theoretically use the driving time more efficiently to take care of sorting or smaller administrative tasks, e.g., scanning or announcing arrival while the vehicle does the driving. These advantages need to compensate for higher investment costs, as autonomous ground vehicles are likely to be more expensive than regular cars or vans, at least initially. However, the delivery person will likely not be allowed to move freely while the vehicle drives, limiting the tasks that can be performed in transit. We find it difficult to see how the savings in terms of streamlined administrative tasks can compensate for the higher investment cost.



Droids. Small autonomous vehicles, only slightly larger than a regular parcel, deliver parcels to the doorstep. These vehicles are relatively slow at 5 to 10 km/h and use the sidewalk rather than the street to reach their destination. Such droids also need to be supervised, but due to their size and low speed, developers currently believe that a single supervisor could manage 50 to 100 of them.



3

This vision will become reality within the next ten years

Generally, we believe that most economic prerequisites are already in place for the outlined future of the last mile to become reality, but the speed at which different countries will adapt depends fundamentally on three factors:

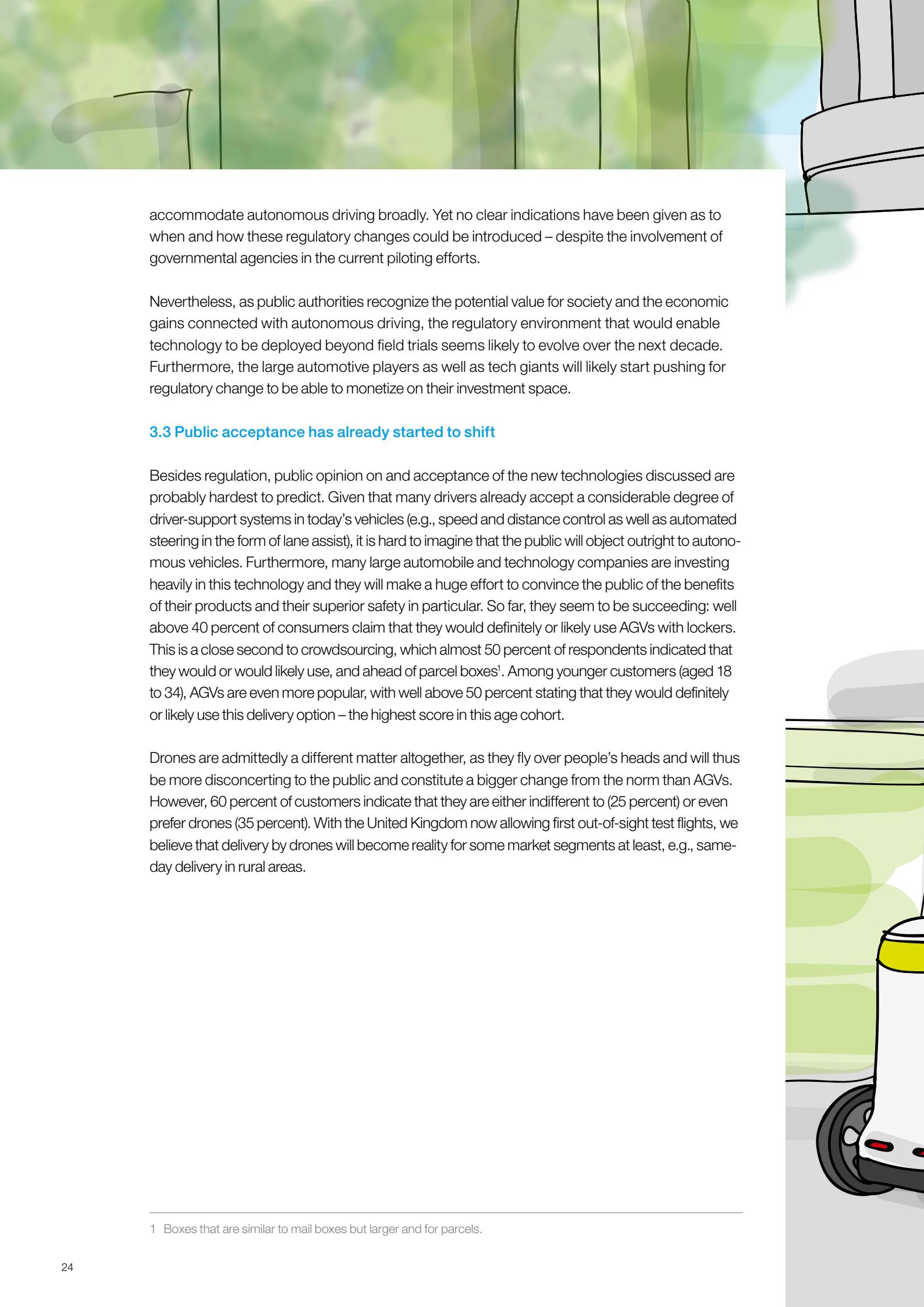
- **Opportunity cost.** As the cost of labor increases, technology becomes relatively more affordable, accelerating the transition to automation. Eventually, this will also be the case in developing countries.
- **Regulation.** Current regulation does not properly address autonomous vehicles. This will need to change dramatically before autonomous vehicles can gain traction.
- **Public acceptance.** The public is generally very skeptical of change. How will it respond to the large-scale introduction of autonomous vehicles?

3.1 Opportunity cost determine the adaption in developed countries

Our conclusions so far hold true for countries with labor costs above ~ EUR 10 to 12 per hour, i.e., more or less for the entire developed world. With labor costs below this threshold, however, traditional last-mile delivery as we know it today will continue to be predominant. Many developing countries have labor costs at such low levels. There, incentives to switch to more autonomous and therefore asset-intensive forms of delivery are significantly lower for the time being. Furthermore, in developing countries, last-mile services are often still in their infancy. It is true that countries such as India and China are catching up fast, and in some ways may have already overtaken Europe or North America, but in many smaller countries, in Africa or South-East Asia for example, emerging players will look for operational models requiring lower upfront investment to minimize risk. However, the scenario we painted for developed countries requires the greatest investment effort of all – large investments in IT, talent, and technology. Hence, we believe that instead of autonomous forms of delivery, many developing countries will increasingly see crowdsourced fleets competing in the market thanks to their potential for fast, low-risk expansion. Over time, these markets will slowly transform into the future picture outlined for developed countries, with the rate at which wages increase acting as a catalyst.

3.2 Regulation will need to change

While the automotive industry has identified autonomous driving as a major trend, both for passenger cars as well as for commercial vehicles, regulation does not yet allow for delivery models based on comprehensive coverage with AGVs. Major countries currently lack clear legislation that would allow the use of autonomous vehicles outside of diligently controlled field trials. In order for AGVs to reach economic viability, human control has to be limited to an absolute minimum. However, even in field trials, AGVs are currently still required to operate under human supervision. A number of pilots have been launched in recent years or are currently being prepared in major automotive and parcel delivery markets, but so far only US authorities have clearly stated their desire to permit broad public use of AGVs. As for Europe, Japan, Korea, and China, significant regulatory changes would be necessary to



accommodate autonomous driving broadly. Yet no clear indications have been given as to when and how these regulatory changes could be introduced – despite the involvement of governmental agencies in the current piloting efforts.

Nevertheless, as public authorities recognize the potential value for society and the economic gains connected with autonomous driving, the regulatory environment that would enable technology to be deployed beyond field trials seems likely to evolve over the next decade. Furthermore, the large automotive players as well as tech giants will likely start pushing for regulatory change to be able to monetize on their investment space.

3.3 Public acceptance has already started to shift

Besides regulation, public opinion on and acceptance of the new technologies discussed are probably hardest to predict. Given that many drivers already accept a considerable degree of driver-support systems in today's vehicles (e.g., speed and distance control as well as automated steering in the form of lane assist), it is hard to imagine that the public will object outright to autonomous vehicles. Furthermore, many large automobile and technology companies are investing heavily in this technology and they will make a huge effort to convince the public of the benefits of their products and their superior safety in particular. So far, they seem to be succeeding: well above 40 percent of consumers claim that they would definitely or likely use AGVs with lockers. This is a close second to crowdsourcing, which almost 50 percent of respondents indicated that they would or would likely use, and ahead of parcel boxes¹. Among younger customers (aged 18 to 34), AGVs are even more popular, with well above 50 percent stating that they would definitely or likely use this delivery option – the highest score in this age cohort.

Drones are admittedly a different matter altogether, as they fly over people's heads and will thus be more disconcerting to the public and constitute a bigger change from the norm than AGVs. However, 60 percent of customers indicate that they are either indifferent to (25 percent) or even prefer drones (35 percent). With the United Kingdom now allowing first out-of-sight test flights, we believe that delivery by drones will become reality for some market segments at least, e.g., same-day delivery in rural areas.

¹ Boxes that are similar to mail boxes but larger and for parcels.



Outlook

The future last mile offers tremendous opportunity for existing and new service providers in the field, given the fast expected growth of between 5 percent p.a. in Germany and 17 percent p.a. in China over the next years, as well as the significant changes to the operating model that we have outlined in this brochure. However, before companies can move ahead and bring to life the new last mile, they should take one step back, as it is crucial to develop a strategy that suits the market environment and the company's strength. It is also important to bear in mind the competitive landscape with at least three groups of companies battling for predominance in the future last mile: incumbents, e-commerce players, and highly dynamic start-ups disrupting the marketplace. In Germany, for instance, players from each of these peer groups have already started pushing ahead: small droids are currently being tested for delivery by incumbents, drones are already flying every day operated by incumbents and e-commerce players (if only with major exceptions to current law), and start-ups are aggressively pushing into the market to gain access to new profit pools.

Looking at these three archetypes – which of them is generally best positioned to win the race? Incumbents clearly have the advantage of already having a solid and suitable network in place, enabling them to win in at least the markets served with drones or AGVs with lockers. But will they be quick enough to adapt their IT and HR strategies to keep pace with e-commerce players who are heavily investing in this space? Start-ups have mostly focused on the point-to-point market. But will their agility in adapting new business models be sufficient to fend off the e-commerce players or the incumbents?

As indicated before, most of the insights in this brochure can only serve as a starting point and input to a full last-mile strategy, but we hope it is a good one. We do not lay claim to clairvoyance, and events will no doubt unfold in unforeseen ways – but overall, the outlined developments seem very likely and we believe that those intending to compete in this space need to act now.

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